SNOW SAFETY CONTROL OPERATIONS: AN INTERACTIVE WEB-BASED APPROACH

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ABSTRACT:

Snow safety and ski patrol at ski areas are faced with the daunting task of maintaining avalanche control routes and artillery controlled areas. In this digital age, the majority of ski areas still maintain and archive their routes, shot locations, and results on paper. Although this method of record keeping is sufficient, it does not readily lend itself to the immediate use of data for querying and identifying patterns.

Advancements in digital mapping and web-based environments, allow for an interactive application that combines the storage, input and analysis of operational data. This provides snow safety personnel the ability to data mine archived data and identify patterns in a visual environment.

From 2009 to 2012, Snowbird Ski Patrol using GPS, collected shot locations, avalanche starting zones, transitions and runout locations, along with aspect, slope and elevation of starting zones for each of its control routes. A web-based Geographic Information System (GIS) application was built using the route data combined with imagery and terrain data to create an interactive atlas of the Snowbird Snow Safety operation.

This application provides a method for control results to be directly entered into a database from any internet location increasing flexibility and usage of the application data. Once entered into the database, the results are immediately available for querying and viewing. Not only is this application an operational management tool and knowledge base, but it captures institutional knowledge that may otherwise be lost. In addition, explosives accountability and tracking are simple by-products of the data and reports that can be generated easily by the application.

1. INTRODUCTION

Effective risk management practices begin with having solid data to base decisions on. For snow safety, the data collection and management process can be a very daunting task given the extent of a ski area and the number of control locations. The primary goal of snow safety is to keep snow enthusiasts within the ski area safe, not to spend their time being data managers. The value and usefulness of the avalanche control data collected and archived is often overlooked leading to many snow safety newcomers asking what happens to the data they spend hours each season writing down on paper. A web-based application has been developed to assist with the data collection and risk management practices of snow safety and to ease the burden of maintaining good data while allowing easy access to the archived data. This ability to have immediate access to the data can be critical to snow safety operations and making informed decisions.

2. STUDY AREA & DATA

The test site for the development of this application is Snowbird Ski and Summer Resort located in Little Cottonwood Canyon of the Wasatch Mountains in Utah. Snowbird consists of 10 skiable square kilometers (2,500 acres) with a vertical drop of 988 meters (3,240 ft) and an elevation that ranges from approximately 2,345 meters (7,700 ft) to 3,353 meters (11,000 ft).

Over the course of three seasons from 2009 to 2012, GPS locations were collected along 43 control routes, consisting of 676 shot locations, avalanche starting zones, transitions and runout locations. In addition, aspect, slope and elevation of starting zones for each of its control routes were collected. The collected data was then added to a Geographic Information System (GIS) running a...
Microsoft SQL Server database backend. The collected data was then overlayed on aerial imagery and elevation data that provided basemap reference data.

The historical control results of the mapped shot locations dating to 1973 were added to the database to provide a historic archive of avalanche activity at Snowbird. The historic data consists of the data variables previously collected on the paper control result forms. The variables currently being collected include date, route, shot, path name, personnel, number of shots used, duds, results, type, size, layers, method, fracture line height, fracture line width, vertical run, percentage of path, comments, and photos. Variables are stored in Snow, Weather, and Avalanches: Observational Guidelines for Avalanche Programs in the United States (SWAG) compliant formats.

3. APPLICATION

The value of collecting avalanche control data is that one can review, analyze, display, and have a historic record of the snow safety control events that have occurred. Often ski patrollers and snow safety personnel collect data first in a paper format and then when personnel need light duty work or there is a lull in the season, the data is entered in to some digital format. The digital data may or may not be accessible by most personnel and may also be difficult to access. This rather outdated data collection approach diminishes the value of the collected data and its ability to be used by others. The original goal of developing this application was to create a system that would provide ski patrol and snow safety with access to the control results data that was collected in an interactive visual spatial/map environment that could be queried immediately upon request and assist in decision making. In essence, the primary goal is to add value to data that more often than not remains filed in a notebook or stored in an inaccessible digital data format.

The application goal was achieved by developing an interactive web-based GIS system using ESRI's ArcGIS Server 10.0 platform with a SQL Server database backend. The application is accessible via the internet and consists of a basemap, overlayed with the shot locations of all the routes or a selected route. The user has the choice of either a snow off aerial image or a “winter” snow on image created from highly detailed elevation data as the background basemap. The shot locations are color coded according to the route they are part of and displayed on top of the basemap (see Figure 1). The user has the ability to zoom in, zoom out, and pan around the image. Each shot location is selectable and when selected the route, path, path name, elevation, aspect, and slope are listed in an information window (see Figure 2).

Figure 1: Application showing all route shot locations with aerial imagery basemap.
In addition to being able to see the shot locations, proximity of routes, and associated terrain information, the user can also query the shot results data to display the avalanche results by defined time period, avalanche class, aspect, and elevation. The available queries can be easily customized to the user group and their preferences and the data can be queried according to any of the recorded data fields.

This application also streamlines the data entry process. Through a web-based data entry interface, users are able to add their control results directly into the database eliminating the need for paper forms and subsequent data entry. By entering data directly into the database, the results are available for display and query in real-time. Database data backups are scheduled throughout the day to insure against data loss.

4. DISCUSSION & CONCLUSION

The development of this application is intended to provide a platform for users to visualize, query, and easily capture data. The intent is not to answer any questions or make predictions, instead the hope is that being able to visualize and query the data will invoke questions and hypotheses and help in the snow safety decision making process.

With the current and historical avalanche results being archived in a commercial database with GIS capabilities, there are many potential uses for this application. First and foremost is the improved record keeping and data management. The additional steps needed to convert paper data to a digital format are eliminated and the ability to immediately verify the inputted data is added to the system. Users are able to input data and access the application from any internet connected computer (a mobile version is not currently available). The increased accessibility to the data allows snow safety personnel to review control results from all over the mountain and not just their individual control route and to query the data based on a number of variables. Snow safety personnel will also be able to review the conditions and control results on the mountain during their days off so that they are up to date on the activity occurring around the mountain on their return to work.

With the potential for stiffer explosive regulations always looming, this application provides an easy way to generate reports on the usage and distribution of explosives. Since the user enters the type and quantity of explosive used and its location, it is now a straightforward database query to identify the total volume and location of explosive usage over a season or any given time period or spatial area.
Institutional knowledge about the individual shot locations and their potential transition and runout zones is captured during the initial data collection phase further increasing the value of the data. By input of remarks into a comments field, continuing institutional knowledge is captured and stored for future reference by all. This application can also be used during training to familiarize new mountain operations personnel to the routes and potential avalanche areas and provide a window into the historical activity of the area.

The types of queries available to the user are determined by the data collected and the preferences of the user group. The current application has several pre-built queries in place.

As Snowbird Snow Safety begins to operationally use the application this coming winter the available queries will be updated based on user feedback to meet the needs of the group. The application is easily customizable and implementing new queries is a straightforward process.

The web-based application and its GIS and database framework is portable and customizable to any potential avalanche prone area making it easily modified or adaptable for any ski area, resort or transportation department.

Future application work consists of being able to link visual weather data (currently a separate program presented by P.B. McNeally at ISSW 2006 and 2008) with this application to create a one stop environment for reviewing control activity and weather data.

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6. REFERENCES


