

Early Warning Systems for Natural Hazards: Reliability Analyses and Guidance for Decision Makers

Martina SÄTTELE^{1*}, Michael BRÜNDL¹, Daniel STRAUB²

1 Research Group Avalanche Dynamics and Risk Management, WSL Institute for Snow and Avalanche Research (Davos Dorf 7260, Switzerland)

2 Engineering Risk Analysis Group, Technische Universität München (Munich 80290, Germany)

*Corresponding author. E-mail: saettele@slf.ch

INTRODUCTION

In Switzerland, federal authorities apply an integrated risk management approach that incorporates mitigation measures to reduce damages caused by natural hazards. Early warning systems (EWS) are increasingly applied as cost-efficient risk mitigation measures. These non-structural measures are implemented as prototypes, specific to needs of risk mitigation projects for primarily site specific, alpine hazard processes such as debris flows, snow avalanches and rock falls. Decision makers are increasingly confronted with the question how to design a cost-efficient EWS, but the effect on risk reduction and their economic benefit has rarely been evaluated. To support decision makers a comprehensive guideline is required.

METHODS

The project ReWarn was initiated by the Swiss Federal Office for Civil Protection (FOCP) to assess the reliability and the economic benefits of EWS. Within the project ReWarn we conducted case studies that allowed the identification of key factors influencing the reliability of EWS to receive scientifically based results for the guideline.

To be able to identify factors that have a main influence on the reliability in a structured manner, we classify site specific EWS into a) alarm and b) warning systems and assess their main units systematically (**Fig. 1**).

In the present paper we exemplarily present the Illgraben debris flow alarm system case study. We model both the technical and the inherent reliability of the alarm system with a Bayesian Network (BN). The reliability is expressed as a measure of the Probability of Detection (POD) and the Probability of False Alarms (PFA) and illustrated in Receiver Operator Characteristic (ROC) curves.

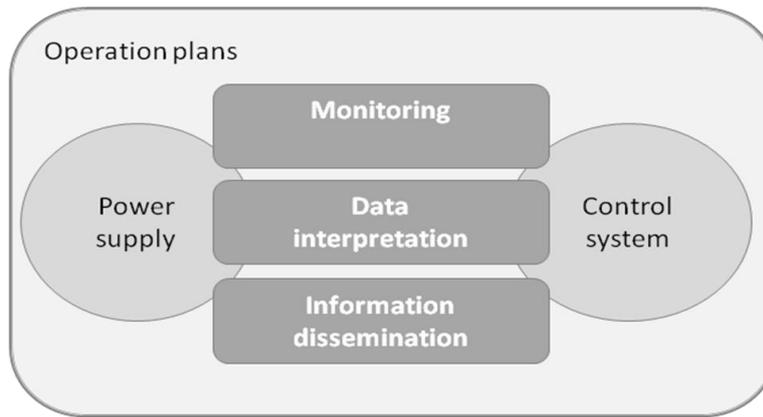


Fig. 1: Units of an early warning system.

RESULTS

A holistic reliability analyses address both, the inherent and the technical reliability of EWS. We found that the technical reliability of the Illgraben system depends on the failure probabilities of individual components and their configuration in the system.

A technically reliable EWS is based on a redundant system configuration, includes a control system and its components are protected from external failure sources. Economic limitations do often lead to weak points in the system configuration. These flaws are tolerable, if the resulting risk is considered and understood by all system stakeholders.

The inherent reliability of the EWS is its ability to detect dangerous events and prevent damages. It is increased through a multi-level monitoring approach and depends directly on thresholds and the positioning of individual sensors in the field. False alarms will decrease the compliance of endangered persons to the intervention measures.

These and findings of an second case study are summarized in the guideline for decision makers. The final guideline includes relevant background knowledge about natural hazard processes, the available monitoring options and a structured classification of EWS. It also includes detailed descriptions of EWS that are currently operated in Switzerland. Decision tools such as checklists address relevant questions and allow a comprehensive system evaluation on the inherent and technical reliability of EWS.

CONCLUSION

Reliability analyses are applied to support the development of a guideline for decision makers. The guideline is based on results of holistic reliability analyses which address both, the inherent and the technical reliability of EWS. The project ReWarn and the guideline are currently realized with the financial support of the Swiss Federal Office for Civil Protection (FOCP).

Keywords: Early warning systems, reliability, decision maker, guidelines