A RULE BASED RISK MANAGEMENT SYSTEM BASED ON MAPS AND DANGER LEVEL

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ABSTRACT: After a tragic accident where 16 soldiers were killed in an avalanche during a military exercise in 1986, the Norwegian Armed Forces took several steps to ensure the safety of soldiers. The result is a risk management system that relies on avalanche maps and an avalanche bulletin. Avalanche maps show potential avalanche release areas (Zone 1) and potential run-out areas (Zone 2). During military exercises an avalanche bulletin is produced every day by an experienced avalanche group. Restrictions in areas available for ground maneuvering are imposed by using military regulations for each of the danger levels in the European avalanche danger scale. The result is a risk management system that is in wide use in the Norwegian Armed Forces.

1. INTRODUCTION

The Norwegian Armed Forces (NOAF) conducts exercises in mountainous terrain during winter, exposing soldiers to avalanche risk. During exercises the soldiers are working, and they are therefore required to have a low risk acceptance. This setting is distinctly different from a recreational ski trip in avalanche terrain where there is no official requirements for a low risk acceptance.

In 1986 during a military exercise in Northern Norway 16 soldiers lost their lives in an avalanche. After that, severe steps were taken to ensure the safety of soldiers. Among these was the development of avalanche maps for use by military personnel. The maps are used together with avalanche forecasts and used as a tool to control the risk military personnel will be exposed to during work. The first avalanche maps were produced by NGI for NOAF in 1987.

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Another example of an approach where terrain analysis and avalanche warnings are used together is the system used in Canada where combination of the ATES rating for travel routes (Statham et al., 2006) and the Avaluator Trip Planner (Haegeli and McCammon, 2006).

2. METHODS

2.1 Hazard maps

The maps are produced after GIS analyses and field observations and show two zones (Figure 1):

Zone 1: Avalanche starting zones. Terrain steep enough for avalanches to release. As a first approximation, these zones are defined as areas steeper than 30°. Field mapping is carried out to check the validity of this approximation, and if necessary adjust the release areas. Potential release areas in dense vegetation are not drawn on the map.

Zone 2: Avalanche run-out zones. Terrain below starting zones which may be exposed to an avalanche. The α-β model (Lied and Bakkehøi, 1980) is used heavily when evaluating the run-out distance, but other computational tools are also used with a relatively high frequency design event. During field mapping the areas are adjusted as for the release areas.

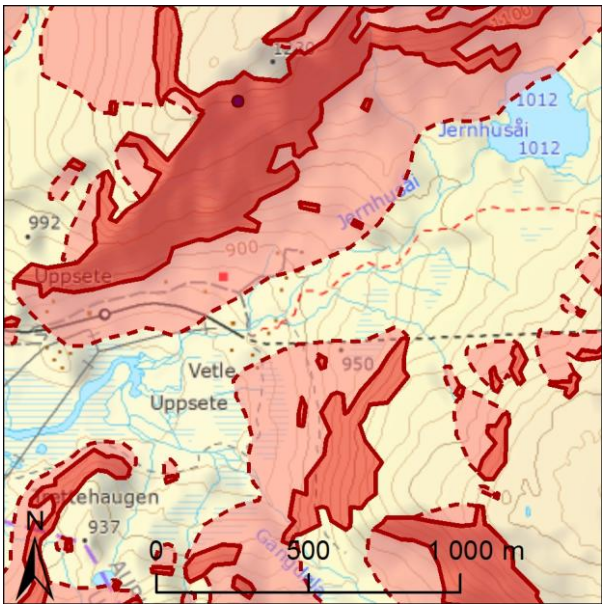

Figure 1: Example map showing Zone 1 (dark red) and Zone 2 (pale red). The small release areas on the right-hand side show that the maps are quite detailed.

Cartographically, the zones are projected on top of the standard 1:50.000 maps most often used for backcountry travel. Additional information is printed on the back of the maps. The zones can also be acquired digitally from a WMS server, allowing people to use the zones with a background map of their own choice.

2.2 Restrictions on ground movement

Restrictions in areas available for ground maneuvering are imposed by combining Zone 1 and Zone 2 and the avalanche danger level. The European danger scale is used with the descriptors “Snowpack stability” and “Avalanche triggering probability”, with military regulations added (Table 1). For example, at danger level 4-High during an exercise, military personnel are not allowed to enter Zone 1 and Zone 2.

2.3 Avalanche bulletin

During exercises the danger level is issued by a military avalanche group. The group consists of 5-10 experienced avalanche forecasters working in the field usually in teams of two. During most of the day the groups are outside travelling in the back-country. Helicopter is also occasionally used to cover large areas. After fieldwork the group meets to present the observations, discuss and finally decide on the danger level. A bulletin is issued for the following 24 hours. The bulletin is distributed through normal military communication channels.

3. RESULTS

Military personnel have maps with the avalanche zones and every day during an exercise they get an avalanche bulletin. The routes must be planned according to the additional military regulations for the danger level issued by the avalanche bulletin.

The combination of avalanche maps and danger level provides the NOAF with a rule based risk management tool at the level of the individual soldier. The group issuing the avalanche bulletins use a knowledge based approach to the construct the avalanche bulletin.

Table 1: Military regulations for the danger levels

Danger level	**Military regulation**
5 Very high	Movement in zone 1 and 2 is not allowed. Avalanches may have longer run-outs than marked on the avalanche map
4 High	Movement in zone 1 and 2 is not allowed.
3 Considerable	Movement in zone 1 is not allowed. Movement in zone 2 is allowed but only far out in the run out zone. Long stop or bivouacking is not allowed.
2 Moderate	Movement in zone 1 is not allowed. Movement in zone 2 is allowed but bivouacking or long stops should be done further out than half of zone 2.
1 Low	Movement in zone 1 is not recommended, zone 2 considered to be safe.

4. DISCUSSION

A number of potential problems exist with the avalanche maps. For example, contour lines with 20 m equidistance were used to construct many of the maps that exist. This means that smaller areas where avalanches may release might not be on the map as Zone 1 unless very detailed fieldwork was carried out. There has been a number of fatalities in small-scale terrain above small streams, so this is a real issue.

The system is unique as it takes into account the avalanche run-out zones and not only the steepness of the terrain. This limits available terrain, but takes the decisions away from individuals.

5. CONCLUSION

The described risk management works well for the NOAF but might also be used other places where risk acceptance is low.

6. REFERENCES

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