Handling of avalanche risk for the "Bonaigua" and "Beret" roads, Aran Valley, Spain

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ABSTRACT: The Aran Valley, located on the northern side of the Central Pyrenees, is one of the areas with the highest rate of avalanche danger of the whole mountain range (52% of the Aranese territory is affected). Not only are high mountain areas exposed, but also 6 population clusters and 3 main roads. On the roads with which this paper is concerned, a combination of temporary and permanent protective measures is applied. Over a total of 31,5 kilometres, there is a total of 82 avalanche prone areas (affecting 63 % of the road), of which 32 present at least a yearly frequency. Most of the slopes affecting the road are south faces, with elevations between 1600 and 2300 metres. Until the year 2003, the risk on the road was handled on the basis of the regional avalanche advisory. In the winter of 2003/2004, a local forecasting system was set up. In order to do so, a snow and weather observation network was implemented and a specific danger scale -adapted to the needs of the handling of the road- was developed. In the winter of 2008/2009, a helicopter based triggering system has been set up, using the device known as Daisybell®. The implementation of a local forecasting system has represented an improvement in the connectivity and in the safety of the road. The Daisybell triggering protocol has proved useful whenever: a) triggering can take place immediately after the snowfall; b) the wind during the snowfall has not been too strong.

KEYWORDS: Pyrenees, Avalanche forecasting, mitigation

1 INTRODUCTION

1.1 The Aran Valley

The Aran Valley is a 600 km2 territory located at the north face of the central part of the Pyrenean range. Though it is part of Spain and legally under the administration of Catalonia, a good amount of competences have been transferred to the local government (Conselh Generau d'Aran –CGA). Civil defence and handling of avalanche risk for the Aran Valley are among these transferred competences (Figure 1).

Local avalanche forecasting is carried out for two roads: the leg of route C-28 that passes along Port dera Bonaigua and the access road to Plan de Beret, route C-142b.

Both are quite important roads: route C-28 connects the Aran Valley with Catalonia and it constitutes an important entrance for winter visitors. Route C-142b is the way in to the zone of Baqueira Beret ski resort that hosts the biggest parking lot, made up by more than 6000 parking spaces.

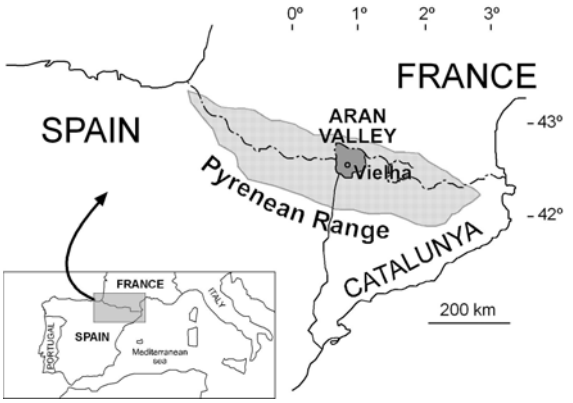

Figure 1. Location map.

The entity responsible for the roads is the Catalonian Road Service, belonging to Generalitat de Catalunya (Servei de Carreteres de la Generalitat de Catalunya -SCGC). An agreement has been subscribed between the SCGC, the Geology Institute (Institut Geològic de Catalunya-IGC) and the Aranese government (CGA), allowing the latter to run the local avalanche forecasting. In addition to this task, CGA's Forecasting Centre does avalanche forecasting for a series of mountain itineraries on the most visited areas of its territory (Gavaldà and Moner, 2008).

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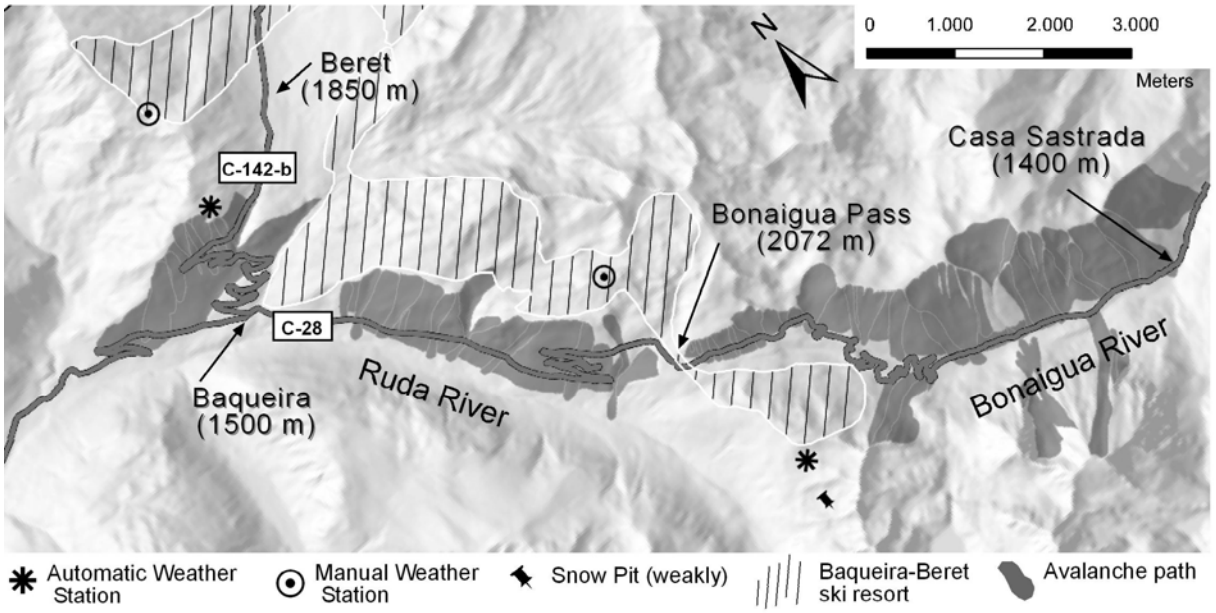

Figure 2. Location of routes C-28 (Bonaigua) and C-142-b (Beret)

1.2 Climatology

The study area presents an oceanic climate, receiving a strong influence of the wet fluxes coming from the Atlantic Ocean. Precipitations are abundant, over 1000 mm per year, even reaching 1500 mm at 2000 m asl. The total amount of fresh snow at 2200 m asl is about 600-700 cm per year and the distribution of precipitation is quite homogeneous throughout the year (Oller et al. 2006).

Route C-28 presents two differentiated sectors in terms of climatology. The northern leg is clearly dominated by the characteristic northern fluxes that affect the north face of the Pyrenees, while in the leg that stands on the south face - although also under the influence of the Atlantic Ocean- precipitations are less abundant. Fluxes coming from the north and the north-west are channelled along the valley of Ruda, originating strong winds which cause important circulation problems as they reduce visibility and form snow drifts and wind slabs.

1.3 Terrain

The leg of route C-28 that passes along Port dera Bonaigua connects the Aran Valley with the south face of the Pyrenees. It is divided in two parts: north and south face (figure 2).

The north leg of route C-28 which is affected by avalanche activity starts at the population cluster of Baqueira (1500m) and goes up to Port dera Bonaigua (2072 m). It is 9 km long and it travels up the valley of Ruda in an approximately NW-SE direction. Along these 9 km, it passes by a total of 20 avalanche areas, many of them with a return period of less than a year.

The area's vegetation ranges from deciduous shrub woods on the lowest elevations to young pine woods (Pinus uncinata) starting at 1750 meters and continuing up to 2000 meters asl. At the avalanche starting areas, located between 1700 and 2300 m asl, the vegetation is made up by scattered trees and alpine meadows. Though the average slope is about 30º, in many areas the slope is steeper than 45º.

The south face leg of route C-28 goes from Port dera Bonaigua (2072m) down to Casa Sastrada (1400 m). It is 11 km long and it follows the valley of Bonaigua in a NW- SE direction, along the SW face and passing by 28 avalanche areas. At the highest areas, the vegetation consists basically on alpine meadows, and only at the southernmost end are there deciduous woods. The slopes range from 30º to more than 45º and most of them are between 35 to 45º

1.4 Defence works

Route C-142-b is the road with the greatest number of defence works, protecting most of the avalanche prone areas. Expenditures in these works started back in the 1970's, when snow sheds were built on the upper leg of the road. As of the 1980's, a good number of snow nets have been installed at the areas where avalanches occur most frequently. Terraces have also been dug so as to increase the roughness of the terrain. Even so, no defence works have been installed on the areas where the biggest avalanches with a longer return period occur.

LOCAL AVALANCHE DANGER SCALE

		PROBABILITY OF OCCURRENCE		
		Not probable (Possible)	Probable	Very Probable
AVALANCHE SIZE	Sluff	L	L	L
	Small	L	M	H
	Medium	M	H	VH
	Large	H	VH	VH

L	Low
M	Medium
H	High
VH	Very high

Figure 3: Local avalanche danger scale, designed to meet the needs of local forecasting in the Aran Valley

On the north face of C-28 there are no defence works, mainly because of their high cost.

Snow and wind nets have been set up in one of the existing avalanche prone areas on the southern leg of route C-28, but at the remaining avalanche prone areas in this leg there are no protective structures.

2 METHODS

The importance of both roads concerned led to the decision to keep them operative all throughout the winter. That is why an important amount of resources has been dedicated to the construction of defence works as well as to avalanche risk handling.

As of the winter of 2003-2004, a local forecasting system has been set up for both roads in order to provide their administrators with the necessary information to decide whether to keep the roads open or close them temporarily, as well as to improve their connectivity.

2.1 Meteorological and snow measurements

In order to carry out the local forecasting, the local data collecting network has been enlarged so as to count on comprehensive information on the state and evolution of the snowpack.

A FlowCapt station and two automatic stations which measure the temperature and humidity of the air, the direction and speed of the wind, snow height, precipitation and the temperature of the snow, have been set up next to the avalanche starting areas.

The Baqueira-Beret ski patrol takes snow and meteorological measurements on a daily basis at two spots which are representative of the areas that affect the roads.

Snow profiles and stability tests are carried out systematically at the avalanche starting areas and slab fracture lines, thanks to the fact that they are easily accessible from the ski resort.

At present there is a barrier system in order to close it down when there exists avalanche risk.

2.2 Forecasting

Until the winter of 2003-2004, the roads were handled on the basis of regional forecasting, and they were closed whenever danger was rated “high” or “very high”. This caused the roads to remain temporarily closed even at times when the local avalanche danger was low, while sometimes they would remain open with high local avalanche activity, whenever the regional danger was rated with a 3.

In January 2003, avalanche activity was particularly intense in the Aran Valley, affecting the two concerned roads as well as urban developments linked to the ski resort. This led to the setting up, as of the winter of 2003-2004, of a local forecasting system that includes an avalanche danger advisory, providing in depth information on the probability of occurrence and size of the avalanches which affect the roads. This report is issued whenever the Avalanche Centre of the Aranese government (CGA) estimates that there is evidence that avalanche activity affecting the course of the routes might occur.

A specific avalanche danger scale has been designed, including such factors as the probability of occurrence and the size of the avalanches (figure 3). On the basis of these parameters, a 4-level danger scale has been created: Low, Medium, High or Very High. Only natural danger is taken into account, accidental danger is not considered.

The resulting scale is simple and easy to use for the road managers.

Forecasting tasks also include the systematic mapping of avalanche activity.

2.3 Artificial avalanche triggering

During the first 4 years of local forecasting, no preventive avalanche triggering was carried out. When the danger was considered high or

very high, the roads were physically closed to the public by means of barriers.

As of the winter of 2008-2009, preventive avalanche triggering has started, using the device known as DaisyBell®.

A rigorous shooting protocol has been established, since the avalanche areas are located at the area of influence of Baqueira-Beret ski resort and they constitute important off-piste areas. All the concerned entities are involved in this protocol: the Catalonian road service, the Aranese SAR service (Pompièrs d'Aran), Baqueira-Beret ski resort and the Catalonian Police Department, as well as the owners of private businesses located in the area.

Route C-28 has been divided in four sectors with varying levels of warning needs.

During this first season, 4 shooting campaigns have taken place, with a total of 50 shots, of which 14 have been effective, 9 of them of large dimensions (figure 4).

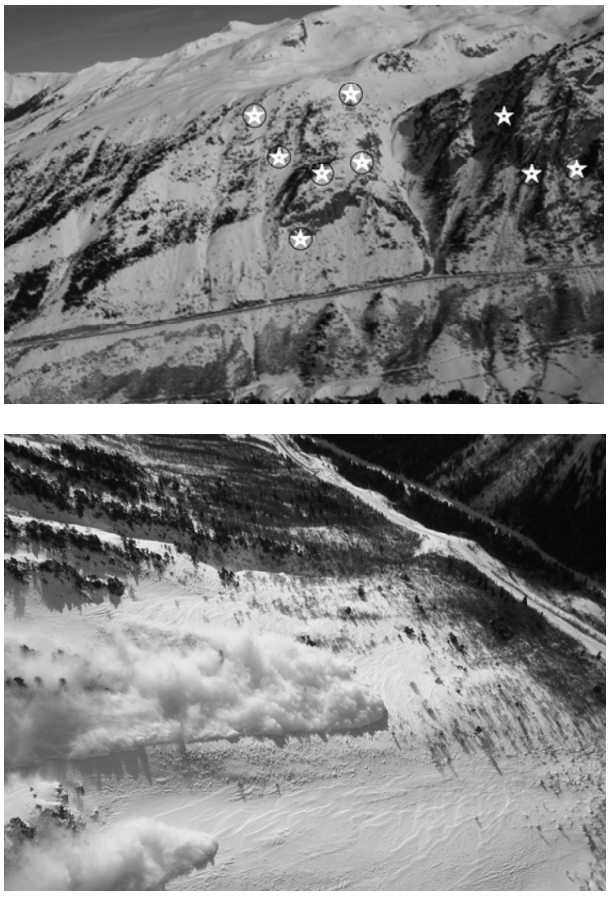

Figure 4. Up: Aerial view of a sector of route C-28 with its shooting spots. Down: Powder snow avalanche triggered artificially.

3 DISCUSSION AND CONCLUSIONS

3.1 Forecasting

Since the very first year the local forecasting started to be applied to the road management, there has been a noticeable improvement in it. Already after the first winter, it became clear that there was a strong discrepancy between regional and local forecasting.

The fact that the roads are oriented to the south makes avalanche situations very specific and peculiar, not always coincidental with regional prediction. Thus, during the first season of local forecasting, over a total of 17 days of regional danger rated 4, the local danger was rated high –and the road duly closed- only in 6 occasions. On the other hand, on 5 occasions in which the regional forecasting rated the danger with a 3, a high local danger was forecasted and the roads were closed to circulation.

3.2 Defence works

Over the years in which local forecasting has been taking place, the systematic tracing of avalanche activity has provided the necessary information to embark in new defence works, namely snow sheds, reforestation and snow nets, thus minimizing danger in those avalanche prone areas with a higher frequency of occurrence.

3.3 Preventive avalanche triggering

This first year of pilot usage of the DaisyBell® has allowed for the testing of the device in different situations, coinciding with a peculiar year with regards to the unusually high intensity of avalanche activity in the Aran Valley.

The device was used in 50% of the danger situations. In the remaining cases, the snow and meteorological conditions did not make it possible. In all the situations in which the DaisyBell® was used, even in those cases when the shots did not trigger the avalanches, danger descended from High to Medium, allowing for the immediate initiation of snow clearing works and therefore reducing the time the roads had to remain closed.

4 ACKNOWLEDGEMENTS

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