GRAPHICAL REPRESENTATION OF SKI AREA AVALANCHE CONTROL RESULTS

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1. INTRODUCTION

Traditional methods of recording avalanche control methods and results have not advanced as fast as today's technology at hand. Data recording has revolved around using Xerox copies of photographs of areas of concern, (or acetate overlays), and indicating methods and/or results using colored pencils or markers. Individual route forms would reflect weather history and recommendations. As the season progresses a thick, three-ring binder of pictures, snow pit studies, recommendations, and notes is developed. The history of an area will be well documented but this data would be difficult to view as one graphical representation of actions taken and results.

The ability to view the ongoing season's worth of data or one individual day's data quickly has been difficult. This year the Copper Mountain Ski Patrol used commercially available, (and inexpensive *$89.00 US*) computer software to graphically record the above data.

This program, *ADOBE PHOTO ELEMENTS*, has the ability to use different colors, fonts, line drawing, area color fill in, text, and most importantly; layering of a day's data over a high resolution photograph. This enables the snow worker to view one day, a series of days or the whole season worth of data as an overlay. As the adage states: "one picture is worth a thousand words". This system is very efficient to "see" areas where too much effort has been used, not enough effort, or specific problematic areas of repeater activity. Detailed route atlases can also be generated with this program

In conjunction with the above, a database using *Microsoft Access* records avalanche control methods; manpower, explosives used, and results are used. Digital pictures, and/or movies of activity, snow pit studies, and weather data from Campbell units can be accessed as well. Summaries of manpower, explosives used, and slide activity are easily obtainable. This can help the snow worker better understand and negotiate the season's problems and be stored for future use by successors to the program.

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2. DISCUSSION

For years avalanche mitigation data has been stored in three ring notebook binders. Information from weather reports to avalanche activity to control recommendations to storm profiles has found its way onto paper and into a binder. To be able to sort out information one would have to read through many reports to be able to find the information one wanted.

Years ago with the advent of computers, reports could be saved as a digital copy on a hard drive or disk. This data could be collated and reviewed easily. The only downfall was that not every ski patrol had access to computers especially at a duty station. Fortunately, the price of computers has come way down and most ski patrols now have access to computers and many are hooked up to a network. Internet use has expanded and detailed weather forecasts that were once privileged information to only the National Weather Service and universities are now a tool the snow worker routinely checks before and during weather events.

A program like "Snow Pro" has made pit data easier to record, display and use. Computer files and folders that are full of good research can be called up at a moments noticed to check on snow pack stratigraphy and history. Comparisons with data saved earlier in the season to show how a snow pack or layer strengthened or weakened can be easily viewed.

Snow safety computer programs have also been developed to use historical weather data and slope profiles to assist hazard forecasting. Previous avalanche activity with known weather events can be analyzed and a prediction to what might occur with a similar set of weather factors can be utilized. Wind roses in conjunction with snow fall amounts, density, crystal type, temperatures, etc. have been

developed to help forecast areas of hazard and instability.

Many ingenious ways to use the strengths of computer data storage and processing have been developed by snow workers and used successfully. However, the one field of data storage and processing which seems to be lacking improvements is the portraying of the avalanche control route itself. How do we as avalanche mitigation workers record our data in a user friendly way to show where explosive placements were, where ski cuts were made and their results, where boot packing was performed, where avalanche activity occurred, etc. Xeroxed pictures of the control route terrain have been used for years. All of the above information has been recorded using pencils and paper pictures to show the “how’s”, the “what’s”, and the “what happened’s”. We became more sophisticated by using higher resolution digital cameras, better printers, colored pencils, and in some cases, numerous clear acetate sheets to write over a picture so we could better “distinguish” the methods used and results over a period of time.

Unfortunately these documents once again lived in a three ring binder or a three ring flip clipboard. If you wanted to review all the work performed or activity in one area you would have to look at the individual sheet of each control mission. You were relegated to using your memory as you looked at each sheet to try to get the “big picture” of what was going on, what you were doing to it, and what to do next. If a resort had perhaps 75 avalanche paths with work being done on a daily bases you could quickly have hundreds of entries over a short period of time. You could facilitate the data snafu by having binders designated for certain routes to help bring some order to this. However, there is just too much data to be easily digested. The seasoned snow worker has a general “feel” of what has been done or happened but if this wasn’t your route or you were new to the program you would be quickly over whelmed absorbing data. Getting specific details of a certain area has become a time consuming process.

It would be difficult to comprehend how many ski cuts were made in one general area, were all areas of potential instability cut, were explosives adequately used, what were their exact placements, results etc. There are a thousand and one questions that can be asked about the instabilities and mitigation performed and no really good way of portraying this data in a user-friendly means.

Advances in digital photography and computer technology have made it possible to take a high quality digital photograph of an area in question and use simple programs like Microsoft Paint and draw in the particulars of the mitigation process as it is happening. Once again you can only fit so much data per page before it looked like modern art. It would be difficult to have several days of work or activity displayed in a usable document. If you were fortunate to have access to a color printer, you could print out these pages for the good old three ring binders once again. Whether you saved these documents as computer files or printed a hard copy you still had to view each page individually. Once again you would have to commit each page to memory to see trends, repeater activity, areas of too much concentrated effort, areas of not enough effort etc. You could store data files by date but it still would be difficult to view more than one page at a time. To be able to look back at previous years data it is easier to use computer files than the paper records, but it is still severely limited in scope or comparison of daily entries.

What is really needed is a way to digitally make “transparent page layers” which could be superimposed over each other. In this way you could see the area of concern, what methods were used on the area, results, if too much focus was placed on one part and not enough in another, etc. Such a program has existed for the last 10 years but you needed to spend hundreds of dollars for the program and take a college level computer class to understand how to use it.

This program is called Adobe Photoshop. It has had many versions through the years but it is still a high end product. Fortunately about 3 years ago Adobe came out when a slimmed down version called Adobe Photoshop Elements 2.0. This product doesn’t come with the high price tag (retails for under $89 US) and is commonly bundled for free with software packages for digital cameras or flatbed scanners and is easy to use.

The beauty of this program is that it can save data as a dated “layer” over a high quality digital image. Imagine the ability of saving each day’s data on digital “acetate” sheets in a computer. Each “transparency” can show a range of information from explosive placement, type and amount used, results; ski cutting passes showing where, how many, and any releases; ski or boot packing passes, natural activity, or any other mitigation techniques used. One day, several days, multiple days or the whole season’s mitigation efforts can be easily brought up on a computer screen. An area’s hazard and mitigation

characteristics are easily discerned. It will be quickly apparent if certain areas have had too much or not enough mitigation. Repeating slide activity might point to an underlying problem within the snow pack. If one were to take a digital photograph of activity of an area from the same general vantage point as the original "route" picture, a "transparent" avalanche activity layer can be generated and placed over the layers of mitigation work or previous activity. A visual assessment and comparison of how past work is related to present activity can be made. As the old adage states, "a picture is worth a thousand words" is very apparent with the above techniques.

The program is able to handle up to 8000 individual layers per file depending on the power of your computer. This is more than enough for a season's work on one particular area. Layers can also be merged together effectively "flattening" the image to save on hard drive space if needed. Tools, which can be used range from written text to free hand pencil tools for outlining ski cuts, explosives placement, to colored "fill in" functions within outlined areas to show areas that avalanche and the extent of the debris field, to "locking layers" so they can not be changed. Zooming in and out abilities, cut, copy, and paste functions also exist. The list of what you can do is almost endless and up to a good snow worker's imagination on how they want to "view" and store their data.

Another very strong application that can be developed is creating a route atlas for all your areas of concern. A high quality image representing an area of concern can be labeled with all the contributing hazard characteristics, i.e. name, slope angle, bed surface, loading winds, shot placements, etc. Adjacent areas can be slightly grayed or highlighted to show how one area is related to another. The entire route atlas can be done in this manor and easily accessed by computer or prints can be made for hard copy uses.

Photo merge functions are also available for making panoramic images of large areas. A complete bowl, ridge or large avalanche event can be "stitched" together helping to view entire areas or events that would otherwise be impossible to observe. Again, imagination will fuel how and what data is used and stored.

This technique of using Photoshop Elements is used in conjunction with a database utilizing Microsoft Access. This database will further help store the information generated from the snow safety program thorough the season. The second half of the paper by Ron Simenhois will explain this method.

- *The need for computerized snow safety database.*

Almost everyone involved in snow safety work as a ski patroller comes across stories of patrollers that have been caught in an avalanche, or have experienced it first hand. These occurrences are usually related to an unusual snow pack or rare weather events. Since these events are usually rare, they are eventually remembered as anecdotes. The events' relevant knowledge and information that is accumulated is not passed over the years. Furthermore, the knowledge of mitigating unusual snow condition avalanche hazard is not learned by all the snow workers on the mountain and new experience is needed to be re-learned every time. The information related to rare snow conditions that is learned over the years can be very beneficial to the snow safety work if it is available before the workers are heading out to mitigate the hazard.

Some people have different backgrounds. As a snow safety technician is filling a control work report, he or she is filling the report according to their background. This situation creates a collection of different styles and methods of recording activity, conditions, control measurements and comments. The lack of one agreed standard creates difficulty in understanding the reports or finding important information in a timely manner. The need to follow a standard may even help the crew on a control work focus on what they are looking for and what they are trying to achieve on the control work instead of following the "usual routine".

When a snow safety technician is not directly involved in the snow safety work on a specific terrain for some time, they need to fill the information gap to be able to work effectively and safely. Furthermore, some control results can give us a hint or important information on the condition and can be taken into consideration when negotiating the avalanche hazard in other parts of the ski area. Sometimes, patrollers share this information over the phone or by using the radio, but it is rarely shared with snow safety technicians in neighboring ski areas that negotiate a similar snow pack. The ability to share the history of recent control work and results in one clear standard form and have it available with the next weather information or almost at real time can be

an important tool to help negotiate the snow safety work ahead.

The advances in technology allow us to easily record data and information related to snow safety work as files on the computer. Technology such as digital pictures, videos, snow pit records, graphical visualization of the control work, etc lay in the computer's hard drive. This data can be used better if it could be linked together to an organized and complete report of the recorded event.

The ability to link a photo or video to a starting zone snow profile and graphical and textual description together with notes on the latest weather event and other observations with the ability to easily retrieve it can be very useful tool for the snow safety technicians in the future.

As the season progresses, different snow safety technicians are using different methods. Those differences may be driven from different terrains and snow pack. But in some cases, some methods may work better in some circumstances than others and there is no way to tell if one method is more efficient than another or if some terrain requires considerably more resources to get open than other. A system that is able to generate statistics and analyze different methods, terrains and resources can help improve snow safety control work.

The difficulty in using and communicating the information that is accumulated during snow safety work suggests that we should look into other methods of information management than the one we use. Computers are already part of everyday life and they practically exist everywhere. They are getting cheaper and they can be used as a tool to manage and share information. Therefore, creating a computer database to negotiate the difficulties above can be one approach to solving the problem.

The ability to use computers to store the control work information can be a catalyst in creating other byproducts. Budgets can be created for our control work on different parts of the mountain, in order to work more efficiently and analyze the effectiveness of different methods on more scientific bases.

- *Specifications and Designed consideration.*

When considering a computerized system to log and use the information and knowledge that being collected, i.e. database for snow safety work, the system designed should aim to fulfill the following specifications:

The database should be affordable to accommodate the constraints of the ski patrol budget. On this note, the control work database should be able to run on the existing ski patrol computers, i.e. compatible with Microsoft Windows.

Giving these specifications, we decided to build the database in the patrol. The database program that I chose to use is one that already existed on the patrol computers - Microsoft Access. Other requirements easily fulfilled by using Microsoft Access were the ability to store and manage many types of formats and be able to link in between them. This enables us to link pieces of information that relate to specific control work. For example, as the database developer I wanted to link and present as one complete package specific control work notes, i.e. the graphical (on Adobe Photoshop Elements 2) and the textual description of the same route with a digital photo of the control results, the snow pack profile of the start zone, and the related weather notes to this route.

The database is still in the development process and from time to time we find ourselves adding different pieces of information or creating new features and more powerful queries. Therefore, flexibility of the database is an important requirement and is a big part of the design consideration. The database should be flexible enough to allow those changes without losing any information that is already logged in and without converting the existing database into another database with another structure. Furthermore, we wanted to take advantage of the in-house development process and encourage the rest of the patrol staff to bring more ideas and requests that we didn't consider in the initial designed.

Copper Mountain has a big future expansion plan. In order to enable us to add the terrain in the new expansion plan with relative ease or to use the system in other ski areas, we wanted the database to be easily customized. We wanted to create a self- learning system as much as possible.

When designing the system we wanted to create the user interface (man machine interface – MMI) as self-explanatory as possible. We wanted the system to be user friendly from the beginning to accommodate people that are not computer savvy and prevent negative initial response to the system. The MMI is designed to be related to the control work process and not to the database design itself in order to make sense to the user. This will help the user bring and remember important observations from the field. The MMI is

designed to have drop boxes also known as combo boxes with “agreed on” signs and symbols to help the user work within one standard and help him concentrate on logging important information and not on the description of the data itself. In addition to being user friendly, the system interface should look good and be somewhat attractive. This will help a new user to get exited about using it and learn how to use it.

To make the database a source of useful information in real time and a good learning tool as well as finding information related to all aspects of control work, the database has filters to retrieve information that is requested. For example, if a snow safety technician wants to find information on the control work a day after the mountain received 45 cm or more of new snow, they can query the database for control work on similar weather events and get all the routes that have been done after a 45 cm of snow or more. This information includes a list of patrollers name that were on those routes, textual and graphical description of those routes and any related information that exists, like digital photos and video of control results, fracture profiles, etc. The ability to add more filters to the database on demand is important in order to create a user-friendly workspace and to accommodate the needs that may be presented and had not been addressed in the initial design.

Databases should be able to grow and expand with the information that is entered in it without creating stress on the computer’s memory and computing ability. In other words, the size of the database should not drain the computer memory before it holds sufficient amount of data. The database should generate a summarized report of the control work during the last weather cycle. This will inform the rest of the control work crew on the area’s latest history and create healthy discussion on the next control actions.

The summary should include important information related to specific terrain as in personnel names, their notes from that specific terrain, a list of concerns that have not yet been addressed and weather notes since the last control work.

Another benefit of using the system is the ability to generate a report of manpower, methods or any other resources used. By adding this capability we can budget the control work and analyze the resources it will take to mitigate the avalanche hazard and costs in opening and maintaining terrain in any part of the season.

- *Abilities*

The database contains and links textual data to digital and graphical information that is relevant to the control work. Control work data units contain the textural and graphical description of the route with any digital photos or video from the control work and snowpack notes on the route.

Clicking at the bottom of the database program does editing of the graphical information of the control work and the relevant photo is opened by Photoshop Elements.

The database can easily be adapted to different ski areas. There is minimum amount of work in the initial setup. After the initial process, the system is capable of learning place names during the control data entering process.

The database has a strong set of queries. These queries can retrieve information on a specific control route relevant to patrollers name, date, weather event, snow pack, and terrain specification. On top of that the database set of queries can be easily expanded to carry a specific task or retrieve relevant data to other criteria.

- *Limitations*

The snow safety control work database has its limitations. It is important to understand those limitations and to know what to expect from the system.

The size of the database is limited to the memory size of the computer it’s running on. Furthermore, the speed that both Access and Adobe Photoshop Elements 2.0 are running on the computer is directly related to the computer memory size and power – sometimes, size does matter. In most cases it is better to run the system and store the information in a network drive if possible. This allows us to access the data from many computers around the mountain and to periodically get backup as part of the network service. On the other hand, many people access the network and someone may decide to clean or “reorganize” the hard drive and delete all the information that has been saved. When the system is working from the network, the network and the connection to network speed is critical to the speed the system will work.

Once the information is being shared with organizations outside of a secured network, i.e. other ski patrols, special security considerations should be considered. For example, we probably would not like to expose the blaster in charge name with our route description on the Internet.

A snow safety control work database that can query information and generate recommendations according to past results can

create a problem in case of an avalanche accident within the ski area boundary, when the control work is not the same as the database recommendations. In this case, someone can argue that there is neglect since the snow safety technician ignored the database recommendations and the local accumulated knowledge.

It is important to remember that this system can become useful in helping us make decisions, be more efficient and effective. But this system cannot be a replacement for a well trained, sound thinking snow safety technician. There are always unknown elements that need to be addressed out there.

- *The next step – a look to the future.*

Once information is logged into a computer, it is relatively easy to use it in many different ways. We are planning to put the control work information on a shared database for the use of other ski areas in the region. For us patrols in Summit Country, CO, it means that information gathered from the snow safety control work is being shared between all 4-ski areas. New methods and ideas can be exchanged. Important information that is usually passed in very general form can be analyzed by the Colorado Avalanche Information Center for the benefit of the public. This information will be recorded and be available to CAIC with the same level of detail as it recorded in the ski patrol database.

Part of the future plans for the system is to be able to analyze snow pit profiles. The system will be able to analyze Snowpro files (or any other widely used software) and generate recommendations according to the terrain and in conjunction with Nearest Neighbor and Ian McCammon and Jurg Schweizer method of identifying weakness in the snow pack and more. As more and more information is added to the database, it can be used to generate recommendations for control work according to latest weather event and snow pack with relation to the data in the system.

3. CONCLUSIONS

The above methods are to be used to help enhance a snow workers recording and understanding of mitigation techniques used and results. By better organization of mitigation information an improved understanding of the problem and methods to manage the problem can be generated. Under no circumstances will a computer program direct mitigation efforts but will serve as a tool to be used in decision-making.