IMPROVED WINTER SAFETY FOR THE OLIVONE-CAMPO BLENIO-COZZERA ROAD IN SOUTHERN SWITZERLAND WITH RADAR-BASED AVALANCHE ALARM SYSTEM AND AUTOMATIC TRAFFIC CONTROL

Susanne Wahlen[1]*, Mattia Soldati[2], Stefano Baggi[2] and Tobias Schoch[1]

[1] Geoprevent, Zurich, Switzerland
[2] Canton Ticino, Office for Natural Hazards, Fires and Projects, Bellinzona, Switzerland

ABSTRACT: The cantonal road from Olivone to Campo Blenio and Cozzera is affected by various avalanche paths that are mainly protected by a tunnel and a snow shed. However, the Toira avalanche paths still pose a risk for the road and have caused multi-day closures leading to inconvenience for the local population in the past. Various measures were considered to improve winter safety before implementing a radar-based avalanche detection system with automatic road closures at the end of 2021. Radar functions in all visibility conditions and allows for real-time detection of avalanches in large areas. The chosen location offers a good view of the starting zones and high sensitivity antennas ensure reliable detection even in the presence of extensive vegetation (forest). Three traffic lights close the road in real-time upon a detection in the relevant zone. Closures are automatically cancelled if the avalanche stops in the channel above a defined area and the road is reopened after a few minutes automatically. Only events reaching the vicinity of the road lead to a permanent closure requiring manual reopening via an online control center. More than 200 avalanche events were detected since radar installation in 2021 whereas 88% of the events are attributed to the previous season 2023/24. Two main cycles were observed with cumulative closure times of approx. 3 hours over 10 days and 6 hours over 8 days, respectively. This represents a substantial increase in road availability compared to the multi-day closures prior to the commissioning of the avalanche radar system.

KEYWORDS: Avalanche detection, Real-time, Doppler radar, road safety, winter safety

1. INTRODUCTION

The cantonal road from Olivone via Campo Blenio to Cozzera is affected by 12 avalanche paths. The presence of the Toira tunnel and the Stübiè snow shed provide adequate protection against the avalanche paths considered most dangerous for the road. However, under certain snow and wind conditions, the south-facing avalanches from the Toira slope still pose a risk to the road. In the winter of 2017-2018, very intense snow falls prevailed and caused several closures and inconveniences for the local population and economy, such as the ski field in Campo Blenio and several larger dairy farms that were unable to deliver their milk to the factory in the valley.

Subsequently, a political dialogue on improving road availability for the affected communities above Olivone was initiated. Various measures were assessed to improve winter safety, including avalanche barriers, protective dams and organisational measures. Structural measures proved not to be uneconomical and remote avalanche control systems are difficult to implement due to their proximity to the residential area. Considering the highest cost-effectiveness and the minimal impact on the environment, a radar-based avalanche detection system with automatic road closures was chosen to increase the winter safety of this road section.

The avalanche radar detects avalanches in real-time regardless of visibility conditions and has been applied in various applications with automatic road closure and reopening, especially in the Alpine region and Norway (e.g. Persson et al., 2018; Meier et al., 2018; Meier et al. 2016). However, the case of Olivone La Töira is a particular challenge due to the forest cover on the avalanche slope and the topographical conditions.

2. MATERIAL & METHODS

2.1 Avalanche radar setup

The radar site was chosen at the road side to the Lucomagno Pass, as only elevated sites provide adequate coverage of the ROI (region of interets) of the trigger areas on the Toira slope. Due to the vertical extent of the ROI, dedicated antennas with aperture angles of 30x30 degrees (horizontal x vertical) were applied. This antenna setup further allows for increased sensitivity and ensures reliable event detection in the vegetated slope compared to standard antennas often applied in avalanche applications. The detection parameters were tuned to avoid detections

* *Corresponding author address:*
Susanne Wahlen, Geoprevent, Zurich, Switzerland;
tel: +41 44 419 91 94;
email: susanne.wahlen@geoprevent.com

caused by tree movements, while still being able to detect small avalanche events. The radar's field of view covers the main La Toira avalanche path as well as several smaller paths on both sides. The run-out area at the bottom is not visible due to shading by the terrain. Figure 1 shows the individual locations, the radar's field of view considering the topography and the radar opening angles, the main avalanche path and the defined alerting zones.

Three traffic lights were set up along the road, with 2 units on each side of the road section at risk and the third unit holding up traffic at the Toira tunnel. The road section between tunnel and middle unit is, under certain conditions, at risk of avalanches itself and waiting traffic must be prevented in this area. Alarm transmission from the radar station to the road takes place via licensed radio due to the lack of line-of-sight between the sites, and redundantly via mobile radio. The system has two cameras, a remote-controlled pan-tilt-zoom camera at the radar site for event and status images, and a camera at the road side for event images and live views of the run-out area and the road. Upon detection of an event, the radar activates the camera to automatically capture event images of both cameras.

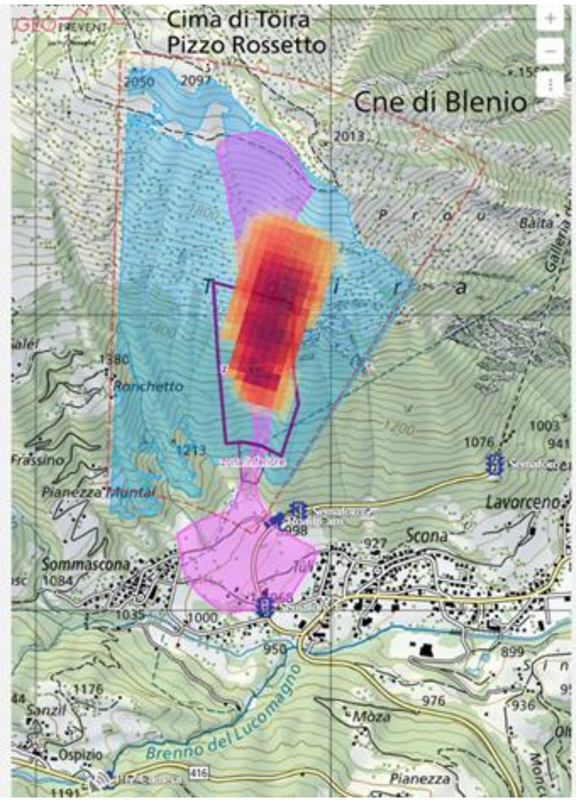

Figure 1: Overview of the setup and visualisation of an avalanche event on the GRAVX data portal. The radar (grey, bottom left) covers the field-of-view (blue) with the main avalanche path shown in pink. The traffic light locations are displayed in blue along the road. The two alerting zones are shown as purple polygons.

2.2 *Alerting concept*

Dedicated alerting zones were implemented to enable automatic management of road closures and reopenings. As soon as the detected event hits the 'zona centrale' (main avalanche path) a road closure is triggered. Upon detection, the radar tracks the event until it comes to a standstill or leaves the field of view. Events that terminate before the 'zona inferiore' (lower part of the main avalanche path) lead to alert suspension and the road is automatically reopened 2 minutes after the last detected movement of the avalanche. Events reaching the 'zona interiore' are considered to be close to or may have reached the road and require manual inspection of the situation. The system automatically informs the responsible stakeholders about the situation via SMS. They subsequently access the GRAVX data portal to view the relevant information on the event, use the live cam to inspect the road and reset the alarm via control center. The road remains closed until it is manually reopened by an authorized persons. This mechanism enables to react quickly and guarantee maximum warning time while minimizing the closure time per event.

Figure 2: Installed avalanche radar system with the Toira slope in the background.

3. RESULTS & DISCUSSION

Since start-up in December 2021, the system has detected 214 avalanche events, 16 of which were multiple events (230 events in total). The two low-snow winter seasons 21/22 and 22/23 produced a small number of events; 5 for the season 21/22 and 20 events for the season 22/23, respectively. The season 23/24 saw high snow heights particularly at higher altitudes and caused the majority of avalanche events (189).

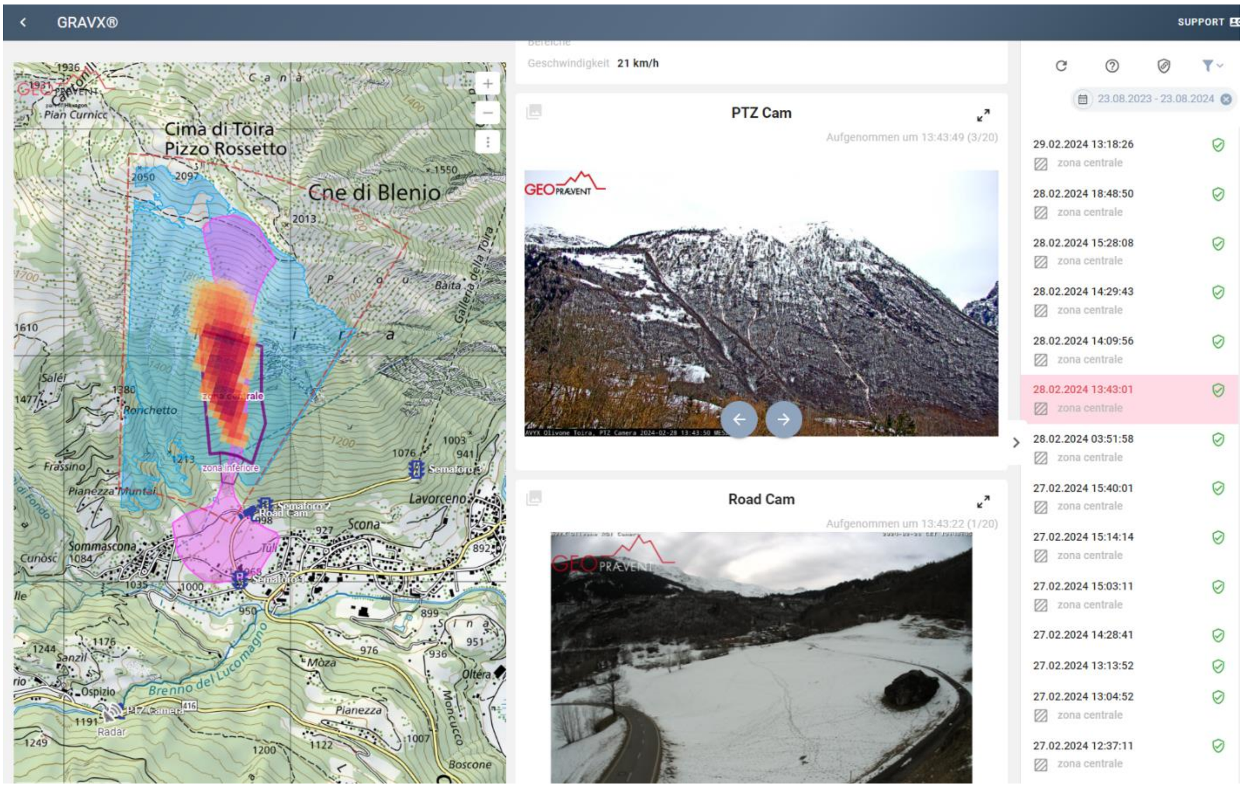

Figure 3: Data visualisation on GRAVX data portal with avalanche map, event characteristics, camera images and an event list.

Figure 4 shows the visibility conditions for all events over 3 seasons. Two thirds of the events are not visually recognisable (poor visibility or in the dark) and 21% are partially visible. Only 13% of the events were well visible by eye. This emphasises the importance of a visibility-independent detection method, such as radar. The frequency of the individual avalanche paths affected is shown in Figure 5. The main avalanche path in the middle is affected in 66% of cases, whereas 18% of these were simultaneous avalanches in the main and an adjacent path. Other tracks on both sides account for 34% of the events.

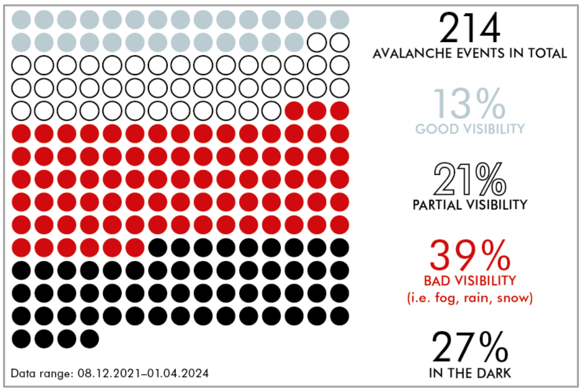

Figure 4: Visibility conditions at time of the detection of the avalanche.

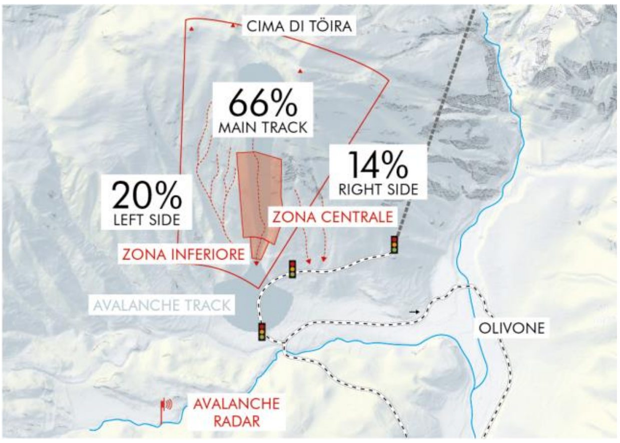

Figure 5: Distribution of the detected avalanches: the main path is responsible for two thirds of the detections.

Of the 214 events, 186 hit the ‘zona centrale’ and caused a road closure. Just under 10% of these events also impacted the ‘zona inferiore’ and required manual reopening (18 events in 3 seasons). 80% of the 186 events that triggered a short-term closure are attributed to the main avalanche track. 20 % of the incidents originate from adjacent paths, which are difficult to distinguish from the main avalanche track due to their proximity. The average duration of all short-term closures (168 events) is 3 minutes, including the closures requiring manual reopening the average duration amounts to 4 minutes.

Winter season 2023/24 accounts to the bulk of detections over the past 3 years. Figure 6 shows the distribution of avalanche events and closures over this season with two main cycles at the end of February / beginning of March and approximetaly a month later respectively. These cycles correspond well with two persistent weather conditions in the Southern Alps.

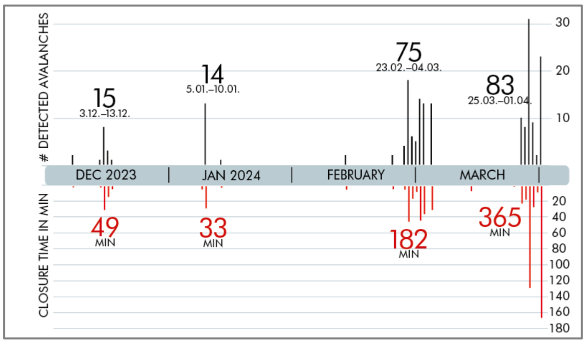

Figure 6: Time series of avalanche events and closure times for season 2023/24. Due to an internal hard disc defect, the radar was not in operation between 7 - 14 March 2024.

The avalanche cycle at the end of February / beginning of March caused a total closure of 182 minutes, i.e. approx. 3 hours in 10 days, with the long closures resulting from the manual interventions. For the cycle at the end of March/beginning of April, it is more than twice as much (6h in 8 days) which is mainly due to 2 longer closures with manual reopening at night (>2h).

4. CONCLUSIONS

The avalanche radar at Toira has been in use for 3 years and has experienced two low-snow winters and one snowy winter at higher altitudes (>1600-1800m asl). Large avalanches occurred in the winter of 2023/24 that reached the valley but did not hit the road and cause any damage. The most hazardous avalanches did not occur, probably due to the lack of snow in lower altitudes.

The closure times are significantly shorter than prior to the installation of the system, when the road had to be closed for several days during extreme weather conditions. The avalanche occurrence data further helps the avalanche commission to better assess the avalanche situation. However, it is necessary to calibrate the system in a snowy winter and to train the responsible stakeholders how to interpret and work with the data as well as to maintain communication between the involved parties, especially after two winters with little snow.

REFERENCES

Meier, L., M. Jacquemart, B. Blattmann, and B. Arnold. Real-time avalanche detection with long-range, wide-angle radars for road safety in Zermatt, Switzerland. In: Proceedings ISSW, Breckenridge, Colorado, 304-308, 2016

Persson, A., M. Venås, T. Humstad, and L. Meier. Real-time radar avalanche detection of a large detection zone for road safety in Norway. In: Proceedings ISSW, Innsbruck, Austria, 597-600, 2018.

Meier, L., M. Jacquemart, R. Steinacher, M. Funk, A. Burkard, E. Zenklusen Mutter, M. Proksch, N. Carlen, and P. Stoebener. An automated alarm and warning system for the Bis Glacier icefall, Switzerland, using a 5km radar and high-resolution deformation cameras. In: Proceedings ISSW, Innsbruck, Austria, 589-593, 2018