MEASURING SUCCESS RATES, REACTION TIMES AND EDUCATION OPPORTUNITIES FOR DEPLOYING AVALANCHE AIRBAGS WHILE SKIING AVALANCHE TERRAIN

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ABSTRACT: A study was conducted to observe and measure the success rates of subjects deploying an avalanche airbag while skiing steep avalanche terrain. A facilitator alerted the subject at a point mid-slope that a fictitious avalanche had occurred. The test was recorded on video so that the attempt to pull the airbag could be evaluated, and reaction times from time of avalanche alert were measured.

The goals of this study were to: 1. Evaluate a skier's ability to deploy an avalanche airbag while skiing avalanche terrain; 2. Determine if attempts to deploy the airbag result in detrimental effects to the ability of the skier to remain upright; 3. Measure the reaction time of skiers to deploy the airbag while skiing; 4. Learn from the subjects' experiences in the test and any lessons they learned.

Initial testing showed that 89 percent of the subjects were successful in deploying their airbag when alerted of an avalanche event. Mean reaction time to pulling the airbag handle from time of alert was 3.4 seconds, with a standard deviation of 1.9 seconds.

Photomontages created from the video of the testing revealed that different subjects used different techniques to deploy their airbags.

Test subjects replied to a survey and identified key lessons they gained from the experience.

KEYWORDS: avalanche airbag, avalanche safety

1. INTRODUCTION

The effectiveness of avalanche airbag deployment has typically been studied through evaluating actual avalanche involvement statistics (Brugger,et al 2007, Haegeli, Falk, et al 2014, Haegeli, Zweifel, Jarry et al 2012, Tschirky and Schweizer, 1996). Some notable studies have been conducted evaluating the effect of airbags on burial and survivability (Kern, Tschirky, and Schweizer, 2002, and Meier and Harvey, 2012) using dummies equipped with airbags. In "The Effectiveness of Avalanche Airbags," however, the authors conclude that, "Non-deployment remains the most considerable limitation to effectiveness." (Haegeli and Falk et al, 2014).

While many avalanche airbag users test their devices to verify functionality, and perhaps familiarize themselves with the apparatus, informal surveys by the author have found that few users have attempted to deploy their airbags while skiing terrain that could produce avalanches.

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The author has found that successful deployment of an avalanche airbag while skiing complex terrain is nontrivial. Success depends on quick decision making, familiarity with equipment, sound skiing skills, and a psychological commitment to the decision of employing the device.

This study aims to measure an expert skier's ability to deploy an avalanche airbag while skiing steep avalanche terrain and analyze what we can learn from their successes and failures. Reaction times from moment of alert of the simulated avalanche event to moment of deployment of the airbag were measured. Reviewing each test helped show if the attempt to deploy the airbag resulted in a subject's ability to stay upright and continue trying to ski downhill.

The study was conducted in the Snowmass Ski Area in the winter of 2021/2022 on an above treeline slope with an average slope angle of 36 degrees. Members of the Snowmass Ski Patrol were used as subjects. High resolution, medium speed (200 FPS) video was utilized to evaluate the performance of the subjects and measure reaction times.

The videos of the tests were reviewed and revealed that multiple different techniques were used by different subjects for deploying their airbag. Images were created from the videos where

overlays show the progression of each subject down the slope and how they deployed their airbag.

2. METHODOLOGY

2.1 Venue

The experiment was conducted at the Snowmass Ski Area, on the AMF ski run.

Table 1: AMF Path Details

Path Name	AMF
Environment	Alpine
Hazard Class (D Size) Potential	2.5
Starting Zone Elevation	3603m (11,820')
Path Vertical	131m (430')
Max Slope Angle	40° (entrance)
Average Slope Angle	36°
Central Aspect	NE

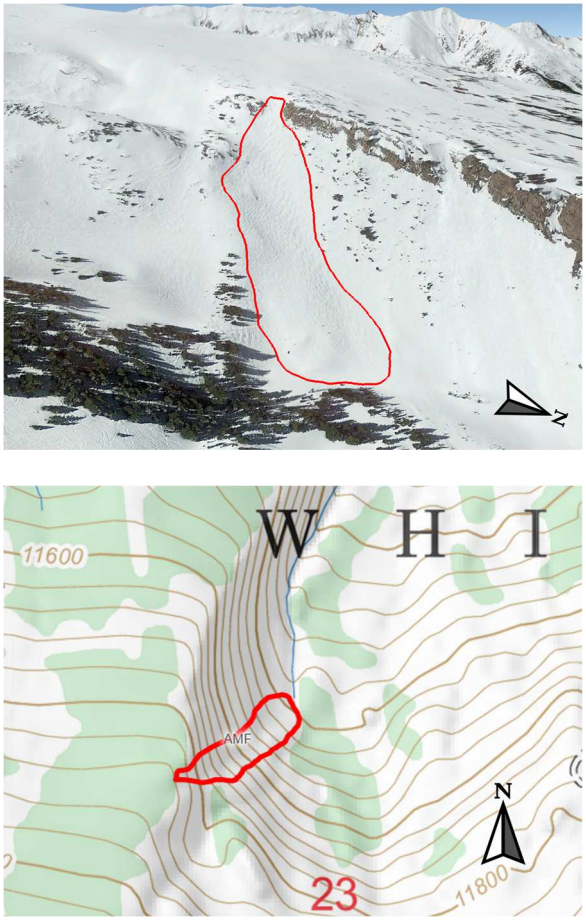


Figure 1: Experiment location

2.1 Subjects

Snowmass Ski Patrollers with a variety of number of years of experience were used as subjects for the experiment.

2.2 Procedure

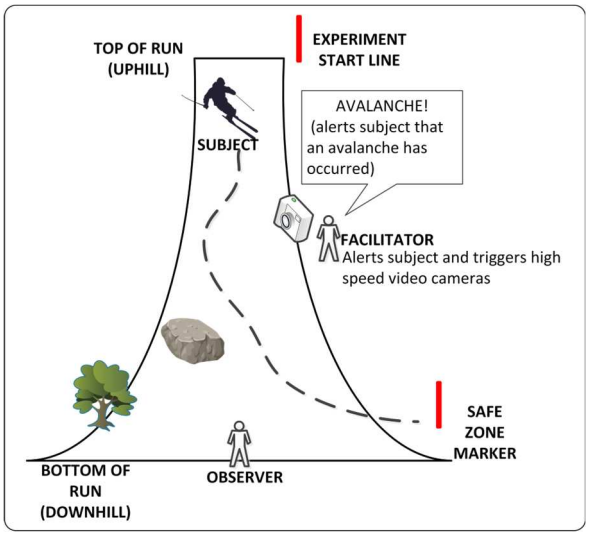


Figure 2: Experiment Overview

All test subjects were given an identical briefing before entering the experiment terrain. They were told to treat the ski run as unmitigated, backcountry terrain that had the potential to avalanche. Subjects were further instructed to ski the run without making ski cuts across the slope, but making turns down the fall line. Subjects were told that their partner had already skied the slope and was waiting for them in a safe zone.

All subjects were equipped with a Scott Patrol E1 40L airbag pack, an electric, fan-driven avalanche airbag pack. Subjects were familiar with the fit and function of this pack as it is the standard pack used daily by the Snowmass Patrol.

Testing was done on consecutive days with static weather so that snow conditions remained very consistent between subjects.

A facilitator stood mid slope with a video camera capable of 200 fps capture set on a tripod (figure 2). The facilitator would radio the subject to enter the test area and start skiing when ready. Once the subject started skiing the slope, he or she was within hearing range of the facilitator.

The facilitator randomly chose whether to alert the subject or not of a fictitious avalanche event, and yell "avalanche!" loudly to notify the subject of the event.

2.3 *Analysis Methods*

Response time from instant of alert to time of airbag deployment was calculated by analyzing the high-speed video. The audio cues on the video of the alert and the airbag activation were very clear when looking at the audio data on video editing software. With the high-resolution video, deployment time was also confirmed by enlarging the image and observing the pulling of the handle by the subject. In all cases, the images and audio data agreed for time of airbag deployment.

Photomontages were created of each subject from the high-speed video which showed the details of how each subject went about attempting to deploy the airbag.

Following the test, subjects also answered a questionnaire asking about their experience.

3. RESULTS

A total of n=19 subjects participated in the experiment.

Of the total number of participants, 17, or 89% were able to successfully deploy their airbags.

The mean response time from time of alert to time of airbag deployment was 3.4 seconds, with a standard deviation of 1.9 seconds.

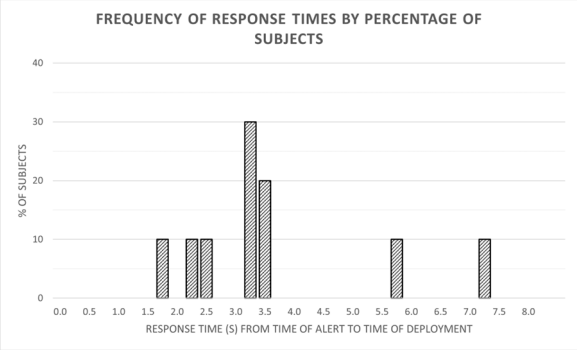
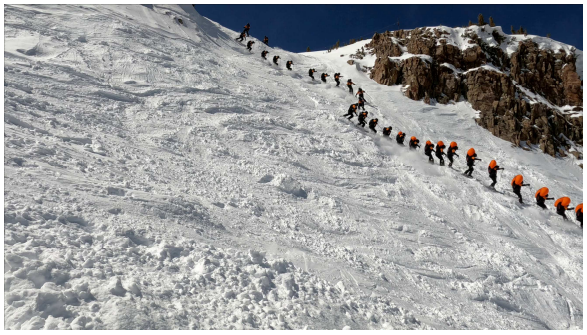


Figure 3: Frequency of response times by percentage of subjects

The videos revealed the subjects' different approaches to deploying their airbag. For example, some discarded their poles before attempting to pull the handle; most kept them, transferring the poles to one hand. Some users reached across their chest with an opposite hand to reach the handle; others used the hand on the same side of the handle (Table 2).



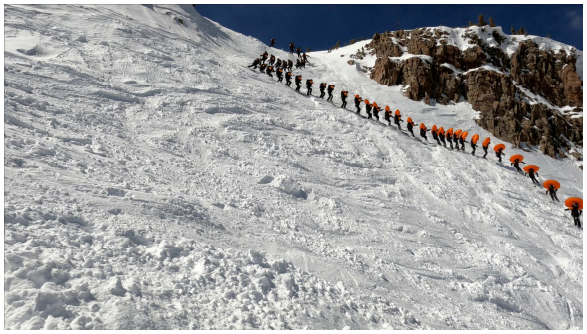


Figure 4(a)(b)(c): Overlay images of 3 different subjects

Table 2: Observed actions and success rates

	percentage of subjects
dropped poles to deploy	16
used same hand as handle to deploy	11
used opposite hand as handle to deploy	79
failed to deploy	11
stumbled while deploying	11
fell while deploying	0

3.1 Survey Results

Survey Question 1:

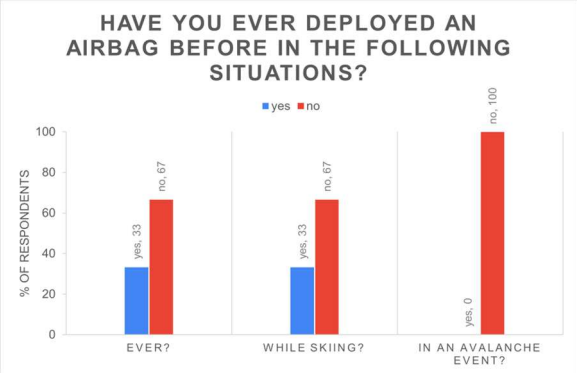


Figure 5: Airbag usage experience of survey respondents

Survey Question 2:

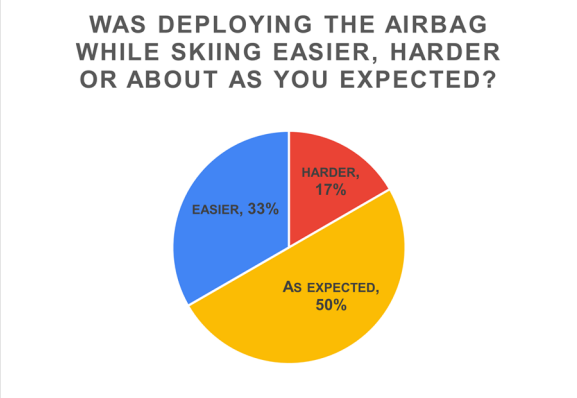


Figure 6: Expectations vs experience of deploying the airbag

Survey responses also point to the usefulness of the experience and possibility for educational experiences for all airbag users. Some questions and responses are included here.

Survey Question 3:

Did you learn anything from the experience? Anything you would do differently? Any advice for someone going into a similar scenario?

Respondent A:

“The whole experience was very educational, but I would say the most valuable thing I learned was the required amount of force to deploy the airbag. I’m not sure I would’ve done anything differently though. My advice to someone would be that you might not hear the airbag deploy so be sure to use a good amount of force pulling it, and be prepared to have your neck and head pushed slightly forward after it deploys which will affect your view while skiing.”

Respondent B:

“To familiarize yourself with the pack, and the position of the handle, adjust the handle to your reach and the best, easiest position.”

Survey Question 4:

Do you have any ideas for a different design of the airbag to improve the experience at all?

Respondent C:

“I thought it was fairly easy to find and pull the trigger. My only thought is that if you moved the trigger more along the midline of your body, you wouldn’t have to reach across your body as far. Overall, I was impressed with the ease of pulling the airbag.”

Respondent D:

"Make sure the handle is in a good spot for your reach, I believe some people just pull it out in the factory setting.”

4. DISCUSSION

This study measures the ability of expert skiers to deploy an avalanche airbag while skiing steep terrain. With a limited number of subjects, the research does not present definitive conclusions, but attempts to begin the process of observing and quantifying real world avalanche airbag usage. This work attempts to begin to address the prevalent issue of non-deployment in actual avalanche incidents.

In the accident report of an avalanche incident on 2019/01/05 in the Upper Senator Beck Basin of Colorado, investigators from the Colorado Avalanche Information Center (Greene, Davis et al, 2019) found that, "Skier 2 was wearing an airbag backpack. After the accident we determined that the system was functioning properly, the trigger out of the pack strap, but the bag was not deployed.”

Avalanche airbags have become standard equipment for professional avalanche practitioners, and are now commonly utilized by recreational users. In theory, airbag deployment while skiing should be straightforward. In reality, many factors such as the physical environment, athletic ability, psychological state, and airbag design can hinder or help the effort. Many users do not practice deployment or do not practice under realistic conditions such as while skiing or riding.

Electric powered airbag packs remove some of the difficulties associated with refilling the devices after deployment that pressurized gas units require. This could encourage users to practice more frequently in different scenarios.

There is significant opportunity for further research in evaluating usage of airbags in avalanche terrain. Deeper understanding and more data could help optimize ergonomic design, appreciate why non-deployments continue to be an issue in avalanche events, and identify educational opportunities for training users to operate the device in the most effective way possible.

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