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A FRAMEWORK TO UNDERSTAND PROJECT ROBUSTNESS

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1. Introduction

Product development is often conducted as a project [Pahl & Beitz, et al., 2007]. Despite the long history of project management a multitude of projects fail the forecasts regarding costs, duration and customer requirements, what is usually judged as unsatisfactory success [Gericke & Blessing, 2006], [White & Fortune, 2002].
Complexity, intransparency and dynamic of product development tasks are barriers for the execution of product development projects [Dörner, 1996], [Strohschneider & van der Weth, 2002].
In addition to these general barriers for project execution in the domain of product development, projects are affected by further factors. Technical, organisational and social factors are important [Hales & Gooch, 2004].
Causes for deviations in projects were identified in several empirical studies e.g. changes of project goals, poor forecasts and inadequate communication [Gericke & Blessing, 2006]. Following the problem of deviations will be addressed with the focus on Small and Medium sized Enterprises in the domain of mechanical engineering.
The problem of deviations from project-plans and forecasts is discussed in standard literature of project management. Numerous methods and approaches are offered [Kerzner, 2006]. Project monitoring, change management and e.g. gate-reviews do enhance the situation, but these approaches are basically reactive. This means actions for mitigation or compensation of disturbances and deviations will not be implemented until the project is already in a precarious situation. The concept of product development project robustness aims for proactive solutions.
Inspired by the concept of robust design in the manufacturing area, the research questions are:

- How can the concept of robustness be interpreted in the context of product development projects?
- How to enhance robustness?

The concept of robust design was developed by Taguchi to reduce the consequences of disturbances during the manufacturing process [Kerzner, 2006]. A disturbance is defined as an *event that hampers, disrupts or affects an action in a way contrary to the actual intention of the initiator* [Badke-Schaub & Frankenberger, 2004].
In this paper a framework will be developed to understand robustness in the context of product development projects. Based on this different generic approaches to enhance project robustness will be presented and discussed.

2. State of the art

Established methods for the execution of complex design tasks are project management and risk management approaches [Kerzner, 2006], [Wallmüller, 2004]. An overview about project management, related tools and methods is given e.g. in [Kerzner, 2006] and [White & Fortune, 2002].

2.1 Success criteria

The success of projects can be judged by a multitude of criteria. The criteria that are used depend on the point of view of the person who is judging. Because of this, subjective criteria like personal benefit from the project or the accordance with organisational objectives may affect the judgement. Based on empirical findings of [White & Fortune, 2002] the accordance to:

- client's requirements,
- schedule and
- budget

are used as the main success criteria for product development projects.

2.2 Success factors

The problem of giving adequate advises to practitioners to enable them ensuring the success of projects has been investigated by e.g. [Kerzner, 2006], [Litke H.-D. , 2005], [Lechler & Gemünden, 1998] and [Dvir & Lipovetsky, et al., 1998]. Most relevant success factors are:

- structuring of projects
- emphasis oft the definition phase (goal definition)
- clear objectives and specifications that are known by all stakeholders
- transparency regarding the project status
- early detection of risks
- fast reaction on disturbances
- personalised responsibility

These success factors are accepted and comprehensible but difficult to transfer into practice. A barrier is the claim of most of these lists of success factors to cover all kinds of projects. To match this claim the factors have to be formulated in a generic way.

2.3 Risk management

Risk management is defined as *„The systematic application of management policies, procedures and practices to the tasks of establishing the context, identifying, analysing, planning and managing Risks in a way that will enable organisations to minimise loss and maximise opportunity in a cost-effective way.“* [DIN IEC 62198, 2002]
Risk management is usually displayed as an iterative process, consisting of risk identification, assessment, treatment and monitoring/communication [McMahon & Busby, 2005]. The challenge is to identify relevant risks and assess them correctly. An overview of methods and tools used for each of these phases is given in [DIN IEC 62198, 2002] and [Oehmen, Dick, Lindemann, & Seering, 2006]. Risk management aims at reducing the probability of occurrence and the severeness of events that may cause deviations.

2.4 Other approaches

One trivial approach to enhance the robustness is to provide buffer in the budget and schedule [Flanagan & Eckert, et al., 2005]. This approach may be reasonable in some cases. Regarding the concept of robustness it means a shifting of the target value or an enlargement of the acceptable deviation (see chapter 3.2.).

Due to business competition and increasing time pressure this approach is difficult to justify.
Another modelling approach [Chalupnik, Wynn, Eckert, & Clarkson, 2007] tries to reduce the slippage rate of product development projects. Using the P3 Signposting software different process configurations in terms of probability of rework, expected minimum and maximum duration of a task were simulated. In doing so, he is able to identify process elements that affect the process outcome in a severe way.
This approach allows new insights into the process behaviour. To obtain this, rich knowledge about the process is necessary. Especially for new product development this can be difficult.

3. Project robustness

Robust design focuses on manufacturing processes. An adaptation of this concept to product development projects will be presented.

3.1 Robust design

Taguchis quality philosophy is based on a comparative observation of a target value with the realised values. This perception, which uses a quality loss function, is a turning away from the traditional perception of using a target corridor.
Accordingly every deviation of a process result regarding the target value is a loss. The traditional perception accepts deviations that range between defined limits [Kamiske & Brauer, 1995].
To minimise the losses Taguchi introduced the concept of robust design. Robust design aims at a robust (insensitive) dependency between the process result and disturbances which can affect a variation of a control factor (see Figure 1). According to Taguchi the term robust is defined as:
"Processes are robust, if the result of the process depends as little as possible from inevitable variations of parameters, material properties, environmental conditions etc." [Kamiske & Brauer, 1995]

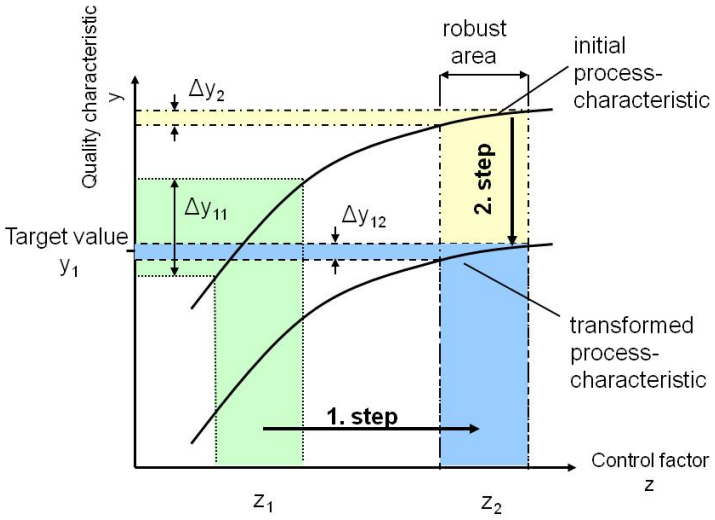


Figure 1. Robust Design (according to [Kamiske & Brauer, 1995])

To affect the robustness the dependency between a control factor and a target value can be changed in two steps (see Figure 1). With the assumption of a non-linear relation between the control factor and the target value a control factor is chosen, which will have less influence due to a variation on the value of the quality characteristic than the original control factor. In a second step the process

characteristic is transformed in a way that the target value can be attained with a minimum of tolerances and so with a minimum of loss [Kamiske & Brauer, 1995].

3.2 Robustness of Product development projects

Taguchis concept focuses on the manufacturing process. Due to the different nature of projects (unique) and manufacturing processes (mainly repetitive) an adaptation to the characteristics of product development projects is necessary.

3.2.1 Framework

To emphasis the distinction between manufacturing processes and product development projects the definition of robustness is reformulated:
Robustness means that project goals will be reached despite of unwanted and unexpected deviations from the original project plan.
The presented success factors in mind (e.g. costs); a project is robust, if a disturbance does not cause an unacceptable deviation of the project's outcome. This relation is depicted qualitatively in Figure 2.
The postulation of a zero-defect strategy and the reality of product development are leading into a trade-off. The claim of a zero-defect project is problematic since the necessary resources may overrun the benefit. Because of this, the acceptable deviation has to be defined with carefulness.
The basic assumption of this framework is that the possible deviation is dependent on the relation between the *need for actions* and the *application of actions*.
The considered actions aim at a reduction of the deviations what means that the project will be more robust. An action can be a method, a tool or prescribed behaviour pattern e.g. feasibility studies, training programs, design reviews, etc. The ratio of *application of actions* and *need for actions* is a theoretical, qualitative construct. It illustrates the basic idea that appropriate actions are able to reduce the occurrence of deviations. Only actions that are suitable for the problem and the project context should be considered.

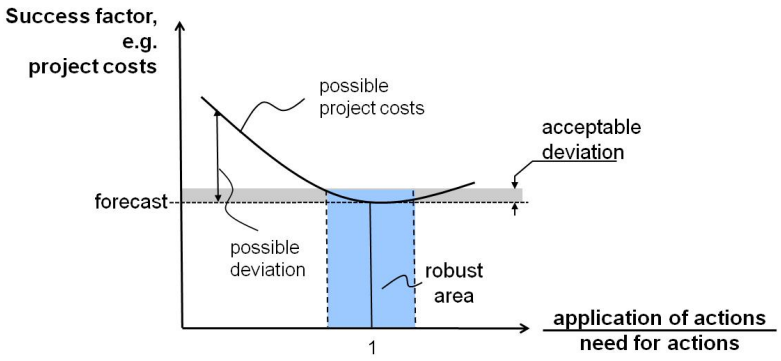


Figure 2. Robustness of product development projects

3.2.2 The need for actions

A project is defined as: *Intention, that's basically characterised by matchlessness of conditions in their entirety, e.g. definition of goals, target setting, temporal, financial, personal or other boundaries, assignment to other intentions and project-specific organisation* [DIN 69901, 1987].
According to that a project is individual and therefore the totality of actions that are adequate to execute the project is also individual.
An overview about factors which influence a project is given in [DIN 69901, 1987], [Litke H. D., 1993] and [Dvir, Lipovetsky, Shenhar, & Tishler, 1998]. These influencing factors can be used to prescribe the need for actions.

3.2.3 Influencing factors

The framework of project robustness of product development projects addresses factors, which have a decisive influence on the project execution e.g.:

- Precision of goal definition
- Complexity (management, product, stakeholders)
- Innovativity
- Uncertainty (market, technology, corporate)
- Risk
- Dynamic
- Interdisciplinarity
- Temporal limitation
- Limited resources
- Strategical goals of company
- Size (financial, team, temporal)
- ...

Little mistakes heightened by these factors can affect severe disturbances and deviations because of the interrelations of these factors. The presented success factors (see chapter 2.2.) and the influencing factors are strongly related, but their aim is different. Influencing factors entitle important variables and can be used to distinguish projects on an abstract level; success factors indicate favourably characteristics of them. Considering product development projects the mentioned factors cover three main areas (see Figure 3):

- the Project Management,
- the Product,
- the Stakeholder

These factors are highly interrelated – between the areas and inside of each area. They cannot be addressed separately but always have to be considered as a whole.
Figure 3 depicts the causal relation between the influencing factors (grouped into three areas), their influence on possible disturbances and the resulting deviations. The relations are not specified because of the manifold variants. The ambition of the model is to illustrate the causal relation and to divide approaches, aiming at a reduction of deviations regarding their objective (PM, product or stakeholder) and their nature (proactive vs. reactive).

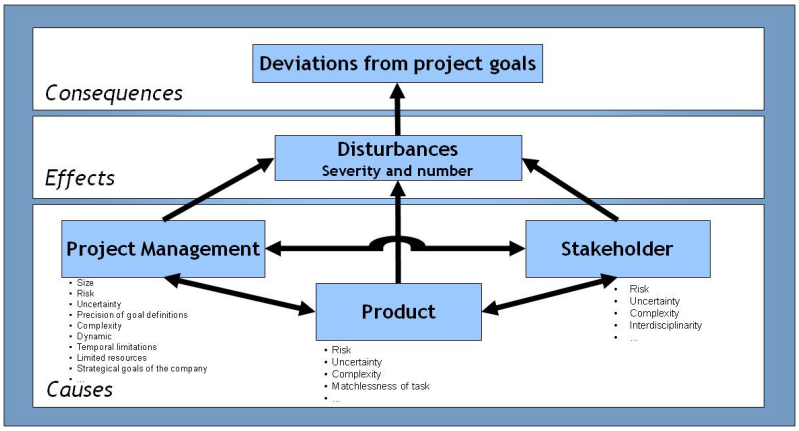
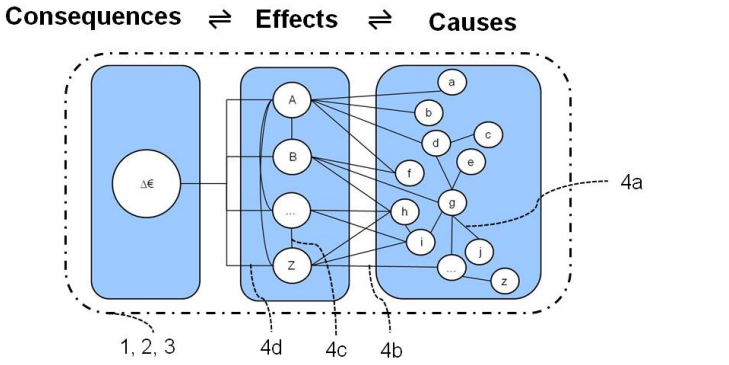


Figure 3. Causal relations of project robustness

4. How to enhance project robustness?

The concept of project robustness aims at enabling project-workers to help themselves and therefore to finalise the project successfully. But how to achieve this?
Analysing the dependencies between the influencing factors and the causal relations some generic approaches can be formulated. As examples four promising approaches will be discussed. In Figure 4 the area of application of each approach is displayed. While e.g. the enhancement of flexibility can be applied on all elements of the causal model the reduction of interdependencies focuses on the connections between the elements. Further concretion of the mentioned approaches enables a more detailed allocation of the area of application.



1 **Reduction uncertainties /Managing risks**
2 **Enhancement of flexibility**
3 **Enhancement of sharedness of mental models**

4 **Reduction of interdependencies**
a – between causes
b – between causes and effects
c – between effects
d – between effects and consequences

Figure 4. Approaches to enhance project robustness

4.1 Reduction of uncertainties / Risk management

The reduction of uncertainties and risk management is broadly discussed in literature. These well established approaches are necessary to enhance product development project robustness.
To assist the project team / the project manager the process of risk identification in particular needs individual support by e.g. tailorised checklists. For such individualised tools more empirical knowledge is required.

4.2 Enhancement of flexibility

The goal of a more flexible project is a reduced impact of disturbances. Enhancing the flexibility of a project can be achieved e.g. by creating fallback-positions for the project plan and a balanced team composition, which allows easier handover of tasks. Other approaches are creating solution-alternatives or reducing the number of levels of planning. That means the operational level of the project execution is less predetermined while the project team still works towards the same overall goal and forecasts regarding time and money and the same requirements.

4.3 Enhancement of sharedness of mental models

The concept of shared mental models is used in the context of design thinking research. According to [Neumann & Badke-Schaub, et al., 2006] four types of mental models exist in design: task, process, team, competence. Mental models in these areas have to be communicated to get a better

understanding within the project team. Sharing these mental models the team will collaborate more effectively and is able to detect deviations earlier and thus react earlier when deviations are still little.

4.4 Reduction of interdependencies

Interdependencies between factors across areas and/or within one area (project management, product, and stakeholders) have a severe influence on the whole project. A reduction of interdependencies requires an extensive analysis of existing interdependencies. Reducing these interdependencies in their quantity or intensity, the effects and their consequences can be reduced. First of all, the reduction of interdependencies reduces the complexity and increases the transparency. As a result the project manager gains a better overview about interactions between selected actions and their impact on the project.
The reduction of interdependencies can be obtained by e.g. a reorganisation of the team and a standardisation of communication channels.

5. Conclusions

The described generic approaches should be used as a whole. The reduction of interrelations, enhancement of flexibility and sharedness of mental models are thereby complementary to a reduction of uncertainties and risk management. These three complementary approaches make it possible to accept certain risks while risk management aims at controlling the project's inherent risks and uncertainties and at eliminating their impact on the project.
In the authors opinion it is vital important to accept some risks and uncertainties in the domain of product development. Excluding every uncertainty can limit creativity and courage to try something new. These are preconditions for product development.
Providing a contribution to practitioners on the basis of the framework of project robustness more specified approaches and advises how to detect the need for actions are necessary. As shown before the individuality of projects has to be taken into account. To facilitate this, a more detailed classification of projects is necessary. Based on an explicit description of a project regarding the influencing factors specified approaches can be defined and best practices can be formulated less generic.

6. Summary and further research

A framework for understanding robustness was developed. The individual relation for each project between the *application of actions* and the *need for actions* has been argued. Based on this, the demand for a more detailed insight into project specific approaches and best practices was discussed.
The assumption is that for similar projects the same specific approaches will succeed. For this a classification of projects regarding the use and success of approaches is necessary.
The basic idea of project robustness and four generic approaches and their complementary relation have been discussed. These are a prerequisite for further research and will be supplemented by specific approaches and best practices based on empirical insights.

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