

## RESULTS OF A SURVEY AMONGST AVALANCHE PROFESSIONALS ON PREVENTIVE AVALANCHE CONTROL

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**ABSTRACT:** With the aim to improve our understanding of decision making processes amongst avalanche professionals in relation to preventive avalanche control, we invited English and German speaking professionals to participate in a survey. In total, 279 participants consisting of 126 English and 153 German-speaking professionals responded to the survey. Our analysis reveals that for English and German-speaking respondents the most important criterion of avalanche control measures is the 'Safety during the operational use'. The most important factors to consider for decision making related to avalanche control are 'Local data', 'Experience of the user', 'Visual observations' and 'Other avalanche activity in the area'. Finally, the respondents rank the 'Explosive detonation above snow (360° effect)' as the avalanche control measure affecting the largest area.

**KEYWORDS:** Preventive avalanche control, practitioner, survey, decision-making.

### 1. INTRODUCTION

Our goal is to gain a better understanding of decision making processes amongst avalanche professionals in regards of avalanche control and the practitioner's view on the effectiveness of different avalanche control measures.

With this study we intend to analyze and present the practitioners view on avalanche control measures and their effect as well as important factors to consider for avalanche control and important criteria for their operations. Practitioners deal with avalanche control measures daily and therefore represent a valuable knowledge base.

Similarities in the experiences and opinions amongst English and German-speaking respondents are discussed such as the factors playing a role in decision making whether to conduct avalanche control.

### 2. METHODS

We invited German and English-speaking avalanche professionals working in the European Alps and North America to answer a survey which consisted of 11 questions. The survey was provided in English and German language. The English and German surveys were analyzed separately.

The survey covered work experience and the type of operation, operational criteria of avalanche con-

trol measures, important criteria for their operation, factors considered for avalanche control and the effectiveness of different measures.

The respondents ranked several (operational) criteria of an avalanche control measure regarding their importance for them and their operation. Ranks ranged from 'not so important', 'more important' and 'very important' to 'extremely important'. The ranks were weighted with 1, 2, 3 and 4 respectively and multiplied with the number of answers. Criteria resulting in the most points were regarded the most important and vice versa.

The respondents also ranked the affected area and side-ways distance of avalanche control measures. Ranks for the area ranged from '1 (= smallest area)' to '6 (= largest area)'. The ranks were weighted with 1-6 respectively and multiplied with the number of answers. Selectable (side-ways) distances were 5 - 10 m, 10 - 30 m, 30 - 50 m, 50 - 80 m, 80 - 100 m, 100 - 130 m, 130 - 160 m and > 160 m. The distances were weighted with 1-8 respectively and multiplied with the number of answers. Measures resulting in the most points were regarded as affecting the largest area or widest distance.

### 3. RESULTS

#### 3.1 Survey respondents

The survey was **answered by 279 professionals** consisting of 126 English and 153 German speaking respondents. About 45% of the respondents answering the English survey followed an email invite sent to professionals in the USA and about 30% of the respondents followed an email invite sent to Canadian professionals. Over 20% of the respondents followed links posted on social media (e.g. Facebook, LinkedIn).

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Most of the respondents work at ski resorts, for highways, in the guiding business (English survey) and in operational local forecasting (German survey) (Figure 1). Two thirds of the respondents are very experienced with 10 and more years of experience in their field of work. Also, two thirds of the respondents perform avalanche control in a typical winter evenly spread from 1 to >40 days.

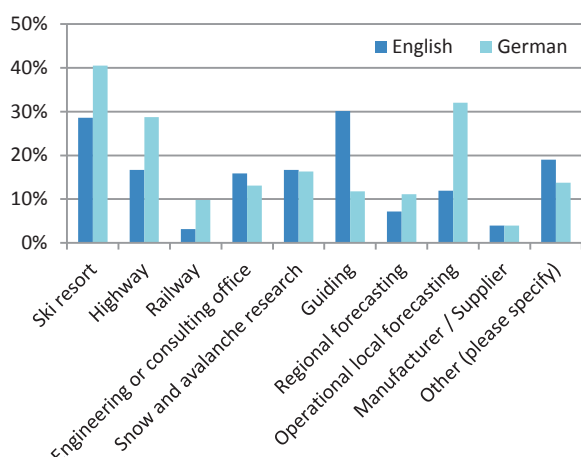


Figure 1: Operations for which the respondents work.

### 3.2 Operational criteria

'Safety during the operational use' of an avalanche control measure is the most important criteria for all respondents (Table 1). English speaking respondents rank the 'safety of workers during maintenance' next whereas German speaking respondents consider the 'ability to use the measure in any weather condition and daytime' second important.

In the English survey the amount of time it takes to perform avalanche control is more important to professionals working for highways and railways than any other professionals.

### 3.3 Criteria for the respondents' operations

The 'documentation of avalanche control missions and the consequent results', a 'specific training for the workers who perform avalanche control' as well as the 'optimization of internal running costs' are the most important criteria for the respondents' operation according to the English speaking professionals (Table 2). Professionals who answered the German survey ranked the criteria in the same order except that 'a reduced environmental impact' is considered least important.

Table 1: Operational criteria of an avalanche control measure (English survey).

Most important	Safety during operational use (e.g. are workers exposed to hazards while using the measure).
	Safety of workers during maintenance (e.g. pre-season preparation).
	The detection whether the release of an avalanche (after blasting) was successful or not?
	Ability to use in any weather condition and daytime.
	The automatic detection of misfires (= the measure did not or only partly perform as planned).
	How long it takes to perform avalanche control with the used measure.
	Notification whether the measure produced its full power or less.
Least important	

Table 2: Criteria for the respondents' operations (English survey).

Most important	The documentation of avalanche control missions and the consequent results
	Specific training for workers who perform avalanche control (e.g. an avalanche control blasting course)
	The optimization of internal running costs (e.g. helicopter and worker costs for pre-season maintenance)
	A reduced environmental impact (e.g. small concrete foundation or biodegradable materials)
	Low investment costs (e.g. construction costs of measure)
Least important	
Least important	Low running costs of consumables (e.g. explosives)

### 3.4 Factors to consider for avalanche control

All respondents see 'local data', 'experience of the user', 'visual observations' and 'other avalanche activity in the area' as the most important factors to consider for decision making regarding avalanche control (Figure 2). These four factors are followed by 'public exposure' in the English survey and 'pre-defined thresholds' in the German survey. Almost half of the German speaking respondents consider the 'regional avalanche bulletin' to be an important factor whereas not even a quarter of English speaking respondents share that opinion. In both, the English and German survey, professionals consider the same factors as important regardless of the operation for which they work.

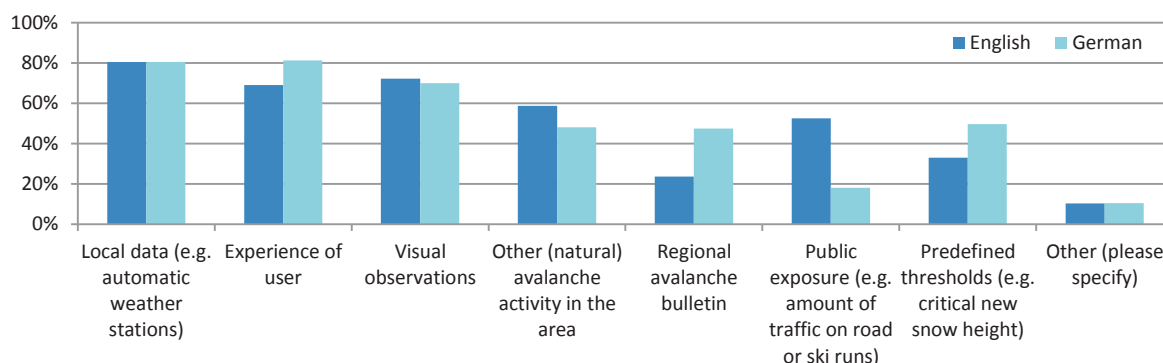


Figure 2: Most important factors to consider for avalanche control in the respondents' operations.

### 3.5 Area vs. side-ways distance affected by avalanche control measures

The survey participants were invited to rank avalanche control measures with respect to the affected area and side-ways distance by the measure. Contrasting the professionals' experience in the affected

area with the side-ways distance shows similar results in the English survey: only the 'additional large load of mass' and the 'explosives detonation at the snow surface' switch adjacent positions (Table 3). In the German survey the ranking for both, the affected area and side-ways distance, is identical (Table 4).

Table 3: Ranking of the affected area vs. the affected (side-ways) distance. A result of the English survey.

Area		Distance
Explosives detonation above snow (360° effect)	Largest/Widest ↓ Smallest	Explosives detonation above snow (360° effect)
Directed gas explosion		Directed gas explosion
Explosives detonation at snow surface		Additional large load of mass (e.g. cornice blast)
Additional large load of mass (e.g. cornice fall)		Explosives detonation at snow surface
Explosives detonation in snow		Explosives detonation in snow
Additional small load of mass (e.g. skier)		Additional small load of mass (e.g. skier)

Table 4: Ranking of the affected area vs. the affected (side-ways) distance. A result of the German survey.

Area		Distance
Explosives detonation above snow (360° effect)	Largest/Widest ↓ Smallest	Explosives detonation above snow (360° effect)
Explosives detonation at snow surface		Explosives detonation at snow surface
Directed gas explosion		Directed gas explosion
Additional large load of mass (e.g. cornice fall)		Additional large load of mass (e.g. cornice blast)
Explosives detonation in snow		Explosives detonation in snow
Additional small load of mass (e.g. skier)		Additional small load of mass (e.g. skier)

The graphs of the English survey give more insight in the answers of the respondents (see Figure 3). Most noticeable are professionals' experiences with the measures 'directed gas explosion', 'explosives detonation above snow (360° effect)' and 'explo-

sives detonation at the snow surface'. All three measures got assigned an effect on large areas and experienced a shift towards smaller distances when professionals had to assign distances in meters.

The graphical results of the German survey represent a more congruent picture, even though the high percentage of respondents (almost 50%) who assigned the 'explosives detonation above snow (360° effect)' to affect the largest area is remarkable (Figure 4, left). However, opinions differ upon how wide the affected distance is in meters (Figure 4, right).

#### 4. CONCLUSIONS

In conclusion, safety is one of the key factors avalanche professionals want from control measures. Both investment and running costs of consumables seem to be surprisingly less important for the operations compared to other factors, at least according to the survey participants. In addition, local observations and experience play a major role in deciding whether to conduct avalanche control or not. Finally, explosive detonations above the snow cover are considered to have the largest impact on the snow pack.

Our survey highlights the willingness of practitioners to share their experience and knowledge. Especially for surveys with many participants the resulting conclusions can provide very valuable information, which should not be underestimated in its quality, in addition to very specific, and often more scientific, studies.

#### ACKNOWLEDGEMENT

We thank all participants who filled out the survey and contributed to this study.

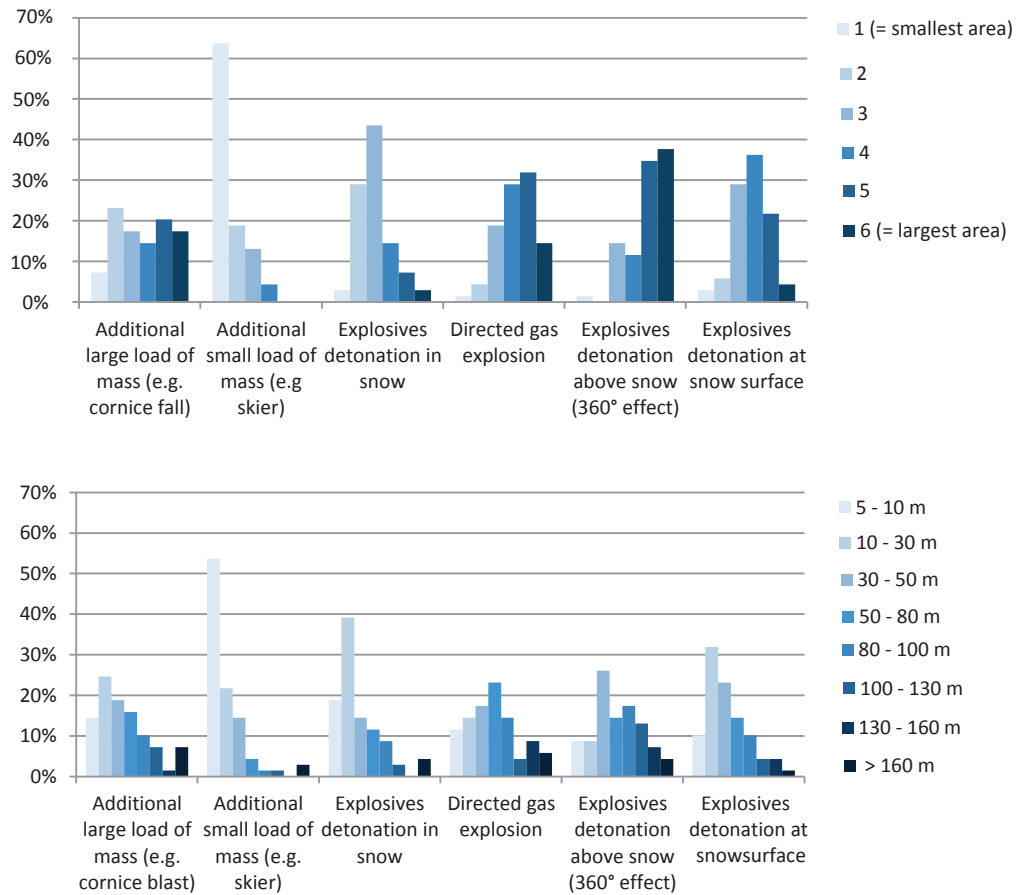


Figure 3: Affected area (left) vs. the affected (side-ways) distance (right) of avalanche control measures. A result of the English survey.

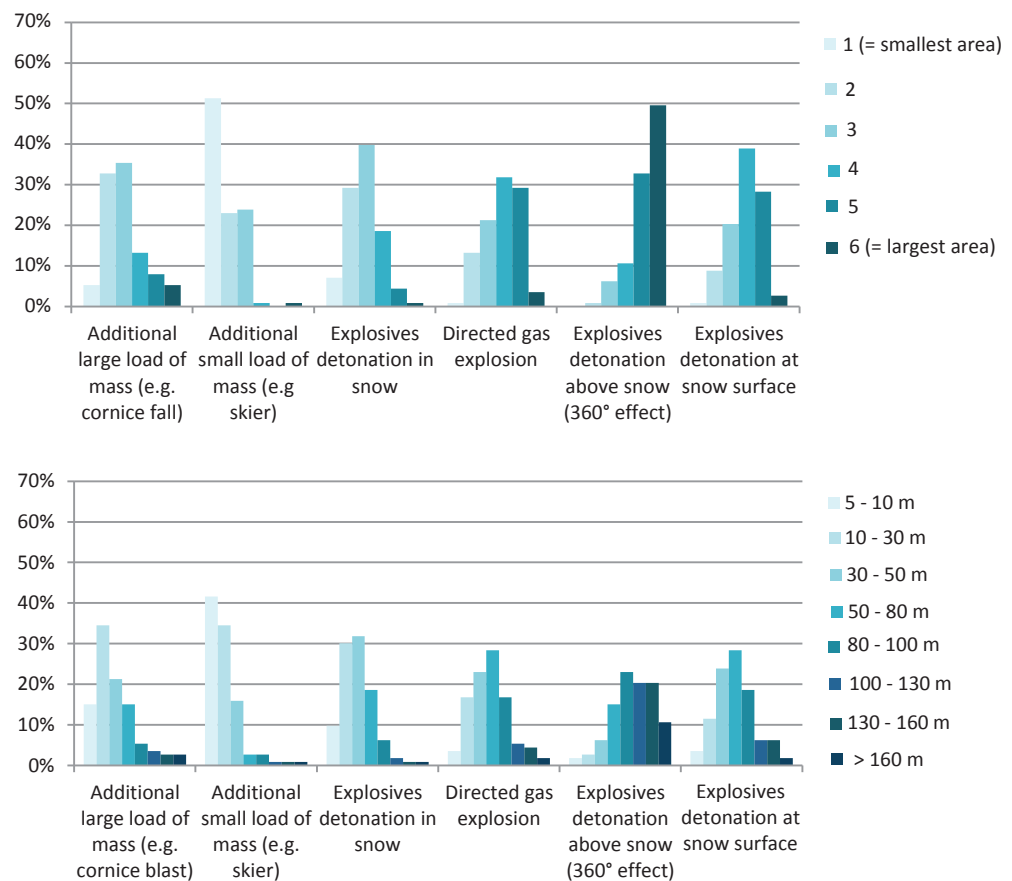


Figure 4: Affected area (left) vs. the affected (side-ways) distance (right) of avalanche control measures. A result of the German survey.