E.P.A.: AVALANCHE PERMANENT SURVEY, MORE THAN 100 YEARS OF OBSERVATION UPDATED FOR MORE RELIABILITY

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ABSTRACT: E.P.A. (Avalanche Permanent Survey) is a descriptive report of selected avalanche areas. Survey is conduced, each winter, by observers assigned between French Alps and Pyrenees. Data collection was initialised in 1899 by the French Forestry Administration. O.N.F. (Forestry National Office) and the Cemagref research institute were developing the database and cartography the surveyed areas.
Recently, during 5 years, E.P.A. has been updated, adding photos, rebuilding location maps and defining observation methodology.
Current uses include public information, risk assessment and large scale statistical studies.

1. WHAT IS E.P.A.?

1.1. Definition

The *Enquete Permanent sur les Avalanches* (E.P.A.) is a report describing the avalanche events on approximately 3,900 determined paths in the French Alps and Pyrenees.
Avalanche occurrences have been recorded since the beginning of the 20th century; Mougin (1922); along with quantitative (runout altitudes, deposit volumes, etc.) and qualitative (flow regime, release cause, etc.) data; Jamard et al. (2002). The field observations are collected by forest rangers and stored by the Cemagref research institute. The data collection protocol and observation network has seen several changes since the beginning of the report, including a major update in 2002, which considerably increased the reliability of the information.

1.2. History

The first registered avalanches were observed in Savoie in 1899 thanks to Paul Mougin, forestry office leader engineer who thought that a scientific knowledge about avalanches could permit to understand avalanche activity and prevent many incidents that occurred the years before: destroyed buildings, wiped out forests, dead people…
Data collection was extended to the whole French Alps during the 20's, and to the Pyrenees in the 60's.

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1.3. E.P.A. Glossary

Avis d'avalanche: avalanche card
Carnet d'avis: avalanche card notebook
Carnet forestier: Forestry notebook
C.L.P.A.: Carte de Localisation des Phénomènes d'Avalanche (Localization Map of Avalanche Phenomena)
E.P.A.: Enquête Permanente des Avalanches (Avalanche Permanent Survey)
Event: occurred avalanche
I.G.N.: Institut Géographique National (National Geographic Institute)
Intermittent site: Avalanche path observed once a winter
Permanent site: Avalanche path observed after each snowfall
O.N.F.: Forestry National Office
R.T.M.: Restauration des Terrains en Montagne (Mountain Restoration Lands), ONF territory in charge of natural hazard management in mountain areas
Seuil d'alerte: alert threshold
Seuil d'observation: observation threshold
Site: Avalanche path
Stopped site: Avalanche path no more observed due to the lack of element at risk and/or interest

2. THE E.P.A. DOCUMENTS

E.P.A. is made of several documents:

2.1. Carnet: Forestry notebook

Since the beginning, observers describe, in a specific notebook, the characteristics of an occurred avalanche: date, altitude, location, weather, triggering factors, victim, damages and every other remark.

Usually, there's one forestry notebook per town. Each notebook contains at least two pages per avalanche path (*site*). The first page is for the name, location and description of the site; others pages are for all reported events.

In some case, notebooks can contain a map made by observers themselves to permit to their substitutes or successors to know which sites are observed.

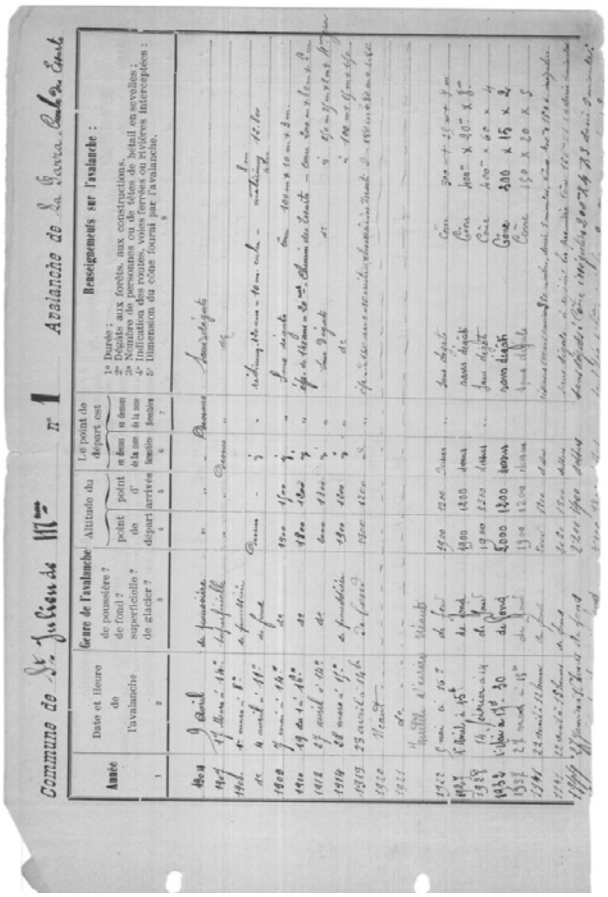


Figure 1: Forestry notebook (carnet forestier) from the beginning of 20th century.

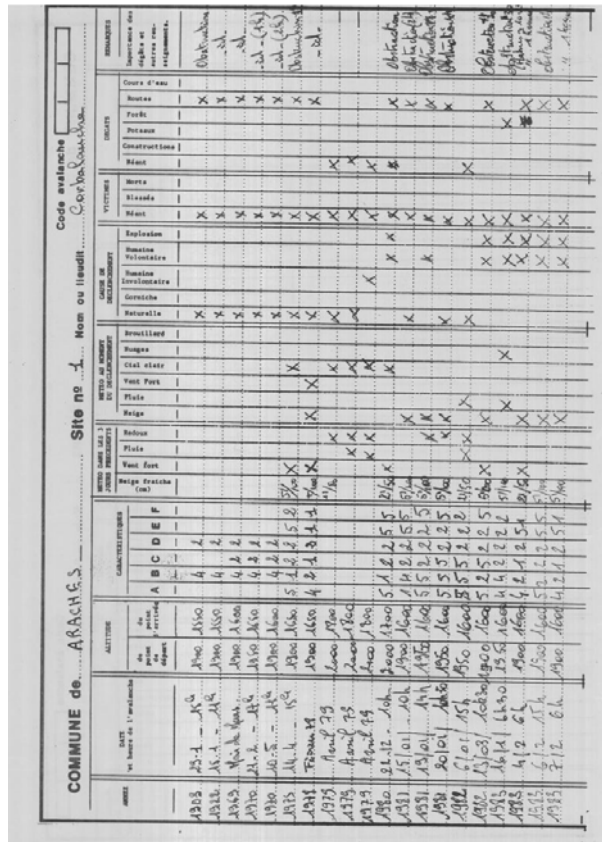


Figure 2: Forestry notebook (carnet forestier) from the 60's.

2.2. Maps

E.P.A. maps are location documents.

E.P.A. maps are scale 1:25000 with I.G.N. BW background, A3 format for easier use, and total compatibility with C.L.P.A. maps.

Cemagref use a grid to apply the same printing boundaries in all maps concerning E.P.A. and C.L.P.A. Each square of the grid has coordinates with letters for x-axis and numbers for y-axis.

Each site, numbered, is marked by a brown line and delimited by a green line. The observation threshold (blue line) and the alert threshold (blue dotted line) are used by the observers to make avalanche cards.

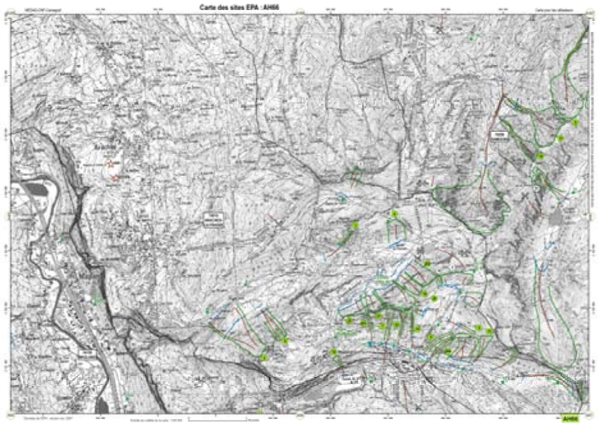


Figure 3: E.P.A. map AH66

2.3. Pictures

E.P.A. pictures are other location documents.
Since Renovation, each site in observation has been photographed to make observation easier and to permit that someone who does not know the area can report avalanche thanks to documents.
Each picture contains the town, the number of the site and a red line showing the avalanche path. It allows recognizing the area whatever the weather and the snow cover.
Thanks to this picture, in case of substitution of the O.N.F. observer, the new observer can understand easily the site and fill in avalanche card without any error.
Only observed sites are photographed. There's no picture of old observed sites (before renovation) and sites were observation has been stopped.
The example of figure 4 shows the importance of picture to localise a site because in some cases, it is not easy to determine the correct avalanche path using the map only.

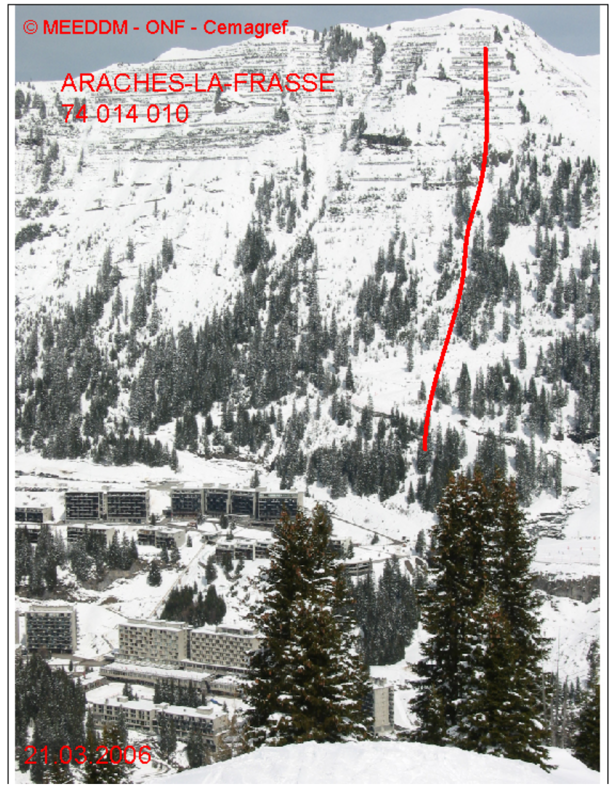
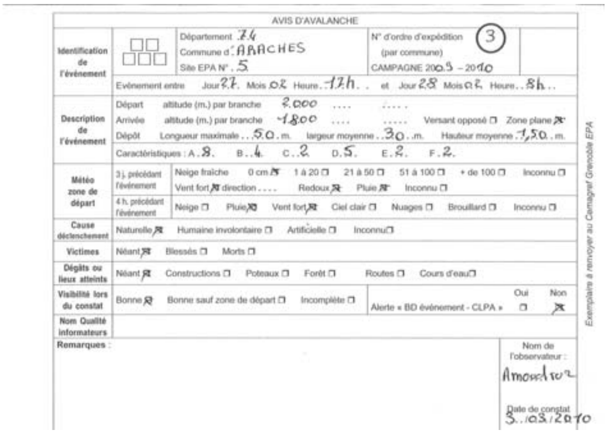


Figure 4: E.P.A. picture – Site n°10 at Flaine ski resort in the town of Arâches-la-Frasse, France.

2.4. Avis

Each O.N.F. observer has an avalanche card notebook that he uses during winter to report each avalanche on each observed site.
The avalanche card contains several information about the location and the characteristics of observed avalanche: release altitude, runout altitude, deposit volume, type of snow, weather during the days and hours preceding the release, type of trigger, damages, remarks and of course the date of observation.
Each card is a triplicate card. The original is mailed to Cemagref research institute, the first copy is mailed to the O.N.F. observer leader for check, the last copy stay in the notebook.



AVIS D'AVALANCHE		
Identification de l'événement	Département 74 Commune d' ARACHES Site EPA N° 5	N° d'ordre d'expédition (par commune) 3 CAMPAGNE 2009 – 2010
	Evénement entre Jour 27 Mois 02 Heure 17h et Jour 28 Mois 02 Heure 8h	
Description de l'événement	Départ altitude (m.) par branche 2.000 ….. ….. Arrivée altitude (m.) par branche 1800 ….. ….. Versant opposé ☐ Zone plane ☒ Dépôt Longueur maximale 50 m. largeur moyenne 30 m. Hauteur moyenne 1,50 m.	
	Caractéristiques : A 8. B 4 C 2 D 5. E 2. F 2.	
Météo zone de départ	3 j. précédant l'événement: Neige fraîche 0 cm ☒ 1 à 20 ☐ 21 à 50 ☐ 51 à 100 ☐ + de 100 ☐ Inconnu ☐ Vent fort ☒ direction …. Redoux ☒ Pluie ☒ Inconnu ☐	
	4 h. précédant l'événement: Neige ☐ Pluie ☒ Vent fort ☒ Ciel clair ☐ Nuages ☐ Brouillard ☐ Inconnu ☐	
Cause déclenchement	Naturelle ☒ Humaine involontaire ☐ Artificielle ☐ Inconnu ☐	
Victimes	Néant ☒ Blessés ☐ Morts ☐	
Dégâts ou lieux atteints	Néant ☒ Constructions ☐ Poteaux ☐ Forêt ☐ Routes ☐ Cours d'eau ☐	
Visibilité lors du constat	Bonne ☒ Bonne sauf zone de départ ☐ Incomplète ☐	Alerte « BD événement - CLPA » Oui ☐ Non ☒
Nom Qualité informateurs		
Remarques :		Nom de l'observateur : Amondruz Date de constat 3./03./2010

Exemplaire à renvoyer au Cemagref Grenoble EPA

Figure 5: Avalanche card (avis)

2.5. Database

All these data are stored in a database in the Cemagref research institute.
Each season end, a report of the year observation is made thanks to the database.

3. BEFORE 2002

3.1. O.N.F.'s work

Since the beginning of the report, the O.N.F. observer's work has not changed a lot.
Each observer goes at a view point for each avalanche site in his area and completes the avalanche card notebook.
During time, the avalanche card evolved to become more detailed and scientific and the volume of destructed forest in an avalanche is not calculated anymore.

3.2. Cemagref's work

Since 1973, Cemagref research institute and O.N.F. decided to register the information of forestry notebooks in a database, creating avalanche cards.
The first EPA maps were at scale 1:50000 or 1:80000 representing each E.P.A. site with a simple black line in the main path and the number on the side.

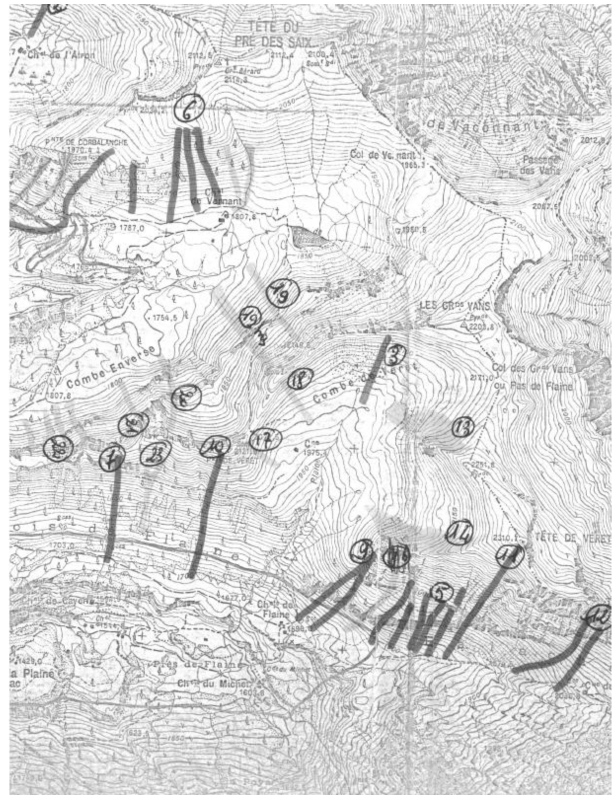


Figure 6: First E.P.A. map from the 60's (detail) from the area of Flaine ski resort (not build yet) in the town of Arâches-la-Frasse, France

3.3. Totals before renovation

Here are some figure and averages concerning E.P.A. from its creation to 2002.

	Total
Avalanche paths (site)	5,800
Events registered	75,000
Average of event/year	≈ 1,000
Towns	543
Average of sites/town	11
O.N.F. observers	260

4. FIVE YEARS OF RENOVATION

From 2002 to 2006, the EPA has been updated. In fact, after 100 years of observation, methodological improvements and homogeneous cartography were necessary to contribute to reliability through time.
The work of renovation was a common decision between three decision-makers: the E.P.A. study leader, the O.N.F. observer and the R.T.M. area manager.

The goal of renovation is to sort out from the whole E.P.A., sites, selected by many criterions: interest, usefulness or feasibility of observation.

4.1. Used Method

The working method consists to go at the best view point for each avalanche area/path thanks to the O.N.F. observer who knows his working area better than no one.
After reviewing the last events in the forestry notebook, the three decision-makers discussed the interest of keeping the site in observation taking lot of points into account:
Elements at risk (construction, road, tourist way),
Snow cover (without snow, no more observation),
Facility of observation (without any risk for observer and/or more than 30 minutes walk to arrive at the view point),
Total reforestation of the path (no starting area),
Regular observation (for statistics).

After discussing these points, the three decision-makers chose to continue observation or to stop it. In some cases, sites have been added following the same method.

If the site is easy to observe, the observer has to report avalanche events regularly (after each snowfall), filling in the avalanche card and mailing it to Cemagref research institute. Survey is then permanent.
If the site is hard to observe, the observer has to report avalanche events at least once in the winter (the best is at the end of it). Survey is then intermittent.
Then, they chose two limits in the path.
The first is the observation threshold. Placed at a distinctive point (rock, footpath, slope rupture), it permits observer to know when to fill in an avalanche card whatever the snow layer.
The second is the alert threshold. Generally placed near exposed elements, it permits observer to warn R.T.M. area manager of the dangerous situation.

At the end of the debate, the three decision-makers signed a renovation card, dated, which contains all characteristics of the site on the front: name, town, number, altitude and description of each threshold, type of observation, etc.

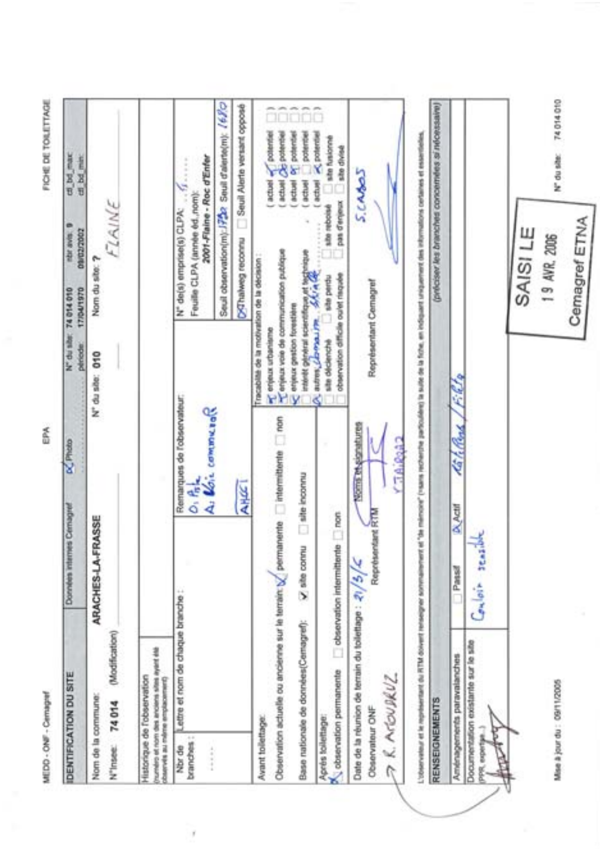


Figure 7: renovation card of the site n°10 at Flaine ski resort in the town of Arâches-la-Frasse, France

4.2. Drawing avalanche path

Each numbered site, is figured by a brown line and delimited by a green line considering the whole part of the avalanche able to pass through the observation threshold (blue line). The alert threshold is a blue dotted line place below the observation threshold near exposed elements.
The view point is represented by a green point with the number of the concerned site on the side.

There is a distinction between permanent sites (number on a green background) and intermittent sites (number on a white background).
For stopped sites, only figures the brown line and the number is crossed-out.

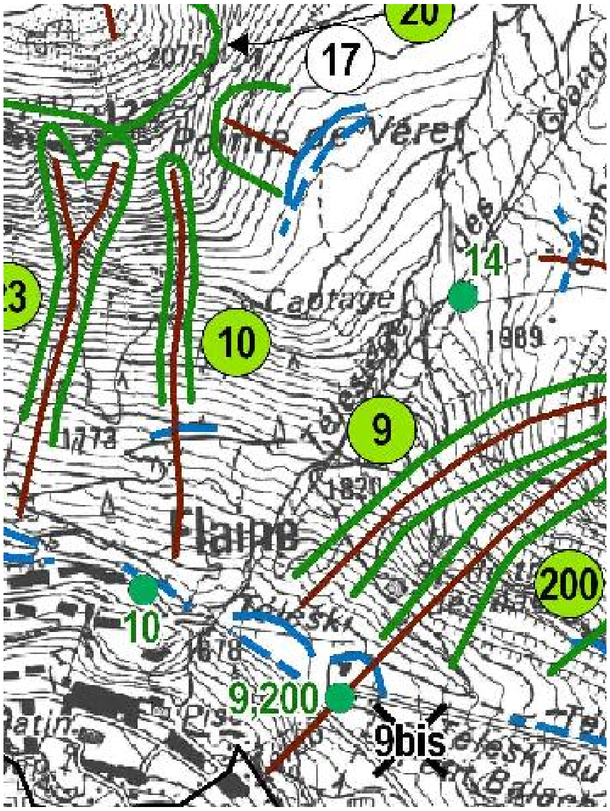


Figure 8: E.P.A. map (detail) – E.P.A. sites at Flaine ski resort in the town of Arâches-la-Frasse, France

4.3. <u>Totals after renovation</u>

The goal of renovation was to reduce the huge number of sites who doesn’t produce any data and to add a few sites that present a real interest.

	Total
Avalanche paths or area (site)	3,900
Towns	465
Average of sites/town	9
ONF observers	260

5. USE

E.P.A. is used in different avalanche studies and serves to experts as a first approach of an area.

5.1. <u>C.L.P.A. users</u>

We can notice that the C.L.P.A. layer (testimonial) is present on E.P.A. maps in a magenta watermark layer. Both surveys are really close and study leaders work in common.

C.L.P.A. study leaders use E.P.A. to have a first vision of the avalanche frequency of their studying area. They can notice various expansions and have an idea of the type of avalanche that occurs. Thanks to the history of the avalanche card notebook, they can research easily documents about important periods and ask questions about a selected time period.

5.2. <u>Other uses: statistics, public information</u>

The E.P.A. report was originally devoted to the evaluation of forest damage. Nevertheless, two aspects of its observation protocol make it highly valuable for various other applications.

First, the data series, even if some of them are incomplete, are unusually long. They are now routinely used for local predetermination using physical modelling; e.g. Naaim et al. (2004), combined statistical–dynamical approaches (e.g. Ancey et al. (2004); and risk analyses; Eckert et al. (2008).

Second, the EPA database’s objective is to be as exhaustive as possible on a sample of paths situated in all the Alpine massifs rather than recording only certain avalanches on all the French paths. Even if the path selection was originally not based on scientific arguments, it gives a relatively accurate view of the spatio-temporal fluctuations of avalanche activity over the last century. Eckert et al. (2007) have highlighted coherent spatial patterns in the northern French Alps. Jomelli et al. (2007) found relations between the local probability of avalanching and weather data. Finally, Eckert et al. (2010) have highlighted large-scale temporal fluctuations possibly related to climate change.

EPA can be also used by people using the internet to search avalanche history of their town.

6. EVOLUTION

Since the end of renovation, observers have to stop to complete forestry notebook to avoid unnecessary copies and errors between avalanche cards - the only document used to register events in the database – and forestry notebooks.

All existing notebooks are now scanned, archived, and are available on the internet for history research.

6.1. Internet registration

Since 2010, observers can complete avalanche card directly on the internet. Thanks to a really intuitive interface, they can fill in avalanche cards. The information is directly scanned to find errors or incomprehensions. This allows avoiding blank or uncompleted card and permits a secured registering of correct data thanks to computer verification.

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“SAFE HAVEN” AT ROAD SIDES NEAR AVALANCHE PRONE SITES

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ABSTRACT: Snow avalanches cause threat to road traffic in mountainous areas in Iceland in wintertime. One or more vehicles are hit by avalanches every year but last year’s no fatal accidents due to snow avalanches have been reported. In case of avalanche accidents several different respond units like police, rescue group personnel and road maintenance personnel will participate in the rescue operation. A number of rescue vehicles and a base for onsite commander will need a space near the accident site during operations. Other vehicles must be able to turn safely from the accident site. A two-lane urban road can barely serve as a location for rescue operations.
This work describes how roads in mountainous areas can be improved by adding a safe area (safe haven) at the roadside where the respond units can place their bases during operations and road users can turn back from the accident site. The criteria for the location and design of the safe area is described. Safe area at road site will help all respond units to do their job during operations at accident sites.

KEYWORDS: Road traffic, avalanches, avalanche accidents, safe area.

1. INTRODUCTION

In Iceland as well as many other mountainous countries roads are threatened by snow avalanches in wintertime and every now and then vehicles are hit. According to data from Switzerland around 18% die in vehicles which are hit by avalanches (Margreth, et al., 2003). Krister Kristensen (Kristensen, et al., 2003) has suggested that 18% is too low for Norway, 40% would be closer to the reality. No research has been done in Iceland but due to many similarities in the road infrastructure the author believes Kristers number could also be applied in Iceland.

In case of an avalanche accident on a road or highway several different respond units are involved in the rescue work such as the police, the rescue groups personnel and road maintenance personnel.

Road closures due to avalanche accidents cause usually the normal road traffic to stop until the rescue operation or avalanche danger is over. Often a space limited mountain road is not wide enough to “have room for” rescue operation base or to allow long vehicles to turn. Vehicles can be stuck on the road untill it opens. In bad weather stuck vehicles can also cause drifting snow problems and they can hinder the rescuers from travelling to and from the accident site.

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2. THE AIM OF THIS WORK

The aim of this work is to present simple methods to assess avalanche danger at sites where rescue operations can be operated from as well as to introduce a layout of a safe area (“safe haven”) at road sides for the rescue operation personnel, vehicles and equipment’s. Also to give a space for vehicles so they can turn safely from the area.

3. AVALANCH HAZARD ASSESSMENT FOR ROADS

Systematic avalanche hazard assessment for Icelandic roads has not yet been made, only few and relatively small sections have been studied so far.

There are several ways to assess the avalanche danger. One simple method is to use the statistical α/β-model, originally presented by the Norwegians (Lied, et al., 1980). Later this model was adapted to Icelandic avalanches (Jóhannesson, 1998) and the author has been using that model for Icelandic roads and powerlines for several years. A part of the following text refers to two of those studies i.e. one existing road section in north Iceland (Jónsson, 2007) and one proposed road section in east Iceland (Jónsson, 2008).

The α/β-model can also be presented as α/β-diagram, see Figure 1. For each avalanche profile along the road alignment the angle from the road to the potential starting zone is measured (here called α_{road}) and the β-point is also measured at the same profile.

Even though those models are derived from so called “extreme events”, which for Icelandic conditions are only ~100 years, one can also use them as a guideline for smaller avalanches. The author has noticed from previous work for the Icelandic Road Authority and in work for different avalanche prone communities in Iceland that the runout of small avalanches, with return period from less than a year up to 10+ years, are close to the α+2σ which also happens to be very close to the β-point.

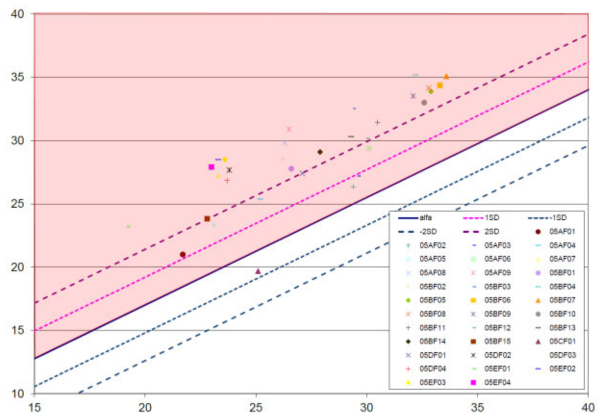

Figure 1: Icelandic α/β-diagram for a road section in Northern Iceland, see part of the road section in Figure 3. The vertical scale represents the α-value and the horizontal scale represents the β-value of the Icelandic α/β-model. The values in the diagram represent observed α-values from the road to the starting zone. All observed values below the mean α-value (the middle line) are thought to have longer return period than the mean α-value and all observed values above (in the shaded area) have shorter return period. Here most of the values are above the α+2σ line which indicates that the road can be hit by avalanches yearly. Records from this road show that the road is hit by avalanches several times pr. winter. Statistical analyze of this dataset can give an indication of the overall safety of the road. By splitting the road into sections of similar geographical or terrain conditions, see lines in
Figure 3, one can indicate the safety of each section.
This method can also be applied to transmission lines and many other linear constructions endangered by avalanches.

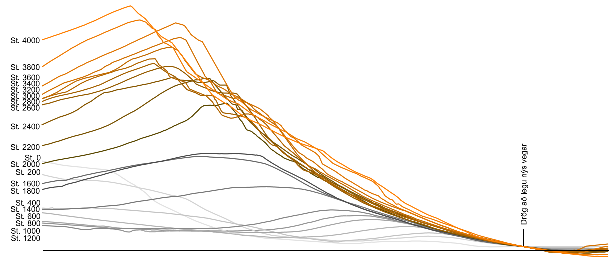

Figure 2: This figure shows cross sections to a mountainside and how they can be view a by fixing each cross section to the linear construction, in this case the road. Those cross sections are taken at 200 m interval. It can be seen how the average slope angle from the road to the top (and where the mountain is steep enough, the starting zone) increases and by measuring the angle one can have an indication of the level of avalanche danger. Station numbers are given at the left hand side of each cross section.

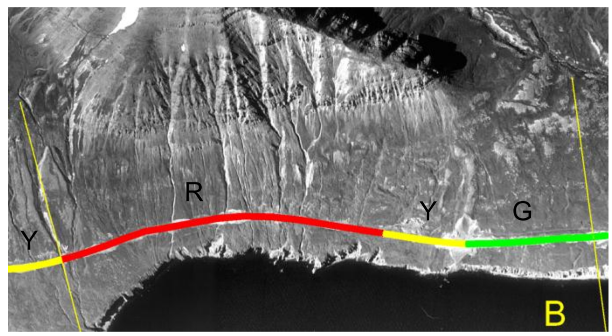

Figure 3: A road section in northern Iceland that has been divided into three levels of avalanche hazard. Lines at each end of the picture mark each section and the section shown here is B. Aerial photo: National Landsurvey of Iceland.

The above mentioned methods are simple tools which can be used to divide the road into levels of avalanche hazard which is similar to avalanche hazard zoning for villages. Below are definitions which the author has used in the mentioned work.

Safe	Moderate danger	Danger
Green (G)	Yellow (Y)	Red (R)

Green: The terrain indicates that avalanches cannot start or the frequency is very low. If green zone between two yellow zones is shorter than 100 m then the zone will be yellow.

Yellow: Avalanches are not known to reach the road. The terrain indicates that avalanches can

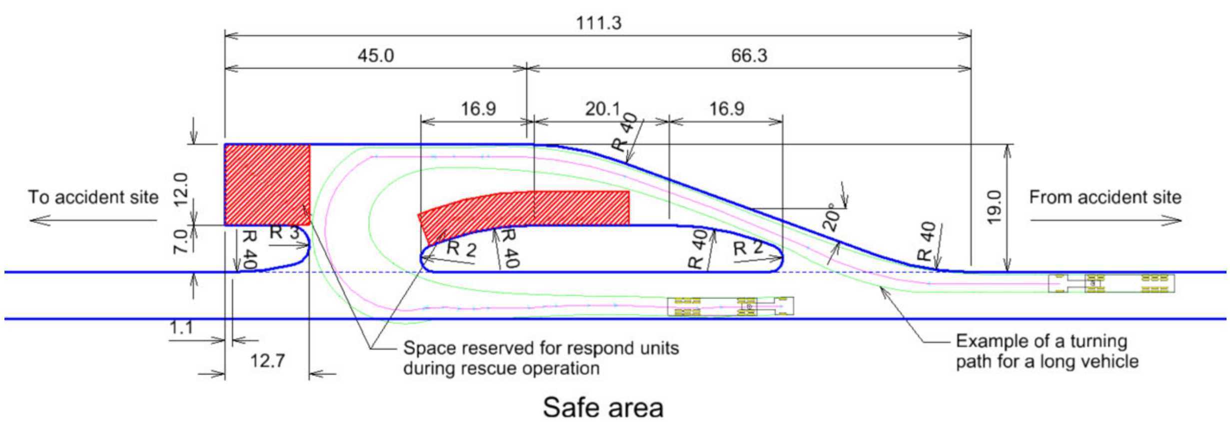

Figure 4: Principal layout of safe area.

reach the road in extreme conditions. The length of yellow zone is not shorter than 100 m. Yellow zone is always between red and green zone.

Red: Avalanches are known to hit the road and the frequency is higher than or equal to the reference frequency set by the Road Authority. If the width of a yellow area between red areas is shorter than 100 m then the area is also defined as red. The length of a red zone shall not be shorter than 50 m and it shall reach min. 50 m out of known avalanche path.

4. LOCATION OF SAFE AREAS

The location of the safe area should be on each side of an avalanche prone area so rescue personnel can advance from both sides if necessary and the road traffic from both sides can turn back safely. This is the ideal case but it is not always easy to accomplish this. In some cases the road section can have short safe areas and endangered areas for many kilometers which make it difficult to position only two safe areas for rescue operations. It is not easy to give guidelines for the number of safe areas or the location of them in such cases but their location must be related to the terrain, the road geometry and the traffic volume.

The general rule should be to build safe areas in green zones. If it is necessary to build safe area inside the yellow zone a detailed hazard evaluation should be worked out prior to rescue operations. It should also be born in mind that a safe area located in a yellow zone can be used by road travellers in wintertime when avalanche danger is persistent. Safe areas should never be built inside red zones!

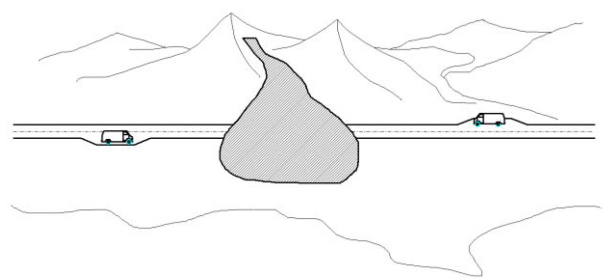

Figure 5: Principal sketch of location of safe areas on each side of avalanche area.

It is extremely important, when rescue personnel arrive at accident site, that they are aware of potential avalanche sites on the way to the accident site as well as possible avalanche danger on site.

5. DESIGN OF SAFE AREA

The design of safe area introduced here is partly based on a design of a vehicle inspection area for urban roads in Iceland (Jóhannesson,et.al., 2007). One of the main feature about the design of a safe area is that it has reserved areas for the rescue personnel and it gives drivers of long vehicles an opportunity to turn from the avalanche site instead of lineing up in long queues and wait till the closure is ended. Most avalanche prone road sections in Iceland are along low traffic urban roads where traffic volume can range from less than a hundred to several hundred vehicles pr. day.
The form of the safe area has two designated areas for rescue operation; an area of ~150 square meters located at the site facing the accident site for the onsite commander and an area for rescue vehicles and equipment in the

middle (see hatched area in Figure 4). If necessary the total length and the width of the safe area can be extended, this applies also to the area for the onsite commander. Due to the importance of being able to turn long vehicles the two areas are separated which can be a disadvantage for the safety of rescuers who have to cross the turning lane.

STANDARDS FOR SAFE AREA

Winter maintenance

The same maintenance protocol should be applied to safe areas as to the road it serves which means, if the road is cleared in wintertime the safe area has also to be cleared at the same time. One can reason that the safe area should be cleared before the road through the avalanche prone area in case something would happen to the maintenance personnel during the clearance. It should be a part of the winter maintenance protocol.

Communication

The location of safety area should take into account the quality of mobile phone connection, VHF, Tetra and/or other communication alternatives rescue personnel use. If it is not possible a thought must be given to a suitable location for beacons which is necessary for the onsite commander to communicate with rescue headquarters, hospitals or police stations.

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