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NEDIES Project

LESSONS LEARNT FROM AVALANCHE DISASTERS

Edited by Alessandro G. Colombo

1. Introduction

A first meeting on "Analysis of Catastrophic Avalanches occurred in the EU and Proposal for Concrete Measures" was held at the EC Joint Research Centre Ispra on 4 and 5 October 1999. The meeting was organised in the context of the NEDIES project conducted in the Institute for Systems, Informatics and Safety (ISIS) of the Joint Research Centre. Main aims of the meeting were:

- To have a presentation of recent avalanche disasters occurred in Europe and discuss the main lessons learnt from them;
- To produce recommendations to deal with the management of avalanche disasters.

This document gives a short presentation of the main lessons learnt from the avalanche disasters presented at the meeting. Recommendations are presented in a different document.

2. Avalanche in Austria

Hubert Vetter (Amt der Vorarlberger Landesregierung, Bregenz)

Date of the disaster and location: 22 February 1999, Gargellen (Vorarlberg).

Short description of the event: After heavy snow falls, an avalanche accident happened in Gargellen connected with other avalanche events in the mountains of Vorarlberg. This was an extreme event (return period of the order of 50 years). Two people got dead. The affected area had hard losses on the cable car system and buildings; a restaurant in the ski area was destroyed.

Prevention measures taken and lessons learnt concerned with prevention

Responsible for technical prevention and mitigation measures is the “Austrian Department for Avalanche Defence”. For many years this department has been planning and building up avalanche defence structures all over the alpine countries. Furthermore, the department supports many temporary measures at the local and regional level. This line of activities must go on and be supported stronger.

Lessons learnt

- Although forecasts were issued for 2-3 metres of snow, people ignored the warnings believing that the extreme values predicted were improbable. Then, people were not ready for evacuation.
- Hazard zoning was inefficient: destroyed houses were within green zones. Zoning procedure has to be reviewed. The roads established by the local avalanche committees were not safe.

Preparedness situation and lessons learnt concerned with preparedness

The base of preparedness is the Austrian system of disaster response with the volunteer fire and rescue services. Nearly in every village there are good trained and equipped stations of Fire Brigade, Red Cross and Mountain Rescue. In case streets are blocked by snow and avalanches (or other disasters) the first response starts from these stations and initial measures are setting out.

Lessons learnt

- The training of volunteers, financing of the fire and rescue services and updating of equipment must be maintained. These measures could be an example for other European countries.

Response actions taken and lessons learnt concerned with response

In the case of this avalanche disaster the field activities were coordinated by the responsible of the village of Gargellen and the Fire and Rescue Services of the Montafon valley. The field activities were supported by the Austrian Gendarmerie, the Austrian Army, helicopters from Swiss and German Army and a staff from the ski area. The measures have been set according to the regional law “Katastrophenhilfegesetz Vorarlberg”.

Lessons learnt

- Volunteers constitute a successful basis for first response measures in alpine areas.
- Roads were blocked and helicopters could only had been used one hour per day, due to bad weather conditions.
- Volunteers (fire fighters, mountain rescue teams) contributed satisfactorily to the rescue actions taken in each village.

Information to the public (prior to the event, during the event and after the event) and related lessons learnt

The public was informed by federal and local radio, television and directly by the municipality. Coordination and further information was given by the Regional Alarm Centre. After the event, a document was produced jointly by the Department of Tourism (Informationsnetzwerk Elementarereignisse) and the Regional Alarm Centre.

Lessons learnt

- The major problem identified was informing the public (especially tourists).
- Information flow and relations were good with the local press. However, these means were not so good with the international press.

Other lessons learnt

- Consequences were not only local but also more global because of the tourist industry.

3. Avalanche in Switzerland

Walter Ammann (Swiss Federal Institute
for Snow and Avalanche Research (SLF), Davos)

Date of the disaster and location: February 1999, the whole Northern part of the Swiss Alps.

Short description of the event: Disasters occurred in three periods during February 1999, due to massive snowfall and subsequent avalanches. More than one thousand avalanches damaged people, settlements, property, forest, road and rail infrastructures. This was an extreme event (return period of the order of 50 years). Direct damage: 17 deaths and 450 million Swiss francs. Indirect damage: 7 deaths, more than 160 million Swiss francs. 27,000 people were evacuated. Some regional and international high voltage lines were damaged. 1400 hectares of forests were damaged and problems with flooding were encountered later in May and June due to heavy rainfalls combined with snow melt run-off. About 100 million Swiss francs were due to exceeding snow loads and snow gliding.

Prevention measures taken and lessons learnt concerned with prevention

In general, given the limited number of deaths and property loss, the measures taken to protect cities, villages and settlements proved to be very efficient, despite the increased number of inhabitants, tourists, houses and infrastructures in the Swiss Alps. On the other hand, the remaining risk on roads and railways has been growing due to the enormous increase in mobility of the society.

Prevention measures established in Switzerland during the last 50 years (the last extreme avalanche winter occurred in 1950/51) concern:

- Organisational measures (avalanche forecasting, evacuations, road and rail closings, emergency measures)
- Avalanche hazard mapping, land-use planning
- Technical measures
- Silvicultural measures to protect forests.

Organisational measures at the national level include an early warning message to cantonal/regional and local crisis management teams (3 days in front of potential heavy snow falls and corresponding extreme avalanche hazard), a daily avalanche hazard forecasting (daily at 5 p.m. for the following day with adjustments if necessary at 7 a.m.) and telephone consulting by SLF experts. The SLF provides some specific regions also with a daily regional avalanche hazard bulletin at 7 a.m. The crisis management teams in the

cantons/regions and in the communities are responsible for taking the necessary measures: local avalanche warning, evacuations, road and rail closing.

Avalanche hazard mapping plays an important role for land-use planning. Switzerland distinguishes 4 different zones: red (prohibited area for constructions), blue (limited possibilities for constructions, if reinforced), yellow (powder snow avalanches), white (no limitations). The zones are differentiated according to return periods (30 to 300 years) and pressure (30 kN/m²). Avalanche hazard mapping proved very efficient mainly to prevent property loss.

Technical measures consist in avalanche defence structures (mainly steel bridges and wire nets), avalanche deflecting and catching dams, protection sheds for roads and railways. These long-term permanent protection measures proved to be very efficient. Up to 500 damaging avalanches have been prevented. Few avalanche defence structures have been damaged.

The protection forests played an important role too. Only a few avalanches had their starting zone within a forested area.

Lessons learnt

Organisational measures:

- Early warning, national and regional avalanche bulletins, information on actual snow and weather situation were very useful in the decision making process.
- The existent Swiss network of automatic snow and weather stations has to be completed.
- The precision in time and space of the avalanche bulletins can be improved with additional regional bulletins.
- Regional/local snow and avalanche experts have to be formed to support the SLF Davos and the local decision-makers.

Avalanche hazard mapping:

- Only half of the avalanche prone municipalities in Switzerland have legalised avalanche hazard zones. The incorporation of hazard mapping in land-use planning procedure has to be accelerated.
- Only about 40 avalanches have over passed the existing hazard zones, mainly due to powder snow avalanches.
- The fracture height in the avalanche-starting zone exceeded often by far the basic assumptions of the mapping procedure. Nevertheless, the run-out distances remained within the limits. The reasons are not clearly understood.
- The avalanche dynamics play an important role in the mapping procedure. Numerical models and tools have to be improved, especially for powder snow avalanches and for combined dense flow/powder snow avalanches.

Technical measures:

- Damage to avalanche defence structures has been modest.
- The limits of the technical measures have been visible.
- Avalanche deflecting and catching dams should probably be designed for more than only two avalanche events.
- Maintenance strategies for the avalanche defence structures become an important issue in the next decade.

- The large investment of over 1.6 billion Swiss francs should show consequences in redimensioning hazard zones. Procedures to evaluate remaining risk have to be established.

Silvicultural measures

- Only a limited number of avalanches occurred beyond the timber line. It is not clear how far the favourable snow cover conditions or the forests were responsible for this fact.
- The effect of silvicultural measures on the protection function of the forests has to be clarified.

Preparedness situation and lessons learnt concerned with preparedness

Most Swiss alpine cantons/regions have defined crisis management teams. The emergency plans in operation for these cantons/region and communities played an important role during the intervention phase.

Lessons learnt

- Each canton with potential avalanche problems should have a crisis management team.

Response actions taken and lessons learnt concerned with response

Main response actions taken include the temporarily closing of roads and railways, the evacuation of people in avalanche-prone settlements, the evacuation (by helicopter) of tourists with closed access roads, the emergency relief and rescue for people trapped in avalanches. The responsables during this phase are the cantonal and communal crisis management teams supported by the fire-fighting service, civil protection and voluntary organisations like Swiss Alpine Club, etc.. The Swiss army can be asked to support the cantons.

Lessons learnt

- Decision making tools for the evacuation and closing/opening process have to be improved.
- Information and coordination among the parties involved have to be improved.
- Training has been improved.

Information to the public (prior to the event, during the event and after the event) and related lessons learnt

Prior to the event. Information released to the public prior to the event was based on the meteorological forecasting and the national avalanche bulletin, which contains also an estimation of the avalanche situation for the next two days.

During the event. Daily avalanche bulletins were diffused (17.00 p.m. nation wide, 8.00 a.m. regional and additional national bulletins if necessary). Public was informed by radio, television, telephone (public number 187), Internet (www.slf.ch), fax-polling service for the bulletin (0900 59 20 21), messages to the SLF (0800 800 187) and newspapers.

After the event. Avalanches bulletins showing decrease of avalanche hazard were diffused.

Lessons learnt

- Means to inform the public have to be improved. An information and communication system has to be established at a local, cantonal/regional, national and, especially, international level.
- An efficient information policy is requested, especially for touristic areas.

Other lessons learnt

- In Switzerland, the cantons are responsible for the management of natural hazard crisis. Based on the existent laws, the Swiss Federal government provides the cantons with financial support for technical measures, hazard mapping, silvicultural measures and for the installation of a network of automatic snow and weather stations. However, the Swiss Federal government does not cover the service and maintenance of these stations as well as the support of decentralised avalanche forecasting experts. Legal adjustments have to be implemented.

4. Avalanche in France

René Feunteun (*Ministère de l'Interieur, Direction de la Défense et de la Sécurité Civiles, Paris*)

Gérard Brugnot (*Cesmagref, Grenoble*)

Date of the disaster and location: 9 February 1999, Peclerey, Chamonix.

Short description of the event: February 1999 was in the Alps a month of exceptional meteorological conditions, with very heavy snowfalls. Peclerey avalanche took place on February 9, 1999. The avalanche originated at approximately 2400 m a.s.l. below the Lachat crest (Bec de Lachat). It seems to have been a "mixed type" avalanche, i.e. consisting in a powder snow flow closely followed by a dense snow flow that wrought most of the damages due to its high energy. The avalanche resulted in 12 fatalities plus 20 chalets damaged, among those 14 with irrecoverable damages.

Prevention measures taken and lessons learnt concerned with prevention

Prevention consists in a long term planning, which needs actions at national and local level.

This global approach must be translated especially throughout:

- "plans de prévention des risques" (hazard prevention plans)
- avalanche defence structures (revised when necessary)
- building prescriptions.

Lessons learnt

- Existing hazard mapping covered a large part of the area concerned by the avalanche. However, the mapping must be regularly revised, taking into account the evolution of the situation.

Preparedness situation and lessons learnt concerned with preparedness

The mayor is responsible for the rescue organisation. According to the severity of the accident, he might ask for help to the prefect who manages rescue plans.

Rescue teams are based on local firemen, "gendarmerie" and other volunteer organisations.

Lessons learnt

- The Peclerey avalanche was a local accident. Rescue teams organised their interventions without particular difficulties. The avalanche concerned a built area; nevertheless, the avalanche problematic implicated others zones, including skiing areas.
- Preparedness must consist in a pack of several measures in order to give the right response as quickly as possible.
- One question to be clarified is the responsibility of the various organisations involved in the whole chain prevention - preparedness - warning and rescue.

Response actions taken and lessons learnt concerned with response

Although this accident was unexpected and involved a relatively large zone, the notice of the event was received very quickly and the rescue operations started quite immediately. The rescue teams had to simultaneously work on detecting buried persons and digging out remnants of chalets where victims were trapped. The accident zone was immediately declared improper for setting up inhabited buildings through a local modification of the «Plan d'Occupation des Sols», the basic French zoning document.

Lessons learnt

- Natural hazard zoning is being reconsidered in the accident area and more conservative measures will probably be decided.
- The government local attorney has initiated a preliminary inquire. It will involve special procedures that are wrapped into a relative secrecy and interfere with the technical post event analysis procedures.

Information to the public (prior to the event, during the event and after the event) and related lessons learnt

This matter is particularly difficult.

Prior to the event. Every day Meteo France releases a weather forecast about snow precipitation and avalanche risk at European scale that introduces, by the fact, early warning. More globally, before winter season, information about natural risk in mountains is made available to the public

During the event. No special action was carried out during the event. In fact, the event evolves quickly. Some road sections are equipped with detection and warning systems. In the case of a danger, traffic lights stop the traffic.

After the event. Information about the rescue conditions and precautions to be taken according to the weather situation is given.

Lessons learnt

- A main difficulty is due to the complex relation between weather forecast, early warning and physical danger consciousness.
- Another difficulty is due to the fact that the prevision must be very local and the warning very general.

Other lessons learnt

- Indemnification of victims. According to a French law dating back to 1982 and

providing quite automatic indemnification in case of natural hazard related destruction, insurance will cover all costs related to material damages. There is a possibility for building rights to be transferred to other locations so that some owners might be able to «rebuild» their chalet. As this is not a classical procedure it is now being studied and might bring out interesting results for similar cases.

5. Avalanche in Italy

Massimiliano Barbolini (*Dipartimento di Ingegneria Idraulica e Ambientale, Università di Pavia*)

Date of the disaster and location: 23 February 1999, Morgex (Valle d'Aosta).

Short description of the event: On the early morning of 23 February 1999, a huge avalanche released from the upper basin of the “Lavancher” area. The released snow volume was about 500.000 m³ with an average release depth of about one metre. The avalanche developed a “mixed” type of motion: the dense part spread out on the alluvial fan, which represents the usual run out zone for this type of events, whereas the powder part, after going out from the channel, deviated from the dense core and travelled on the village of “Dailley” causing great damages to the buildings and one fatality. Deflection of mountain slopes caused the avalanche to attack houses.

Prevention measures taken and lessons learnt concerned with prevention

Although the village of Dailley is often affected by the powder part of avalanches (as in the recent winters 1993 and 1995), in the past this component never produced such kind of destruction. Avalanche hazard zoning was not available for the area concerned, and no restrictions were applied to either the location or design of new buildings. In fact, the more damaged buildings were all relatively recent built up construction, and the oldest part of the village has undergone only minor damage.

Lessons learnt

- Victims and injuries could have been avoided, or at least reduced: (i) with a more suitable location and/or a better method of construction of houses, (ii) by in time evacuation.
- A hazard mapping of the area has been produced subsequently to the disaster.
- Supporting structures to reduce the size of the potential avalanches have been planned in the release zone.

Preparedness situation and lessons learnt concerned with preparedness

In general avalanche danger situation was quite well forecasted by the local avalanche office, and “ordinary” security measures were adopted in time through road closure before the avalanche release. There was a good knowledge of the avalanche, but a

substantial lack of systematic defence strategies against the “extreme” event.

Lessons learnt

- A local commission for danger evaluation should be created specifically for this avalanche site.
- Short-term forecast for effective warnings and evacuation plans should be improved; with this respect the installation of meteorological stations in the release zone has been considered.

Response actions taken and lessons learnt concerned with response

Although the accident was totally unexpected, the notice of the event was received very quickly and the rescue operation started quite immediately. The village of Dailley was evacuated for few days. The field activities were coordinated by the Fire Service and the Alpine Rescue Service of the Valle d’Aosta Region. Volunteers contributed satisfactorily to the rescue operations.

Information to the public (prior to the event, during the event and after the event) and related lessons learnt

There was no information to the public, except from the regional and national bulletin for avalanche danger, based on the international avalanche danger scale. The problem was that the actual danger level for the inhabitants of the Dailley village was underestimated. For the future a specific local commission for danger evaluation has been set up, which should provide continuous information on the avalanche situation to the public and decide about eventual evacuation of the houses under risk.

Other lessons learnt

- Hazard mapping is a crucial tool for a proper evaluation of the risk in the areas threatened by avalanches, accounting also for extreme occurrences.
- Substantial uncertainties affect the current avalanche maps. With this respect, the estimates of the release conditions for long return period avalanches should be improved. Furthermore, uncertainties should be quantified to properly account for the low accuracy of model results and properly evaluate residual risk.
- Aspects of the actual computational models that should be improved include flow regime transitions and mass exchange in dense avalanches, mixed-type of avalanches and interaction of avalanches with obstacles. Different modelling tools should be combined to increase the reliability of results.

6. Avalanches in Iceland

Olafur Helgi Kjartansson (The District Commissioner of Isafjörður)

Magnus Mar Magnusson (Icelandic Metereological Office, Reykjavik)

Two avalanches that occurred in Iceland were discussed at the meeting. A brief description of both is reported in the following.

Avalanche 1. Date of the disaster and location: 16 January 1995, Sudavik (West Fjords).

Short description of the event: On 16 January 1995, at 6.25, an avalanche fell on the fishing village of Sudavik in the West Fjords of Iceland (estimated 80,000 tons of snow, 200,000 m³), starting at 600 m a.s.l., running 1250 m horizontally and stopping at 10 m a.s.l.. On the 1st of December 1994, the inhabitants of the village were 227. The avalanche hit 25 houses; 63 people were in the houses of which 14 died, 10 people were injured and many more sought psychiatric assistance; 128 people were evacuated, 51 people were left homeless. The cause of the avalanche was a winter storm with an unusual wind direction and great accumulation of snow. The main rescue operations began approximately 3 hours after the incident when rescue workers from the nearby town of Isafjordur arrived by sea, as the road to Sudavik was blocked by heavy snows and avalanches and by the severity of the weather. Additional teams from the capital and other areas arrived the next day by coast guard ships. The last one alive was found 23 hours after the accident, last victim was found 36 hours after the accident. Damage incurred 2.2 million Euro, as it was paid out by the Icelandic Emergency Insurance; subsequent cost was much higher. Another avalanche fell at 20.00 the same day destroying 3 houses and damaging the electrical facilities of Sudavik.

Avalanche 2. Date of the disaster and location: 26 October 1995, Flateyri (West Fjords).

Short description of the event: On 26 October 1995, at 3.55 an avalanche hit the fishing village of Flateyri in the West Fjords of Iceland (estimated 170,000 tons of snow, 400,000 m³), starting at 620 m a.s.l., running 1850 m horizontally and stopping at 3 m a.s.l.. The weather conditions were unusual: extreme cold air masses over Greenland and an Indian summer on the continent of Europe. This resulted in an enormous accumulation of snow that provoked the avalanche. Urbanisation played a significant role for the extension of the damage. The avalanche hit 32 houses, 54 people were in the houses among which there were 20 fatalities, 5 injuries and 75 persons lost their home. After the event, a number of people were relocated in the village and some left Flateyri to live elsewhere. The material losses have not been estimated in full; the main damage was to houses, estimated in 3.3 million Euro and paid out by the Icelandic Emergency Insurance. There were damages to the electrical supply system as well as a considerable loss in cultural heritage as the municipal museum with all its inventory vanished.

Prevention measures taken and lessons learnt concerned with prevention

Prevention measures in effect at the time of the accidents. The preventive measures settled were inadequate. Warning was issued in time but the danger was vastly underestimated.

Subsequent preventive measure taken:

- More staff involved with avalanches (on 1 January 1995, 2 people were working in the field of avalanches with an annual budget of 140,000 Euro; on 1 January 1996, 8 full staff plus technical and part time people with a budget of 1,400,000 Euro).
- Responsibilities were simplified and clarified (one ministry instead of three). The responsibility to order evacuation was given to a centralised office (Icelandic Meteorological Office - IMO).
- Total redefinition of the hazard zoning, to be performed under the direction of IMO and reviewed by lawyers.
- A more intense monitoring system of avalanche danger has been established.

- Acceptable risk level defined as 0.2×10^{-4} . A 10 to 20 year programme has been initiated to build up avalanche defence structure so that risk is under the defined acceptable level. Where defence structures are not viable, other precautions such as relocations will be adopted.
- Evacuation zones were established for all villages.
- The village of Sudavik was relocated.
- Deflecting walls have been built at Flateyri.

Preparedness situation and lessons learnt concerned with preparedness

Preparedness measures prior the accidents. Warnings were issued but not forceful enough. People did not realise just how big the avalanches would have been. Evacuation was in effect in both disasters, but evidently insufficient. Lack of preparedness of the local population, lack of rescue equipment, no avalanche probes nor avalanche beacons, thus only a limited number of rescuers were allowed on site. The chief of police and the Civil Defence had learned a lot and gained valuable experience in the accident of Sudavik, which benefited the preparedness in the Flateyri disaster.

Subsequent preparedness measures taken:

- The snow observer network was improved (now, each village has at least one observer, better equipment, more and better training, greater responsibility).
- Evacuation maps were compiled and evacuation zones predetermined.
- It was decided that town and village evacuation orders should be issued by IMO in collaboration with the local Civil Defence Committees. In rural areas, the evacuation is the responsibility of the local chief of policy.
- The emergency medical field equipment was improved.
- Rescue equipment was built up.
- Lines of command were strengthened and made clearer. The division of duties was made clearer as well.

Response actions taken and lessons learnt concerned with response

Sudavik. Rescue work was governed by the chief of police who took over the Civil Defence operation quarters in Isafjordur. It was extremely difficult to get outside rescuers in. Although a decision was made to evacuate completely the village and move the population to Isafjordur, there were no formal plans for doing so. The accident occurred at 6.25; first outside rescuers arrived from Isafjordur at 9.42, rescue force outside the district arrived the following day at 14.20.

Flateyri. All formal precautions had been made. Houses had been evacuated according to the existing hazard zones. Evacuation was completed before midnight in the evening of the 25th of October (the accident occurred at 3.55 of 26th of October). The weather conditions permitted an easier access for outside rescuers compared to the situation occurred in Sudavik. The first outside rescue team reached Flateyri by boat, around 9.30, through a tunnel under construction.

Rescue force from outside the district started arriving at 13.10, by helicopters. Three Coast Guard ships arrived in the period 19.30 to 21.05.

24 inhabitants left with a Coast Guard ship that evening, 2 children had left earlier with a helicopter.

Information to the public (prior to the event, during the event and after the event)

and related lessons learnt

Prior to the event. In this small village there is not a specific sirens warning system. Only the inhabitants to be evacuated were informed, either by telephone or, failing that, by a visit. Every house within the evacuated area was checked.

During the event. The event itself, i.e. the avalanche, lasted for only a few minutes and therefore there was no information to the public during the event. However, immediately after the event, media gave all the available information through press releases by Civil Defence.

After the event. People concerned were informed by public meetings and instruction booklets.

Lessons learnt

- It is crucial to make known the names of deceased with the utmost caution, and ensure that the relatives are informed before the media.

7. Some Considerations

Alessandro G. Colombo (EC, DG JRC, ISIS)

A lot of lessons have been learnt from the six avalanche disasters presented at the meeting. It has to be noticed that, as in the case of other disasters that have occurred in the past, "at posterior" the majority of the heavy situations that happened seem avoidable or, at least, manageable without big losses. In fact, disasters, in particular due to avalanches, occur with an increasing frequency. Nevertheless, people and authorities involved are often not well prepared to face such type of natural event, although foreseen, thus this may become a disaster.

A common lesson learnt is that the responsibility of the various organisations involved in the whole chain: prevention, preparedness and response must be clarified. Personnel called to operate in the disaster area have to be periodically trained. Monitoring of the risk zones is often insufficient.

Specific lessons learnt concerned with prevention include the following:

- people ignored the warnings believing that the (extreme) prediction was improbable;
- hazard mapping either was not available or not updated, consequently risk was underestimated;
- evacuation plan was not available and/or evacuation started with delay;
- building codes were not established with reference to avalanches.

Lessons learnt concerned with preparedness:

- each zone with potential avalanche problems should have a "crisis management team".
- the rescue equipment is often insufficient.

Lessons learnt concerned with response:

- coordination of the different rescue teams is essential;

- Volunteers are often the basis of success of the first response measures.

Concerning information to the public, a very general difficulty is due to the fact that the prevision must be very local and the warning very general. In the tourist areas, it must be taken into account that the implications of an avalanche are not only local, they also involve the tourism industry.

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