Operational Risk Response for Business Continuity in Logistics Agglomerations

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Abstract Risks are part of every business operation and can never be avoided completely. To minimize the danger of corporate crisis, a conscientious and responsible approach to the handling of risks and the resulting impact on business is essential. Unforeseen events pose an especially great challenge for companies and require quick decision-making and immediate reactions. This paper presents a way of structuring decision problems as part of a concept for accelerated decision-making in the context of response to risk. The locus of our research is freight villages, which represent a typical example of logistics agglomerations, and the focus of our research are their business processes, which mainly consist of storage, transport and handling of freight.

1 Introduction

Due to the rapid changes within the business environment that require a steady reduction of reaction times, companies are experiencing a growing vulnerability towards the occurrence of risks. The increased integration of companies in

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interlinked supply chains and the associated cross-company planning, synchronization and control of business processes further amplify the risk potential. This is emphasized by the fact that it often does not require a catastrophic event to cause major disruptions for companies: even relatively small and localized problems within the supply chain can create a corporate crisis (Waters 2011). Especially unforeseen risks pose a great challenge for the supply chain and require particularly quick decisions and reactions in the event of their occurrence (Waters 2011; Engel 2009). Adopting supply chain risk management can increase the quality of decisions (Schneck 2010). Supply chain risk management is characterized by an attentive and systematic handling of potential risks as well as a comprehensive assessment of risk impact (Schawel and Billing 2012).

A thorough evaluation of the situation at hand is often not possible because of the necessity for quick reactions to damaging events. Mesarović et al. (1970) refer to this as the fundamental dilemma of decision-making: “on the one hand there is a need to act without delay, while on the other, there is an equally great need to understand the situation better”. A preventive decision strategy aimed at coping with damaging events can mitigate this dilemma.

In spite of an identified need for quick reactions to damaging events, it is remarkable that little attention is paid in the literature to the handling of risk impacts, with most measures that are discussed being in the context of risk avoidance and risk reduction (Wagner and Bode 2007).

In light of these facts, the main object of our research is developing a model that allows quick, appropriate and systematic decisions to manage risks and their impacts after the occurrence of a damaging event.

The focus of this paper lies on the structuring of decision problems as one important part of decision support. The theoretical approach is based in decision theory and risk management. After the occurrence of a damaging event all business processes should be focused on business continuity management thus focusing all attention on rapid resumption of business activity and maintaining the flow of goods.

The concept is based on the processes of warehousing, transportation and cargo handling within large logistics agglomerations. Freight villages are used as an example as they typify such agglomerations. Each freight village represents a pivotal logistics node within a larger network of logistics nodes, which provide important services for the supply of goods (Nobel 2004).

In the following section, we provide the theoretical basis of our research. Section 3 firstly introduces freight villages as subject of investigation and then presents the first steps of the conceptual design of a decision support model base on decision trees to manage damaging events. These trees enable a decision-maker to break down a problem into decision situations and they help to provide measures and suggested activities for different situations. The paper closes with a short discussion and considers further steps for research in this field of inquiry.

2 Decision-Making Within the Scope of Risk Response

Background knowledge of decision-making is given by decision theory, for which reason we will first discuss the basic principles of decision theory in Sect. 2.1. Specifically, we will focus on the term decision support and the process of decision-making. Owing to our attention to risk, some principles of risk management are explained in Sect. 2.2. Apart from risk management, several other concepts provide a possible basis for strategies for the mitigation of risk after the occurrence of a damaging event. These include crisis management and business continuity management. We differentiate between these concepts and provide a definition of the term "risk response", and our understanding of this term in the context of this paper.

2.1 Principles of Decision Theory

Decision theory draws on different scientific disciplines such as psychology, philosophy, political science, business science, sociology, game theory and engineering science (Jungermann et al. 2005) and addresses the decision behaviour of individuals and groups (Laux et al. 2012). Two different styles of decision theory can be used to perform a theoretical and practical analysis of decision behaviour: prescriptive and descriptive decision theory (e.g. Grünig and Kühn 2013; Domschke and Scholl 2005; Eisenführ and Weber 2010). Descriptive decision theory focuses on the description of real human decision behaviour (Domschke and Scholl 2005). It allows an analysis of how specific decisions are made and what caused the decision to be made in a certain way. Hypotheses gained through empirical evidence lead to insight regarding the real life decision-making process and can be used to ascertain authoritative forecasts of expected future decisions (c.f. Laux et al. 2012; Saliger 2003). In contrast, prescriptive decision theory indicates how a decision will be chosen under the assumption that there is a rational choice to be made between multiple decision possibilities (Laux et al. 2012; Domschke and Scholl 2005). Prescriptive decision theory offers a set of rules and procedures for breaking down information in a structured fashion and processing this information in such a way that the decision-maker is supported in making difficult and complex decisions (Jungermann et al. 2005; Eisenführ and Weber 2010). A situation in which a decision is to be made is considered to be increasingly complex for a larger number of influences impacting the result and the more targets there are to be accounted for. Furthermore a very large or an unusually small number of decision options can increase the difficulty of making a decision (Eisenführ and Weber 2010).

Our research aims to offer an approach to decision support in the context of risk management after the occurrence of a damaging event with a view to accelerating the decision-making process. The aim is not to describe real human behaviour but to break down the underlying problems in a structured fashion and process the available information. Thus this paper may be ascribed to the field of prescriptive decision theory.

Generally speaking, decision-making support is defined as taking measures to improve the efficiency of a decision (Pfohl 1977). We refer to improved decision-making efficiency as the improvement of the quality of decisions as well as a reduced effort in making a decision (Lassmann 2006). In decision theory, a decision is generally defined as the selection of one specific action from a set of multiple possible actions (Laux et al. 2012). Taking this into account, we consider a decision to be a reaction to a specific situation based on processed information, and as an event that separates the state of a system from the next consecutive state (Pfohl 1977). A decision is triggered when an aberration between the current actual state and the target state of a system is recognized (Grünig and Kühn 2013; Rennemann 2007; Pfohl 1977). A decision-making problem is defined as the difficulty that occurs when the discrepancy between target and actual system states can be reduced by multiple decision alternatives (Grünig and Kühn 2013). The basic structure of a decision-making problem can be described by the available decision-making alternatives, the state of the surrounding environment, and consequences of the decision as well as the objectives and preferences of the decision-maker (Eisenführ and Weber 2010). Action alternatives are referred to as decision-variables, action-variables or action-parameters and may consist of multiple individual actions. The state of the surrounding environment lies outside the decision-makers scope of influence and is either known to the decision-maker with certainty or is afflicted with uncertainty. Decisions under uncertainty can be further separated into decisions under risk and decisions under ambiguity (c.f. Camerer and Weber 1992). Consequences arise through the combination of a specific action alternative and the occurrence of a specific state within the surrounding environment. The decision field consists of the action alternatives, states of nature and consequences (Laux et al. 2012). Objectives and preferences represent the attitude of a decision-maker towards action alternatives and their consequences and are expressed by the decision rule (Laux et al. 2012; Eisenführ and Weber 2010). These elements and their relationships to each other are formally represented by a decision model, which is used to support the decision-making process. The decision-making process can be divided into several stages, the first of which is the initial recognition of the decision problem (c.f. Laux et al. 2012; Lassmann 2006; Heinen 1992; Pfohl 1977). Although there are numerous suggested approaches for systematically dividing the decision-making process into separate stages, they can all be traced back to the same basic pattern (Pfohl 1977) and describe the process of decision-making as a process of conscious information collection, information processing and information transfer (Heinen 1992). All stages of the decision-making process require partial decisions to be made that will have a considerable impact on the outcome of the overall decision-making process (Heinen 1992). On the whole, this stage based model should be considered as a methodological tool for decision-making. It provides an overview of the required activities that usually do not have to be performed in a strict sequence (Laux et al. 2012; Pfohl 1977). This paper is based on the decision-making process that is described in the following section.

As a basic principle, the process consists of the stages “will-formation” and “decision implementation” (Heinen 1992). According to Simon (1960) the will-formation stage consists of the three phases “intelligence”, “design” and “choice”. The intelligence phase begins with the recognition of a change in the environment, which calls for action. Once a problem that requires further action has been recognized, the design phase consisting of the three activities of inventing, developing and finally analyzing the possible courses of action begins (Simon 1960). In this phase, the identification and the correlation of the elements of the decision field and the decision rule, as described in the last preceding paragraph, take place. The will-formation stage is completed once a course of action that was designed within the design phase has been chosen, thus concluding the choice phase and resulting in a final decision. The decision implementation stage is characterized by the realization phase and the control phase (Heinen 1992). In the realization phase, the decisions made within the choice phase are applied to the decision situation and, accordingly, to the actual problem. Any deviation between the desired and the actually accomplished results is monitored during the control phase (Lassmann 2006). The information gathered during the control phase may necessitate follow-up activities, which lead to a requirement for new decisions, and this hence returns the decision-making process to the intelligence phase (Heinen 1991). The overall context of these terms and concepts is illustrated in Fig. 1.

This paper mainly focuses on the will-formation process and within that process specifically on the design phase. The conceptual design of a decision support model takes place within this phase, and, in this paper, only one conceptual aspect of our decision support model is presented, namely structuring a decision situation with decision trees.

2.2 *Risk Response*

If a risk situation occurs, difficult and long decision-making processes may not be possible in reasonable time. However, for an informed decision, the single phases of the decision-making process which have to be undertaken can be accelerated. To enable an immediate response to the occurrence of a risk, decisions must be made nearly instantly. An awareness of possible risks and their impacts can lead to a faster reaction in the case of a damaging event. Furthermore it reduces the risk of long business continuity interruptions. The examination of risks before they occur can be carried out in the context of risk management. According to Waters (2011), risk management is a systematic process that aims at the identification, analysis and response to risks throughout an organization.

In this paper, only the part of risk response within the risk management process is given consideration. Alternative strategies can be pursued related to risk response. A multitude of different definitions and terms for such response strategies are defined in the literature. Hopp et al. (2012) differentiate between the two risk response strategies of detection and speed, which are executed after the occurrence of a disruption. Related to supply chains, Ritchie and Brindley (2009) identify four risk response strategies as being: insurance; risk sharing; information exchange and

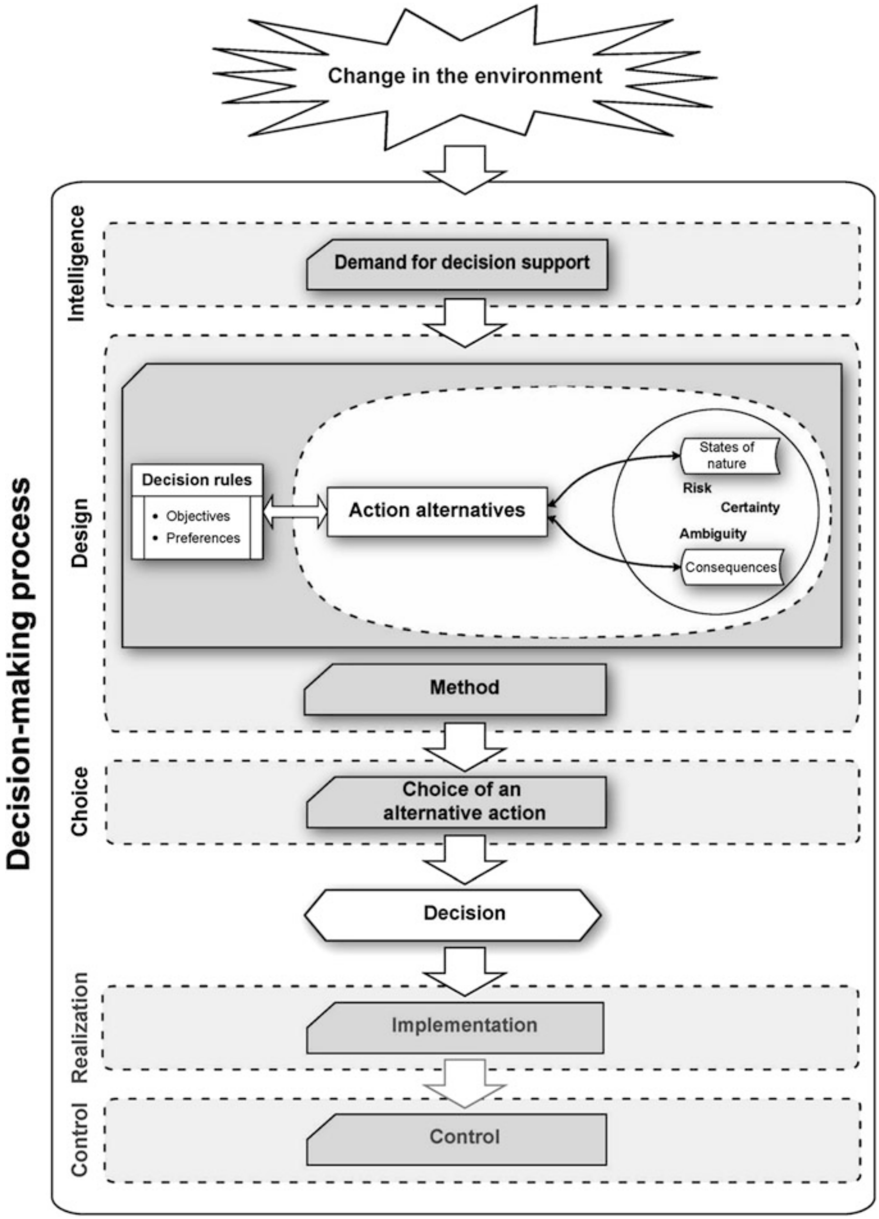

Fig. 1 Decision theory context

relationship development. Waters (2011) proposes a classification into eight risk response types, which cover a wide range of opinions, from ignorance of risks through to complete re-location to another environment. Sudy et al. (2013) propose four risk response strategies and categorize them into avoidance, reduction, transfer and acceptance of risks. According to this definition, the risk reduction strategy comprises measures for reducing risk impact.

Further concepts that deal with the response to risk events are crisis management and business continuity management (c.f. Waters 2011; Tandler and Eßig 2011). Crisis management is closely coupled with risk management and comprises the basic prevention, cognition, diagnosis and elimination of corporate crises (Schawel and Billing 2012). Besides coping with severe damaging events, the focus of crisis management lies in coping with operational misperformances (Brühwiler 2011). Business continuity management is focused on business processes and deals with the quick resumption of business performance (Brühwiler 2011). Crisis management and business continuity management can both be seen as components of risk management (c.f. Waters 2011; Brühwiler 2011).

In this paper, we follow the definition of Hopp et al. (2012) and take the term risk response to mean the reactions to coping with the negative impacts of damaging events that have occurred.

Based on Ross (2011), the central tasks in the risk response process are developing and evaluating alternative courses of action, determining appropriate courses of action and implementing risk responses according to the selected courses of action. These tasks are consistent with those described in the decision-making process in Sect. 2.1. For this reason, risk response itself can be seen as a decision-making process.

So, it can be seen that the development of alternative courses of action is a basic element of our conceptual design. We now turn to applying the approach to freight villages, the subject of investigation.

3 Conceptual Design of a Decision Tree for Risk Response

This section shows how the relevant elements of a decision can be structured to break down a decision problem. Section 3.1 deals with explaining the characteristics of freight villages. The characteristics of the decision elements and their detection in case of a damaging event needing a quick reaction are presented in Sect. 3.2. In Sect. 3.3, the use of decision trees is justified as well as their application for structuring decision situations in freight villages.

3.1 Freight Villages

Freight villages are a special type of logistics agglomeration. They primarily function as an interface between local and long-distance traffic (Welp 2010). A further function of freight villages consists in forming efficient, multimodal transportation chains. Hence, a freight village combines at least two modes of transport, usually road and rail, but sometimes also waterborne and air transport. To fulfill this purpose, a terminal of intermodal transport is located in a freight village (Rall 2008).

Multiple transport and logistics companies are co-located within a freight village. They include, for instance, forwarding agencies, logistics service providers, logistics intensive traders and industrial companies, as well as different transport carriers, all of which retain their legal and financial autonomy (Rall 2008; Kessler et al. 2009). These companies act within numerous connected supply chains and are concentrated within a relatively small area enabling the use of the same modes of transport and technical infrastructure (Wildebrand et al. 2011).

The interests of all participants are coordinated by a central business and development company, which mainly plans, establishes and continually helps the freight village to evolve. The operational business of the village remains, however, with the independent companies located on site (Rall 2008).

Freight villages make a major contribution towards securing the flow of goods at the regional, national and international level (Wildebrand et al. 2011). If a damaging event occurs in such a freight village, the freight village logistics processes of storage, transport and handling of cargo can be interrupted, and a number of business partners, supply chains and the regional as well as the national economy may be affected (Breuer et al. 2012).

In Germany, there is currently a network of thirty-five freight villages. The logistics processes of two of these freight villages were analyzed as part of the study reported here. The processes identified in these villages form the basis for the consideration of possible impacts and consequences resulting from damaging events. Particularly damaging events are likely to result from damage to the infrastructure in freight villages such as the terminals for intermodal transport and road and rail connections.

In the next section, the different decision elements are explained. Consideration is given to failure within the terminal of intermodal transport as an example of a possible damaging event within a freight village.

3.2 Detection of Decision Elements

A detailed knowledge of the decision situation is important to facilitate a comprehensive assessment of the appropriate measures, which will in turn enable an adequate reaction to the resulting negative impacts of a damaging event (Putz-Osterloh 1992). Decision support grows in importance as the complexity of a situation increases (Eisenführ and Weber 2010). According to Luhmann (2009), a situation's complexity grows in relation to the number of possible courses of action, the heterogeneity of the options, or an increase of interdependencies between them. If a damaging event arises, the best option for accelerated decision-making, and choice of the best possible risk response measure, may be arrived at by having already created a structured decision situation that reduces the situation's complexity. The first step in structuring the decision situation lies in examining the elements of a decision problem, already identified in Sect. 2.1: the courses of action, the states of nature, consequences as well as the objectives and preferences (Laux et al. 2012).

The *objective* to be pursued is maintaining the flow of goods. Resulting from this objective are the secondary targets of prompt resumption of business performance and quick recovery of business processes. This means, that in case of a damaging event, the *preferences* to be pursued with regard to the objective are the delivery rate, which should be as high as possible, and the avoidance of bottlenecks. Hence, the crucial logistics processes in freight villages of storage, transport and handling of cargo are at the centre of our attention.

In general, *courses of action* can be seen as a combination of a variety of risk response measures, which depend on the particular situation (Ross 2011). If a damaging event occurs in the terminal of intermodal transport within a freight village, in principle the possible courses of action are: reacting to the event, suspending a decision on action to a later date, or deliberate forbearance of the event. As a course of action to such a damaging event, in general the possible alternatives consist of either rerouting goods or carrying on delivering goods to the affected terminal. The goods that continue to be delivered can either be stored temporarily or turned immediately over to further onward transport. This means that directly after a damaging event there are four possible actions as follows: to do nothing, to reroute goods to another destination, to deliver goods to temporary storage, or to deliver goods and immediately forward them.

Not all courses of action will make sense and this will depend on further limitations imposed by the damaging event such as the scale of the damaging event, the type of infrastructure affected, and the importance of the affected goods. For example, either road, or rail, or both could be affected, and cranes or other equipment for loading and unloading may or may not be affected. It is likely that in most instances when a damaging event occurs, it will be necessary to undertake certain actions which will in themselves make it either necessary or unnecessary to undertake other actions. It is always necessary to understand the overall objectives and ensure that no actions are taken which might impede others actions which need to be taken in order to properly fulfil these objectives.

After a damaging event, there is usually uncertainty about the possible future *states of nature*. Basically, either a decline, an improvement or a perpetuation of the situation is possible. Different scenarios may arise through an association between different influences, for example a declining situation combined with high importance of the affected goods. A set of outcomes, n, with m possible states leads to m^n scenarios. Therefore, the relevant states of nature have to be identified in the context of the objectives being pursued (Eisenführ and Weber 2010).

Consequences represent realizations of objectives (Jungermann et al. 2005), and they result from the combination of states of nature which have occurred with one or more courses of action. Depending on the individual combinations, the following consequences may appear: the impacts of a damaging event are exacerbated, attenuated, absorbed or completely eliminated.

The structuring of the problem can be done by graphical means (Eisenführ and Weber 2010). Thus, in the next section different graphical means of representation are presented.

3.3 Structuring Decision Situations

For the structuring of decision situations, decision matrices, decision trees and influence diagrams can be used (Eisenführ and Weber 2010).

Decision matrices are tables which include the alternative states of nature as columns and alternative courses of action as lines. The cells represent the individual, evaluated consequences (Jungermann et al. 2005). The advantage of decision matrices is their clarity of representation, and they are also extendable. Conversely, a multilevel representation is not possible and as a result of this, decision trees are better. Decision trees can also be used for modelling and structuring of decision problems and are specifically aimed at the graphical representation of decision rules (Drews and Hillebrand 2007). They force a decision-maker to clearly and precisely formulate the objectives, the alternative actions, the states of nature and the consequences in a dendritic hierarchical structure (Eisenführ and Weber 2010). The disadvantage here is, that decision trees are unclear for complex situations in which the problem could be avoided by the aggregation of action alternatives (Recke 2005).

Influence diagrams are clearer than decision trees, but detailed information is missing (Recke 2005). This is because in influence diagrams, alternative courses of action, states of nature and consequences are only included as quantities (Eisenführ and Weber 2010).

Thus, decision trees are particularly suited for decision problems that are characterized by consequences that have a temporal dimension to them, or by a sequence of actions and consequences (Jungermann et al. 2005). For the depiction of the decision elements, three kinds of nodes and two kinds of branches are used (Middleton 2007). Decision nodes are depicted as a square and represent a possible decision situation (Laux et al. 2012). Event nodes, or chance nodes, are symbolized by a circle and characterize the occurrence of possible events (Jungermann et al. 2005). Each consequence represents a combination of certain decisions and states of nature. They are called terminal nodes and are represented by triangles (Middleton 2007). The branches emanating from a decision node symbolize all possible actions available at that point. Branches coming from a chance node symbolize the possible outcomes of an event that may occur at that point. By traversing the tree, decision rules can be established from the combination of certain decisions, states of nature and the connections between them. Subsequently, anticipated developments can be illustrated through decision trees, projecting as far into the future as desired (Jungermann et al. 2005). A sequence of conditional decisions is referred to as a decision strategy and includes multi-decision levels (Eisenführ and Weber 2010). Multi-decision levels make a contribution to an improved decision-making process

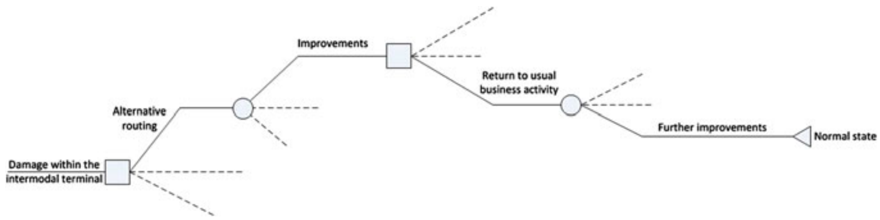

Fig. 2 Example of a decision tree

by showing intertemporal interdependencies of different actions and lead to an improvement of the information level over time. Future actions should be determined in accordance with the present natural state and consideration of all available relevant information (Laux et al. 2012). However, it should be noted that the decision about how many levels to adopt and the decision about further search for alternative actions will precede the actual decision (Eisenführ and Weber 2010).

Altogether, decision trees provide a useful framework and methodology for analyzing decision problems and for identifying a decision strategy as a sequence of decisions and states of nature. This supports particularly quick and appropriate understanding of a decision situation. Depending on the respective developments of the states of nature, the chosen measures can be incrementally adapted and enhanced through further measures.

Referring to a damaging event within a freight village, the specified decision elements in Sect. 3.2 can be combined in a decision tree as depicted in Fig. 2. In the illustrated decision tree, the decision strategy consists of the courses of action “alternative routing” and “return to usual business activity”, which leads to a return to the normal state as the state of nature are continuously improves.

For each possible risk, a decision tree will be created which will include elements referring to a particular damaging event.

4 Further Steps and Conclusion

The purpose of our research is the support of decision-making in freight villages in the case of occurrence of unforeseen risks. Rapid reaction to such events is necessary in order to achieve a high level of business continuity and ensure the continued flow of goods.

Decision trees provide a useful framework for analyzing decision problems and for identifying risk response measures as a sequence of decisions. Hence, our focus lies on the conceptual design of a decision tree as a first methodological step for decision support in freight villages. The single elements of decision situations as well as the combination of these elements in a decision tree have been demonstrated in the context of freight villages.

To further develop the decision trees, the optimal number of decision levels must be determined and appropriate points of time must be selected at which the implemented response measures are to be reviewed. Furthermore decisions must be made in light of possible further exacerbating conditions.

In a next step, a simulation model will be developed which includes the organizational and operational structure of a freight village. The conceptual decision trees developed as part of the work reported in this paper will be implemented in this simulation model. It will thereby be possible to evaluate the different reactions to damaging events as well as the combination of different courses of action and states of nature. Interdependencies between different risks and domino effects may also be identified and considered in the simulation.

The aim of the simulation model will be the assessment of these strategies by simulation experiments.

The results of the modelled decision strategies will be incorporated into interactive standard operating procedures which can be used by a responsible person in a freight village. That person will be guided to appropriate course of action and so will be able to accelerate the necessary decision-making processes by following a path of yes/no questions about the damaging event that has occurred.

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