APPLICATION AND EVALUATION OF THE EAWS GUIDELINES FOR SITE-SPECIFIC AVALANCHE WARNING

Christian Jaedicke[1,2]*, Fabiano Monti[3], Paola Dellavedova[4,8], Lukas Stoffel[5], Sergio Azzarello[6], Antoni Molné[7]

[1] *Norwegian Geotechnical Institute (NGI), Oslo ,Norway*
[2] *University of Oslo, Department of Geosciences, Oslo Norway*
[3] *Alpsolut srl, Livigno, Sondrio, Italy*
[4] *Fondazione Montagna sicura, Courmayeur Aosta Valley, Italy*
[5] *WSL Institute for Snow and Avalanche Research SLF, Davos Graubünden, Switzerland*
[6] *Meteomont - Carabinieri - Servizio Nazionale di Previsione Neve e Valanghe, Italy*
[7] *Oficina de l'energia i del canvi climàtic – Meteorologia, Andorra la Vella, Andorra*
[8] *AINEVA Associazione Interregionale Neve e Valanghe , Trento, Italy*

ABSTRACT: The EAWS (European Avalanche Warning Services) recommendations for site-specific avalanche warning were officially adopted in 2022. The guidelines provide a clear differentiation between regional and site-specific avalanche warning in addition to some basic recommendations for the initiation and organization of site-specific avalanche warning services. Since the publication of the guidelines, several services in Europe have implemented and tested the proposed methods and definitions. Others have discussed the guidelines and provided feedback for further development. In this paper, we present results from a review process that collected feedback from warning services providing site-specific avalanche warning in Europe together with example projects from selected warning areas in Norway and Italy. The results from the survey show that most services agree on the definitions and the differentiation between site specific and regional avalanche warning. Discussions, however, arise with regards to the recommendations on how to set up and run a site-specific avalanche warning service. Additionally, the use and definition of avalanche impact probability proves challenging in comparison to the Conceptual Model of Avalanche Hazard's avalanche size / probability relation employed in North America. The results from the survey and the experience gained from the practical application of the guidelines will serve as a basis for revising the guidelines to achieve a better agreement and more standardized guideline implementation within the various European warning services.

KEYWORDS: Avalanche warning, site-specific, risk management, EAWS.

1. INTRODUCTION

Site-specific avalanche warning is the decisive input to avalanche risk management. While regional avalanche warnings provide a general overview of the avalanche situation in a wider area, site-specific avalanche warning focuses on selected avalanche paths where certain assets such as settlements, roads or other infrastructure are exposed to avalanche hazard. Regional avalanche warning has long been coordinated internationally by the European Avalanche Warning Services (EAWS, The European Avalanche Warning Services, 2017) in Europe and by the American and Canadian Avalanche Associations in Northern America (Statham et al., 2017). The local services that provide site-specific avalanche warning, however, all operate on their own with little cooperation, common methods, and standards. Therefore, the EAWS took the initiative to gather an overview of the services that provide site-specific information (Jaedicke et al., 2018) and to define a common ground that could serve as European recommendations for such services. The definitions and guidelines were presented at the general assembly of the EAWS in Davos in 2022 (EAWS, The European Avalanche Warning Services, 2022) and at the ISSW 2023 in Bend Oregon (Jaedicke et al., 2023a). During the process of preparation of the recommendations, the working group promised an open review process and a revision of the recommendations after publication and testing in practice. This paper presents the results of a survey conducted among the known European Services active in site-specific avalanche warning and gives some examples from the implementation of the recommendations in services located in Italy, Switzerland and Norway.

* *Corresponding author address:*
Christian Jaedicke, Norwegian Geotechnical Institute
0806 Oslo, Norway;
mobile: +47 95992282 email: cj@ngi.no

2. SURVEY

A survey was conducted to gather information of the use and experiences with implementing the EAWS recommendations. The survey was designed such that participants, following some common questions, chose whether or not they apply the recommendations in their warning service. The following questions were then addressed according to that choice. Finally, participants were given the chance to opt for detailed

feedback on each of the definitions and recommendations in the EAWS document. The survey was open for responses in summer 2024 and 30 answers were collected.

The survey was answered by five commercial, 24 public and six other services of which 24 offer regional and 18 offer site-specific warnings. Most answers came from Italy (12) followed by Austria and Norway (5), Finland and Spain (3). A closer look at the affiliation of the respondents showed that some answers represent the same organisation with different people answering the survey.

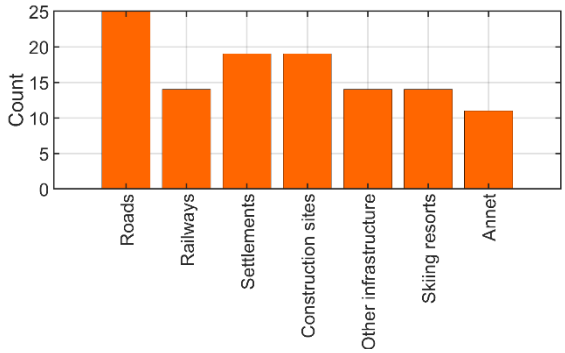

Figure 1: Objects covered by the warning service

The objects covered by the surveyed warning services are clearly dominated by roads. Settlements and construction sites range second, while other objects such as ski areas and railways also are strongly represented (Figure 1).

Of the 34 valid answers, 88% state that they have read the recommendations and 61% report that they use the recommendations in their organisation.

Four of the respondents answering that they do not use the recommendations justified their answer by not knowing about the recommendations prior to the survey. Four argue that the recommendations do not apply to their organisation and three have other reasons. Two respondents mentioned that the guidelines are too strict and hard follow. One answer that they have other guidelines in place, or that they know about the guidelines but have not read them. In the open comments, several respondents mention that they only work with regional warning, others write that they have not previously received information about the recommendations. Two respondents mention that the recommendations still need to be discussed and implemented in their organisations.

The respondents that have implemented the guidelines received several questions on the use and implementation in their services. Most of the services agree that the guidelines are useful for their work. Some of them also adjusted existing routines to the new recommendations. The recommendations are used in promoting the service and in many services, equal routines have been used also previously. There are many respondents that have suggestions for improvements of the recommendations and they also show interest in participating in the working group for a revision of the recommendations.

The respondents were asked if their services comply with the recommendations. The results show that most services communicate an impact probability in their warnings and that they use both the information pyramid and avalanche problems. Stil, a majority also communicate an avalanche danger level according to the EAWS avalanche danger scale (EAWS, The European Avalanche Warning Services, 2016). The question whether the forecasters develop and decide on mitigation measures is answered yes by approximately 57% of the services and a majority of 67% of the respondents answer that they communicate predefined mitigation measures.

There are several distinct recommendations on the set up for site-specific avalanche warning services. The services were asked if they comply with recommendations such as documentation of terrain and avalanche paths, quality control system and logging system for data and the resulting warnings. In general, most of the respondents answer compliance with the recommendations. The largest deviation is the quality control system, where almost 50% answer that they do not have such a system. There is even one service that states that their forecasters do not have appropriate training and education (Figure 2).

In total 85% answered that they would recommend others to use the recommendations.

Figure 2: Compliance of the responding services to the recommendations for the setup of a site-specific avalanche service. Respondents could only answer yes (red) or no (blue)

The free text comments from 16 respondents reveal that they find the recommendations useful for their work and that the recommendations follow a consistent philosophy and are easy to apply. Others point out that the recommendations follow their already established routines and make it easier to ensure a high standard in their services. Respondents indicated the recommendations establish a common terminology and language that promotes better cross-service communication and development. The envisioned standardisation of site-specific avalanche warning allows for better conditions in public and private tenders and competition. Another important point in the feedback is the need for more best-practice guidance such as checklists, workflows and standard documents for documentation of the service. Respondents that apply the conceptual model (Statham et al., 2017) in their services consider the use of the impact probability as a product of release and runout probability as more challenging than the size/probability relation in the conceptual model. A thorough discussion is needed to reveal advantages and disadvantages of the two approaches.

3. CASE STUDIES

The EAWS recommendations for site-specific warning have already been tested and implemented in several services in Europe. Experiences with the use of the guidelines gathered during the last two seasons are presented for site-specific warning services in Italy, Norway and Switzerland. The examples cover a wide range of services, from public avalanche commisions to private consulting services and thus show the variety of applications of the recommendations in Europe.

3.1 Italy

Aosta Valley is an autonomouss region of the Italian Alps with a small surface area of 3 263 km^2. 60% of its territory is at altitudes above 2000 masl. The Regional Avalanche Register records 2310 avalanche paths of which 21% interact with populated structures/areas (Debernardi and Segor, 2013). Over the years, site-specific management of these sites played a crucial role, especially in areas lacking physical mitigation measures (Chiambretti et al., 2014; Schweizer et al., 2012). For management purposes, two operational scales interact: avalanche warning at the regional level and site-specific warning at the municipal level. Site-specific warning is organized through local avalanche commissions (CLVs). Each day in the winter season, the regional warning system communicates an expected avalanche risk severity scenario for each region, evaluating only those avalanches that might interact with infrastructure. The CLVs process this information and then evaluate the situation at the site-specific level (Segor et al., 2012). In doing so, the probability and size of the expected avalanche(s) is related to the infrastructure at risk. Historical documentation of earlier events and lists of managed avalanche paths combined with local knowledge allow for detailed management (Segor et al., 2014a).

During the winter season 2023/2024, several snowfall and avalanche cycles occurred which illustrate the two operational levels. During two cycles in March 2024 an orange alert was communicated from the regional level to the site-specific level. Orange alerts correspond to the following risk scenario: “The expected avalanches may widely affect populated areas, even in sites usually not exposed to avalanche risk. These are mostly medium or high magnitude events." Following this alert, the site-specific services implement closer monitoring of precipitation intensity, new snow (HN) accumulation, ongoing wind condition in terms of intensity and direction, rain-snow elevation line, air temperatures, characteristics of the snowpack, natural avalanche activity and the current protective capacity of avalanche mitigation structures. The CLVs have predefined operational and preventive actions (road closures) for situations when the site-specific assessment indicates a high impact probability in the coming period. At a site-specific level, the final assessment is therefore to estimate when the potential avalanche would occur (Segor et al., 2013).

In the episode between Saturday, March 2nd and Monday, March 4th, 100 to 170 cm of new snow was deposited above 1600 masl. within 36 hours. The rain-snow line was located at approximately 1000 masl. and over 66 avalanches reached populated areas.

Figure 3: Avalanche on a main road in Gressoney Valley in March 2024 - © Regional Functional Center and Planning - Snow and avalanche services Aosta valley - CLV Commission

In the episode between Saturday 30th March 30th and Monday, April 1st, widespread precipitation was recorded above 2000 masl., with more than 120 cm of new snow. The rain-snow line ranged from 1600 to 2000 masl. Many medium to large natural avalanches released in unpopulated areas. Although numerous avalanches were observed, only one affected a road.

At the site- specific level, on March 3rd roads were closed, and several avalanches reached and blocked some roads (Figure 3). On 31st March, on the other hand, no roads had to be closed and no significant avalanche events reached the populated areas despite heavy rainfall.

At the regional level, the orange alert was consistent with the forecast. At site-specific level the operational choices were refined based on local conditions and events during the alert. In the episode on March 31st, the new snow accumulated only at high elevations, while heavy rain fell on lower-elevation slopes. For the site-specific assessment, this was decisive for not closing the roads as wet snow avalanches would not reach the populated areas. This illustrates how the site-specific service uses regional information as input to their assessment of the ongoing situation to determine if and when the impact probability is high.

The experience from these two examples shows several points for improvements in the operational service (Segor et al., 2014b). The time horizon for the site-specific forecast is usually much shorter than for the regional forecast and could be better defined. Communication should also better specify that inputs obtained via monitoring of current conditions dominates the site-specific assessments. Common mitigation measures such as road closures, evacuation and restricted public services should be communicated to the public considerably in advance of possible events to avoid surprising people in the area when such mitigation is enforced. The critical monitoring parameters, the content of standard communications to the public, and possible road closures need to be clearly defined before critical situations arise.

Figure 4 shows some of the texts used this winter to communicate the site-specific avalanche assessment to different users

3.2 Norway

In Norway, infrastructure and settlements are exposed to avalanche hazards from the south of the country all the way to the Arctic archipelago of Svalbard (Eckerstorfer and Christiansen, 2011; Jaedicke et al., 2009), encompassing a large variety of climate zones. Traditionally, the Meteorological Institute issued avalanche warnings at danger levels four and five, where the levels can have consequences for infrastructure and settlements (Meteorologisk Institutt, 2006). Since 2013, the regional warning service varsom.no (Engeset, 2013) provides a daily regional assessment of the avalanche situation in the most exposed regions of the country. This service is extended to other regions when the avalanche danger is 4 – high or 5 – very high.

"Due to the forecast of heavy snowfall, from tonight until late morning tomorrow, residents and tourists are invited to limit travel on the regional road 47 of Cogne. Only necessary and emergency travel is recommended. If the situation and the snow-weather conditions make it necessary, the regional road system may be temporarily closed."

"We inform residents and tourists about the weather forecasts issued by the regional weather office, which can be consulted at the link (https://cf.regione.vda.it/). Heavy snowfall is expected to affect the region from today until late morning tomorrow.

****Call for Caution****

In order to guarantee the safety and flow of traffic in the next few hours, we recommend to limit travel on regional and municipal roads only to cases of necessity, emergency or return to the valley.

Any accumulation of snow could make road conditions difficult and dangerous.

****Constant Monitoring and Possible Temporary Closure****

The municipal administrations supported by the Local Avalanche Commission will be constantly vigilant on the evolution of the meteorological situation. If snow and weather conditions worsen, it may be necessary to temporarily close roads to ensure the safety of all citizens.

For further updates and information, please monitor the official channels and comply with any recommendations issued by the competent authorities.
We thank the collaboration of all citizens and visitors in respecting the recommendations and in dealing with adverse weather conditions with caution."

Figure 4: Example of the texts used to communicate the site-specific avalanche assessment to the public in the Aosta Valley in March 2024

The actual risk management of avalanche hazards is the responsibility of the local risk owner such as municipalities (Justis- og beredskapsdepartementet, 2011), national and county road authorities (Andreassen and Helgaas, 2016) and the national railroad administration. In addition, hydropower operators (Jaedicke et al., 2023b), construction sites, and the military (Kronholm and Ellevold, 2012) frequently ask for avalanche warning as input to their risk management procedures for their winter operations. This has led to an increasing number of public and private operators that provide avalanche warning at a more detailed level.

In some cases, three different assessments in the same location are possible, for example where a national road runs parallel to a county road, with houses between the two roads. Close cooperation between the services involved is essential to exchange data, assessments of the situation and to coordinate communication with the public.

The EAWS guidelines for site-specific avalanche warning (EAWS, The European Avalanche Warning Services, 2022) have been implemented in most services today. The guidelines are flexible enough to encompass different operations both for public and private entities. Common for all services in Norway is that they communicate avalanche impact probability as the main product of the hazard assessments.

The impact probability is closely connected to predefined mitigation measures such as active traffic control on roads, in addition to closures and evacuation of exposed settlements. Experience shows that the weak spot of most avalanche forecasting projects involves the development and implementation of deliberate, well-planned mitigation measures.

The level of detail, the data used, and the period covered by each warning depends heavily on the nominal annual probability that avalanches might reach the object, the presence of assets in the area, and the operational prerequisites in each project. Some of the avalanche warning projects are operative over many years (roads, settlements), while others operate only for one or a couple of seasons (construction sites). The guidelines' flexibility allows the operators to develop and run avalanche warning services that are custom tailored to each project while following the basic requirements for a well-organized and documented service.

3.3 Switzerland

In Switzerland, site-specific assessments are carried out by avalanche safety services. The organization of the services can vary widely. For example, an avalanche service can be responsible for settlements, local roads, winter hiking or cross-country ski trails (one municipality), or for different roads (typically from part of a canton) or railway sections. The ski resorts assess the avalanche danger in their areas and slopes independently with their own avalanche service. In both the cantons of Valais and of Uri, regional avalanche services carry out site-specific assessments and issue recommendations to the authorities responsible for the municipalities as well as for the transport routes.

Depending on the area covered by the service, the number of assessed avalanche paths may vary from just a few up to approximately one hundred. In services responsible for several tens of avalanches, usually only a handful of avalanche paths need an immediate detailed assessment in case of heightened avalanche danger. These avalanche paths correspond to avalanches with shorter return periods reaching roads or other infrastructure. Based on differing scenarios, there are usually several mitigation plans in place. For example, "a large snowfall" may have a different plan than an "an extraordinary situation" or an "extreme avalanche situation".

In Switzerland, the WSL Institute for Snow and Avalanche Research SLF publishes an avalanche bulletin for the next 24 hours at 17:00. each day. In the morning at 08:00., an update for the situation until 17:00 is usually published. The avalanche danger is described in danger levels 1-5. The avalanche bulletin also contains information on the snowpack and the weather.

The local avalanche services assess the avalanche hazard for certain avalanche paths. They carry out a site-specific assessment of the avalanche situation, but do not issue an actual avalanche warning. Important input data for the site-specific assessment include maps (e.g. slope angle maps) and the avalanche cadastre. Consideration of current data from automatic weather stations (snow, wind), local observations, weather forecasts, precipitation forecasts, webcams and detection systems all serve as additional input data. The avalanche bulletin of the WSL Institute for Snow and Avalanche Research SLF provides a further basis for the site-specific assessment.

The task of the avalanche services is to restrict access to avalanche-prone areas for a certain time periods or to make recommendations for such closures. For the work of the avalanche services, the practical aid "Work in the avalanche service" has existed since 2007 (Stoffel and Schweizer, 2007). The Swiss Practical Guide does not deal with definitions (Chapter 1 of the EAWS Guidelines (EAWS, The European Avalanche Warning Services, 2022)), but the recommendations for site-specific avalanche services (Chapter 2 of the EAWS Guidelines) are more detailed. The EAWS Guidelines have been implemented in the Swiss Practical Aid for a long time, which is why the EAWS Guidelines are not distributed to the Swiss avalanche services as a separate document.

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