INTEGRATION OF WARNING SYSTEMS INTO RISK MANAGEMENT

ANALYSING THE RELIABILITY OF WARNING SYSTEMS FOR ALPINE NATURAL HAZARDS

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INTRODUCTION

Risk Management of Natural Hazards is based on technical and biological measures, land use planning and organisational measures. The essential basis for organisational measures is warning systems. The establishment of monitoring networks for various measurements relevant for management of natural hazards and the enhancements of forecast models in the past 25 years have tremendously enhanced the possibility to warn against natural hazards (Bründl et al., 2004; Romang et al., 2009). In many alpine regions, safety in villages and along roads depends on well-functioning electronic, software-based warning systems and human decisions. Therefore, the reliability of these systems is very important for decision making of safety experts. Compared to structural mitigation measures there is a lack of experience in evaluating the reliability of warning systems.

EXAMPLES OF WARNING SYSTEMS

Avalanche warning systems have a long tradition in Switzerland. The WSL Institute for Snow and Avalanche Research (SLF) is responsible for the national avalanche warning for almost 60 years. In order to provide consistent avalanche warning, SLF uses a wide variety of data acquired automatically by measurement stations and manually by field observers. In addition to that, meteorological models and the deterministic snow cover model SNOWPACK (Lehning et al. 1999) deliver basic information for avalanche forecasting. The combination of data with the expertise of the avalanche forecasters at SLF allows for a dependable and continuous warning against avalanches issued twice a day during the winter. Target groups of the national avalanche warning are e.g. ski mountaineers and off-piste skiers. The other target group are local or regional avalanche services, which are responsible for safety in villages and on traffic routes. In addition to the warnings published by SLF, these safety services rely on meteorological models and a set of local data and local observations. Therefore, avalanche warning in Switzerland as a whole, consists of the national warning and of local forecasting and decisions by local safety services. However, little is known about the theoretical reliability of the complex system consisting of monitoring networks, server infrastructure, software, and the humans involved in the warning processes. Failure of one or several components can lead to a failure of the warning system itself.

A METHOD FOR ANALYSING THE RELIABILITY OF WARNING SYSTEMS

In order to develop a method for the systematic reliability analysis of warning systems, we have conducted a performance analysis of the technical components of the Swiss avalanche warning system. Thereby, the following four research questions were asked: (1) What is the constructional design of the avalanche warning system? (2) Which methods are applicable for reliability analyses of warning systems? (3) Which components are the least reliable in the avalanche warning system? (4) How can a concept for reliability analysis of early warning systems look like?
First, a constructional sketch of the hardware on the basis of interviews with IT specialists at SLF was drawn. Second, a logical sketch was created in order to describe the avalanche warning system's data

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flow and workflow. After a literature review of established methods for reliability assessment, the method of Fault Tree Analysis (FTA) was chosen for analysing the reliability. The results of this analysis indicated the critical role of some components, which might cause a failure of the warning system. These results were compared to a ten-year record of system-failures partly verifying the results of the FTA. However, it was found that FTA could not explain all failures.
In addition to the technical analysis described above, the reliability of a local avalanche safety service is contributing significantly to the reliability of avalanche warning as a whole. From the viewpoint of the local population, the availability and reliability of the local safety service is much more crucial in a critical avalanche situation than the availability of the national forecasting. The reliability of a local safety service is on the one hand characterised by the availability of meteorological data and models and information about the snow pack, but on the other hand by the organisation, the education and the experiences of the members of the safety service. By the example of critical avalanche situations this part of the reliability of a warning system, which mainly bases on human factors, was analysed.

CONCLUSIONS

It can be concluded that FTA, being a reliability method mainly developed for technical systems such as e.g. nuclear power plants, can be used for a first estimation of the reliability of the technical part of a warning system for natural hazards. However, FTA is not sufficient to evaluate the reliability of a complete warning system including technical factors and human factors. Although the analysis revealed a number of critical system components, the avalanche warning system can be regarded as reliable from an empirical point of view. During the past 10 years, SLF published its avalanche warnings regularly without any major delays. This is due to the ability of humans to react spontaneously and find work-around solutions in case of a system failure. For safety in villages and on traffic routes, we conclude that the availability of meteorological models and the existence of well-educated persons, which are able to make predictions at the local level are essential. Methods for evaluating the reliability of warning systems have to combine approaches for analysing both, technical and human factors. These conclusions are underlined by experiences of a local avalanche service, which show that human factors are very crucial for a working warning chain from sensors to the affected population.

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Keywords: organisational measures, avalanche warning system, reliability analysis, fault-tree-analysis, human factors