INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'09
24 - 27 AUGUST 2009, STANFORD UNIVERSITY, STANFORD, CA, USA

MEASURE AND FAILURE COST ANALYSIS: SELECTING RISK TREATMENT STRATEGIES

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ABSTRACT

Project Risk Management is used to prevent the failure of projects. Despite its proven use, barriers still exist, which hinder implementation and use by inexperienced persons. One barrier is the lack of systematic support of important steps like the selection of an appropriate risk treatment strategy. The decision of which strategy to select is a challenging task due to the uncertain character of the addressed issue.

While the selection of the risk treatment strategy may influence the course of the project, the decision making is left to the risk manager's expertise. Only a few rather elementary methods are available to support the selection of the risk treatment strategy.

This paper describes the rationale for a systematic selection of risk treatment strategies. Based on this, a method is developed for the support of this important task. Decision making using the proposed *Measure and Failure Cost Analysis* (MFCA) method enables the Risk Manager to compare the arising costs of different risk treatment strategies caused by an occurring risk and risk treatment measures. It is based on a de-escalation principle, which analyzes the course of the impact of an event.

Keywords: Project Risk Management, Risk Treatment, Strategy

1 INTRODUCTION

1.1 Scope

The increasing complexity of products together with shorter product life cycles are driving forces for cost pressure in product development projects [1]. Project Management aims to support engineers in keeping schedules and budgets [2]. Despite the use of Project Management methods, a large number of projects do not meet the stakeholder's expectations. Overrunning of schedules and exceeding budgets are more the rule than the exception [3, 4]. Product development projects are challenging management tasks and make individual demands. Novelty of design tasks, complexity and dynamics of requirements and goals, politely (to strive multiple goals) affect the course of the project [5]. The resulting uncertainty affects project planning and causes adjustments of goals. "A detailed planning is nearly impossible" [6].

Frequent consequences of the mentioned boundary conditions (politely, uncertainty, complexity and dynamics of requirements …) are unwanted events which inhibit a successful project. The possibility of such events is a risk.

1.2 Goals of this paper

The usefulness of Project Risk Management is evident; nevertheless, it is not commonly used [7]. One identified barrier is the effort involved with Project Risk Management [4]. Two different approaches are possible to enhance the cost-benefit ratio. The first is to reduce the costs. The second is to enhance the benefit. In this paper, a method will be presented which addresses the cost-benefit ratio in both ways.

The method was developed based on a comprehensive literature study. Based on this study the rationale for a systematic selection of risk treatment strategies was developed, adapting and consolidating existing approaches. Both the rationale and a method which supports the task of risk treatment strategy selection are presented in this paper.

The method aims to support Risk Managers while selecting an appropriate risk treatment strategy and a related measure. The selection is based on a de-escalation principle. The most favorable strategy is identified through analyzing the rise of the impact of an event, the reaction rate of different strategies and related costs. The analysis of the reaction rate of possible strategies enables the Risk Manager to estimate costs and to exclude unsuitable strategies.

2 PROJECT RISK MANAGEMENT

A risk is defined as "a measure of the probability and consequence of not achieving a defined project goal." [2] This definition implies two components for a resulting event:

- Likelihood of occurrence of an event
- Impact of the event

In this context, an event is an encountered risk [8]. Smith and Merrit concretize this by giving the following definition: "The happening or state that 'triggers' a loss." [9]
Risk Management aims to avoid or reduce the loss caused by such events.

2.1 Risk models

Smith and Merrit gathered different risk models to identify factors influencing a risk. They propose the use of the "Standard Risk Model" (see Figure 1). The Standard Risk Model describes drivers which influence the probability of occurrence and the probability of an impact.

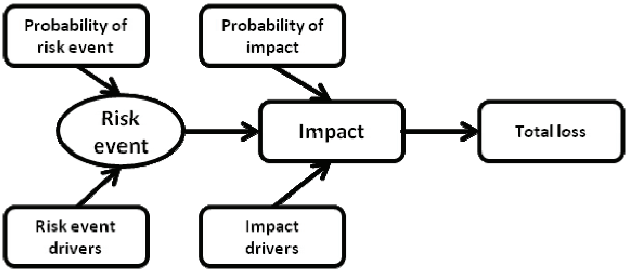


Figure 1. Standard Risk Model [9]

The Standard Risk Model represents the factors which define the riskiness usually calculated to assess and prioritize a risk. This viewpoint is common but does not support the selection of risk strategies, which is important to tackle a risk.
The use of a different risk model is proposed to provide a better basis for this selection. The modeling of risks as causal relations enables a better consideration of time-related effects (see Figure 2) [10].
The causal chain features a bidirectional relation between causes and effects because some effects might be the cause for other subsequent effects. Hence, modeling the links between different risks similar to the Cascade Risk Model [9] is possible.

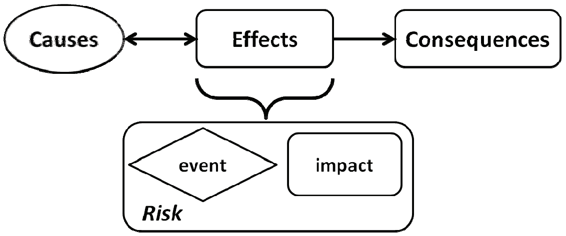


Figure 2. Causality of Risks

The effect combines the event and its resulting impact (the loss or the flawed course of the project). The consequence of a risk describes, for example, the deviations from project goals.

2.2 Time dependency of impacts

An aspect which is usually not considered in standard literature on risk management is the time dependency of the impact of occurring risks. Seibold hints at the importance of this characteristic of

risks [11]. He describes two different courses of the accumulation of an impact (see Figure 3). The first is an impact which increases steadily; the second is a quickly escalating impact. These two different courses describe both possible extremes.
The characteristic of occurring risks to feature a rising impact is an important aspect to consider for the selection of an optimal risk strategy and related measure. Provided that the accumulation characteristic is known, it is possible to gain a more precise statement regarding the total costs (the accumulated impact) for a treated risk

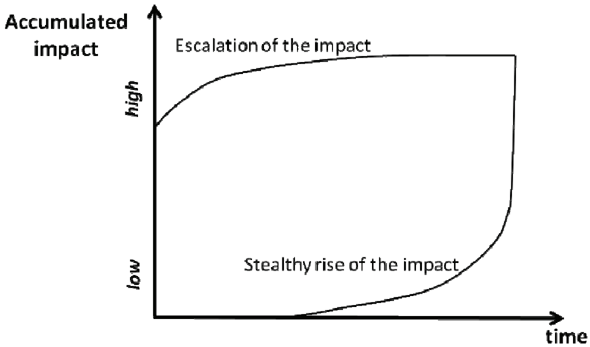


Figure 3. Time dependence of impact caused by an event [11]

2.3 Risk Management Process

"Risk management (…) is the activity of identifying and controlling undesired project outcomes proactively" [9]. Project Risk Management aims at ensuring the successful execution of projects. Various process models have been developed in the past for this purpose. They differ in their number of process steps and level of detail. Irrespective of differences in their terminology and detailing, these models follow a common approach. The Risk Management process which is conducted iteratively consists of four key phases [12]:

1. Risk identification
   The phase of identifying, collecting and specifying risks
2. Risk assessment
   The phase of risk analysis and estimation
3. Risk treatment
   The phase of risk-strategy selection and implementation of measures to avoid deviations from project goals
4. Risk monitoring, review and communication
   A continual process of re-examining assumptions, reviewing developing risk and communicating likely impacts to stakeholders

Risk identification is a challenging task and determines the quality of the whole Risk Management process and therefore the course of the project. It is a precondition for the subsequent assessment and treatment of risks. Risk identification and assessment are topics of numerous research projects and considerable methodical support. In contrast, risk treatment is usually left to the experience of the Risk Manager. [13, 14]

2.4 Risk treatment

Treatment of risks addresses the causes and impacts of an event [15]. Addressing causes means taking preventative measures which eliminate or reduce the likelihood of a risk event occurring. Measures which address the impact of an event are called corrective. Both categories of measures are usually outlined as the following four risk strategies [15]:

1. Avoidance
   Risks are avoided e.g. by reorganizing the project or modification of the assignment
2. Transfer
   Sharing the risk with other stakeholders or insurance

3. Reduction (i.e. mitigation)
   Initiation of measures to control the risk and continuous evaluation of its current status; development of fall-back positions
4. Acceptance (i.e. assumption)
   Risks and possible consequences are known, no measures are initiated

2.5 Selection of Risk Strategies

The selection of appropriate risk strategies is influenced by the corporate risk culture, the willingness of the risk manager to take a risk, the risk tolerance of the team and the companies' Project Management and product development capabilities [2]. A common threat is to overrate one's own capabilities and to take risks which overstrain the development team. This triggers the phenomenon of fire-fighting which is self-reinforcing [16].
While the selection of the risk treatment strategy may influence the course of the project, the decision making is left to the risk manager's expertise. Only a few rather elementary methods are available to support the selection of the risk treatment strategy.

Risk-Reward Matrix

The selection of appropriate risk treatment measures is dependent on several factors, e.g. the kind of risk, maximum possible impact, costs caused by the measure, and available resources.
Additional influencing factors are possible rewards and related chances in the case that a risk does not occur. A reward may be a premium or promotion (on a personal level) or the saving of time/money on a project level. The relation of risk, reward and necessary resources is addressed by the Risk-Reward Matrix [2]. The Risk-Reward matrix points out the trade-off that has to be resolved while selecting an appropriate measure/risk strategy. It does not give any assistance.

Risk grid

A very simple approach to supporting the selection of a risk treatment strategy is shown in Figure 4 [2, 15]. The risk grid analyzes the risk using two criteria: the probability of occurrence and the amount of loss (impact of the event).
Allocation of strategies and measures using this method is inadvisable. It implies that these two dimensions describe a risk in a sufficient manner [17]. Important characteristics of the addressed risks like the evolvement of the impact are ignored.

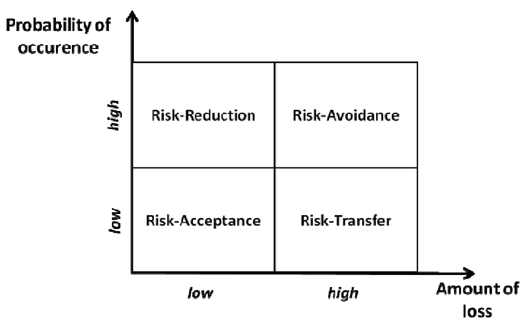


Figure 4. Risk grid [14]

Constraints of risk treatment strategy selection

The selection of risk strategies is strongly influenced by the Project Management philosophy and the risk tolerance of a team/company (see Figure 5). Rigid procedures and less tolerance facilitate the selection of avoidance or transfer strategies. More flexible Risk Manager/Project leaders use a wider spectrum of strategies [2].
The superiority of a strategy cannot be assessed on a generic level. This depends on the specific risks and its describing characteristics. The need to match individual characteristics of a risk with an appropriate risk treatment strategy means that a constraint of possible strategies limit the chance of a successful risk treatment.

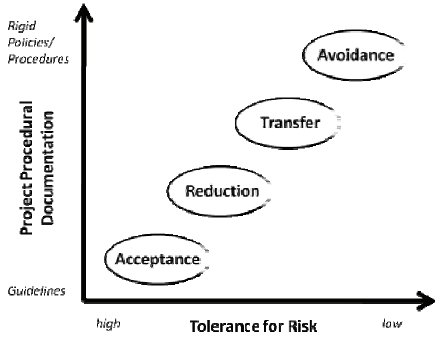


Figure 5. Factors constraining the risk treatment strategy selection [2]

Existing methods do not support the decision making in a sufficient manner and do not provide a basis for an optimization of the risk treatment strategy and measure selection during the Risk Management process. The support of this important step of Risk Management needs further improvement. “As risk management grows, more research will be done in this area.” [2]

2.6 Optimization of the Risk Management Process

The treatment of risks and the impact of an event cause costs. The more Risk Management is conducted the lower the impact. At the same time, costs are caused by Risk Management itself resulting from implemented measures. Despite the positive effects, costs of measures and related effects on the Project plan are popular arguments against Risk Management [4, 7]. Optimization of the Project Risk Management process offers the potential to enhance the efficiency of projects.

The decision of which strategy to select is a challenging task due to the uncertain character of the addressed issue. Prior to the occurrence of a risk only a probability exists, therefore all decisions offer the possibility to be a misinvestment. The decision making is a trade-off between possible costs of an occurring untreated risk and certain costs caused by the measure and additional costs in the case of an occurring treated risk (see Figure 6).

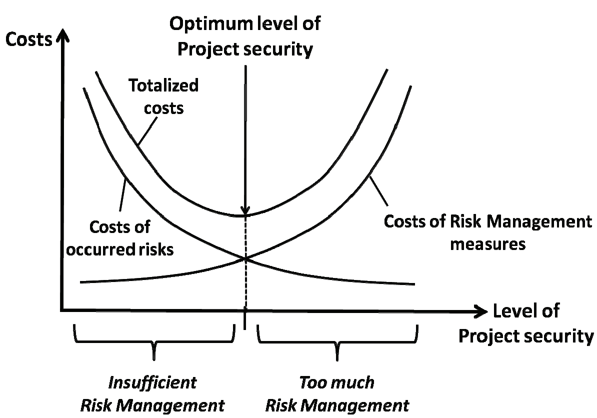


Figure 6. Optimum level of Project security [18]

Preconditions for an optimization of the risk treatment are detailed cost information regarding the risk and possible risk strategies. Costs caused by occurring risks are usually easy to estimate based on data contained in project planning documents.

The estimation of costs caused by selected risk strategies/measures is challenging. An approach for optimization is proposed in the context of the Project Risk FMEA (RFMEA) [19]. This approach suggests iterating the whole process, to identify the most effective measure. The comparison of costs is not discussed explicitly.
The concept of the "risk reduction leverage" (see equation 1) allows the comparison of risk before and after treatment. The efficiency of measures is assessed using the expected loss (in €) and estimated costs caused by the measure (see equation 2) [9].

$$Risk\ reduction\ leverage = \frac{Expected\ loss_{before} - Expected\ loss_{after}}{Cost} \quad (1)$$

$$Probability\ of\ risk\ event\ (P_e) \cdot Probability\ of\ impact\ (P_i) \cdot Total\ loss\ (L_t) = Expected\ loss\ (L_e) \quad (2)$$

The expected loss is calculated for risk assessment. Comparing different risk treatment strategies or risk treatment measures using this value is not appropriate. The costs caused by an occurring risk are not influenced by the probabilities (probability of the risk event is 100% in this case). Using these values, the costs of occurring risks are always defined by the total loss.

The discussed approaches (Project Risk FMEA, risk reduction leverage) are not applicable for an optimization of the risk treatment strategy selection process. A main reason for the inadequacy of these approaches is the used risk model. Existing risk models do not conveniently consider the time dependency of the impact of an occurring risk.

3 CONNECTING RISK STRATEGIES AND CAUSALITY OF RISKS

The mentioned risk treatment strategies (section 2.4) cannot connect directly with the proposed causal model of risks, which comprise information about the course of the risk. As previously argued, the time dependency is an important factor for an optimized decision making process during the phase of risk treatment.
In the following, measures for risk treatment are arranged in three different groups or strategies (see Figure 7). A distinction of measures is possible based on the point in time in which they are implemented, planned and regarding their target (likelihood/impact of the event). The measures are divided into in reactive, proactive and preventive [10].

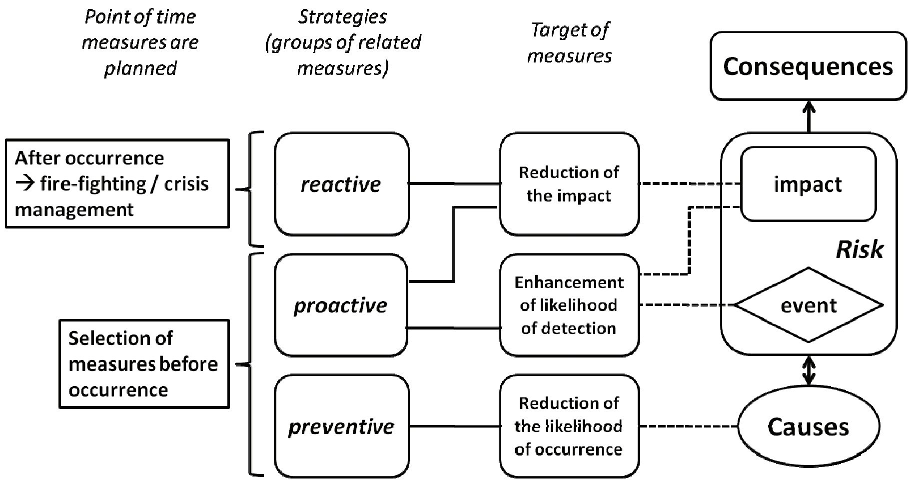


Figure 7. Risk treatment strategies

3.1 Reactive Measures

Measures are selected and implemented after the occurrence of an event. They aim at a reduction or cessation of further accumulation of the impact. Reactive measures are not a subject of Risk Management. They are part of fire-fighting.

3.2 Proactive Measures

Proactive measures might aim at a reduction of the impact or at an enhancement of the likelihood of detection. The selection of the measure takes place prior to the occurrence of the event. Implementation of measures is done either before or after occurrence of the event (dependent on the individual aim).

3.3 Preventive Measures

Preventive measures are necessarily planned and implemented before a risk occurs. They aim for a reduction of the likelihood of occurrence of an event by removing the cause(s). Hence (if the measure works), the risk does not occur and the impact is prevented.

4 IDENTIFICATION OF COST DRIVERS

Using costs as a basis for selection of risk treatment strategies, the composition of costs has to be analyzed.

4.1 Breaking down the course of process risks

The costs (in the following a synonym for the consequences) are analyzed breaking down the course of a risk from the moment of occurrence (the event) until a measure stops the further rise of the impact.

A possible breakdown of the course (see Figure 8) is based on four happenings:

- Risk event
- First detection of the impact
- Implementation of a measure
- Measure takes effect

Hence, the course is separated into four episodes.

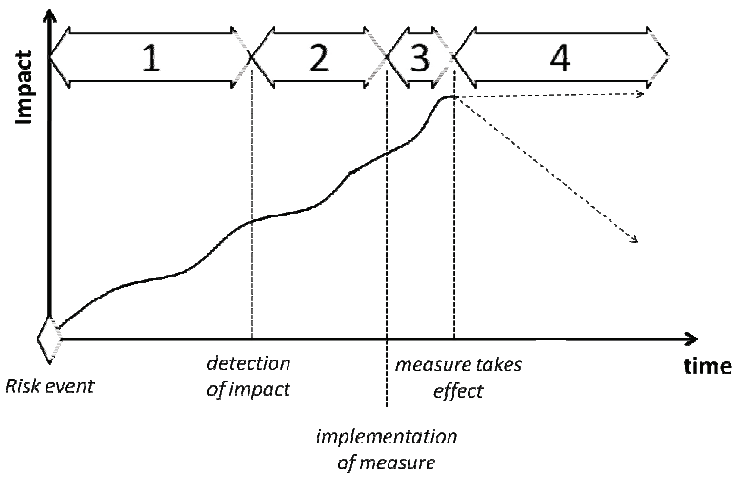


Figure 8. Episodes of impact rise and Risk Management activities

Episode 1

The event occurs and causes a rising impact. The episode is characterized by the undetected existence of the event and undetected rise of the resulting impact. The duration of this episode depends on the controlling mechanisms and the communication culture of the concerned project. The undetected existence is an enormous hazard for the project.

Episode 2
In the best case, the event itself is detected and the possible impact is known. This would reduce the duration of episode 1 to null. Alternatively, the impact is detected. Dependent on the chosen risk treatment strategy a measure is introduced. Due to the delay from the decision to implement a measure to its implementation, the impact rises continually (probably not in a linear manner – see Figure 3). The duration of this episode is the longest in the case of a reactive risk treatment strategy because appropriate measures possibly have to be selected and available resources must be assigned and approved.

Episode 3
The measure is implemented but the impact rises due to the inertia of the process or the involvement of resources for activation of the measure (e.g. designers educating additional personal). After full evolvement of the measure's effects the impact stops rising. The duration of this episode depends on the chosen measure.

Episode 4
An overall assessment of the impact includes an analysis of later project phases. The impact can be compensated or causes an additional impact as a consequence of a delayed working package. Such follow-up costs are difficult to calculate because interdependencies are sometimes not clear and the necessary effort for tracking all follow-up effects might exceed an acceptable level. Nevertheless, a comparison of costs accumulated during episodes 1 to 3 enable the comparison of strategies in a sufficient manner.

The resulting impact of an event is time dependent; hence, the course of the accumulation of the impact determinates the suitability of a risk treatment strategy and related measures. In the following, possible courses are presented and implications for risk treatment strategy selection are outlined.

4.2 Possible courses of the impact
The estimation of the impact of an event is dependent on its individual course. As depicted in Figure 6 two different courses are discussed in literature [11]. In the following, these courses are complemented and analyzed. The discussed courses are qualitative representations and a strong simplification of the real courses. This simplification aims to ease the classification by limiting the number of possibilities. The interplay of multiple risks which may reinforce the resulting impact can be described in the same way.

Escalation of the impact - Sudden burst
The mentioned 'escalation of the impact' (compare Figure 3) describes an event which causes its maximum impact suddenly after occurrence. The subsequent rise is negligible. This course is called 'sudden burst' (see Figure 9). An example is the loss of data caused by a destruction of a data server. If no preventive measures were taken to save the data on a redundant system, the impact occurs immediately. This course is very simple and requires preventive measures because after the event the project team has no time for implementation of measures neither proactive nor reactive.

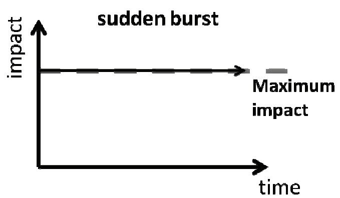


Figure 9. Course of the impact – sudden burst

Constant rise of the impact – Rising

The impact of a risk can rise constantly on a continuing basis. This course is called 'rising' (see Figure 10). An example is a designer falling ill. If this loss of manpower is not compensated the impact rises constantly. Provided the rise is known this case is easy to calculate but should be analyzed with care. The assumption of a linear behavior of a system (or a process) is a common failure and might cause hazardous decisions because most (but not all) processes do not evolve in a linear manner [20]. Impacts which develop in this way can be treated using proactive and preventive measures. Reactive measures would cause a longer duration of episode 2 (see figure 8) which enhances related costs.

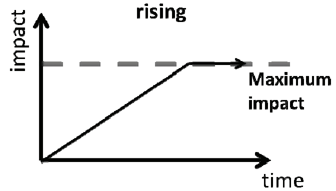


Figure 10. Course of the impact - rising

Steady rise of the impact – Snowballing

This course describes a risk which causes after its occurrence no or only minimal impact. After a certain time the impact rises suddenly. This course is called 'snowballing' (see Figure 11).
A steady rise of the impact is critical. The slow rise at the beginning prevents an early detection of the impact. The appropriate strategy is dependent on the possibility to detect the event itself. If this is possible, all strategies are feasible. If the event cannot be detected it must be treated similar to a 'sudden burst' impact – only preventive.
An example is a failure in the requirements list. The event (the wrong requirement) happens early in the project. As long as no one has to use this information, it causes no impact. All results of subsequent work packages which are based on such a faulty requirement have to be reworked, hence the impact rises suddenly.

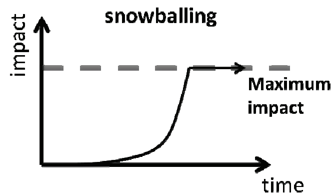
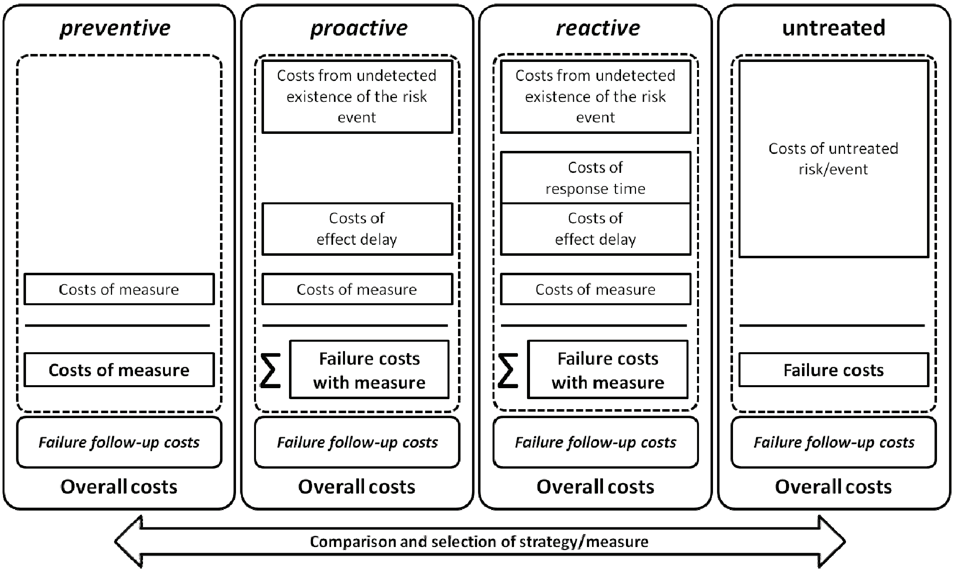


Figure 11. Course of the impact - snowballing

5 STRATEGY SELECTION BASED ON COSTS COMPARISON

Based on the identified course of the impact, different strategies might still be available. To select the most efficient one a comparison of the related costs is neccessary. As previously argued, the overall costs consist of different parts belonging to the mentioned episodes of the rising impact and the measure itself (see Figure 12). The comparison of selected measures based on the overall costs can include the failure follow-up costs if this information is accessible.
Decision making using this so called *Measure and Failure Cost Analysis* (MFCA) method enables the Risk Manager to compare the real costs caused by an occurring risk including measures and related costs as an indicator of the resulting consequence. It is based on a de-escalation principle which analyzes the course of the impact of an event. The method differentiates between the reaction rates of different strategies and proposes the best one. In doing so, Risk Managers are supported by verifying the feasibility of a chosen strategy. At the same time the decision making can easily be documented, which enhances traceability. In cases where the use of the method causes incommensurately effort, it might be used informally as a mind-set to analyze a risk and select the treatment strategy.



6 CONCLUSIONS AND OUTLOOK

The contribution

The *Measure and Failure Costs Analysis* presented in this paper is a method which aims to support the process of risk treatment selection which is currently inadequately supported. The method guides the user through the analysis of the addressed risk. In a first step, the course of the impact resulting from the occurring risk is categorized selecting from three options (sudden burst, rising and snowballing). Dependent on the category a preselection between three strategies (reactive, proactive and preventive) is proposed. In the next step, specific measures belonging to the left strategies must be defined. If more measures are appropriate to tackle the risk the selection is carried out based on a comparison of the overall costs. The overall costs are the total costs for the measure itself, the costs caused by the event (separated in three episodes) and, where applicable, the failure follow-up costs.

Strengths and limitations of the method

The method supports the selection of an appropriate and feasible risk treatment strategy in a systematic, traceable and holistic manner. The necessity of using a risk model that includes information about the course of the impact of an occurring risk additionally to traditional characteristics (likelihood of occurrence and severity of impact) is considered. A disadvantage of the method is the additional effort caused by the necessary estimation of costs parts.

A limitation of the method is the lacking ability to assess the suitability of measures. This depends on the specific risk. The method only assesses the suitability of strategies.

Outlook

The use of this method, especially the categorization of the course of the impact (which is assumed as given in this paper), is subject to current research. First results are promising. There are plans to conduct a validation of the method.

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