Transportation Avalanche Research Pooled Fund Program (TARP)

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ABSTRACT: The Transportation Avalanche Research Pool (TARP) is a partnership of transportation entities to further communication and cooperation on research, development, and evaluation of avalanche mitigation equipment and methodology to improve the safety and efficiency of highway transportation in mountain corridors. TARP was established through the United States Department of Transportation (USDOT) state planning and research pooled fund program and is currently administered by the Colorado Department of Transportation (CDOT). The group's mission is to promote, enhance, and facilitate cooperative interagency research that improves the safety and effectiveness of avalanche mitigation operations. Members contribute funds, develop ideas for projects, and vote on the how to spend money in the pool. Currently, the membership includes groups from the western United States, Alaska, and New Zealand. Projects generally fall under six main categories: remote sensing, mapping and planning, information exchange, worker safety, explosives techniques, remote avalanche triggering, and mitigation effectiveness. To date TARP has, or is currently funding, projects related to mapping, explosives, and remote sensing. Future projects related to information exchange and mitigation effectiveness are anticipated.

KEYWORDS: Transportation, Avalanche Detection, Avalanche Mitigation, Explosives

1. INTRODUCTION

Reducing the avalanche hazard to transportation corridors is crucial to the winter operations of the DOTs in many western states, and, as such, are large budgetary items to these DOTs. Much of the research done by each DOT is relevant and useful to the efforts in other states, but there has not been any official long term collaboration effort in place. Because of this, money can often be spent on the same research efforts in multiple different states. DOTs and Ski Areas associated with the Avalanche Artillery Users of North America Committee (AAUNAC) meet annually to discuss avalanche mitigation efforts, but this covers only a small portion of total avalanche related control and research activity. Additionally, the DOT members of AAUNAC have met in a less formal context to discuss matters specific to highways.

These meetings elicited interest in a more formal means of funding and exploring research related to highway avalanche issues. The resulting effort aims to address these challenges by forming a coalition of transportation related groups with interest in avalanche control research, and create a pooled fund to provide a single source of funding for unified research efforts that will benefit all contributing parties. Combining funds allows for larger and more significant research projects to be undertaken and can result in an overall cost savings by consolidating various research efforts in the same field.

The Transportation Avalanche Research Pool (TARP) was established through the United States Department of Transportation (USDOT) state planning and research pooled fund program and is currently administered by the Colorado Department of Transportation (CDOT). TARP is a partnership of transportation entities to further communication and cooperation on research, development, and evaluation of avalanche mitigation equipment and methodology to improve the safety and efficiency of highway transportation in mountain corridors. The mission is to support collaborative research efforts in the field of avalanche hazard assessment and mitigation, with the goal of improving the safety, efficiency, and quality of control efforts, along with providing better information gathering and analysis

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techniques and seamless integration of new technologies to further these goals.
The participation of many transportation related agencies will also further cooperation in this industry, leading to improved future development of beneficial technologies and improved sharing of information and avalanche data, greatly furthering the safety, efficiency, and quality of the work done in this field for all relevant agencies.

Current membership includes Departments of Transportation from Alaska, California, Colorado, Utah, Washington, and Wyoming, The Colorado Avalanche Information Center, Alaska Railroad, and the New Zealand Transport Agency. The group's mission is to promote, enhance, and facilitate cooperative inter-agency research that improves the safety and effectiveness of avalanche mitigation operations.
Members contribute funds, develop ideas for projects, and vote on the how to spend money in the pool. Projects generally fall under six main categories: remote sensing, mapping and planning, information exchange, worker safety, explosives techniques, remote avalanche triggering, and mitigation effectiveness.

The group will fund research and development efforts to achieve the program goals, with initial proposed research focusing on:

• Infrasonic sensing and mapping/ LiDAR
• Avalanche Safety/ Risk Management
• Avalanche Information Exchange Platform for information sharing
• Mobile Blast Shield – further development
• Explosives techniques
• Avalanche Asset Management
• Other New Technology

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2. PROJECTS

Four projects have been funded to date and are in various states of completion. The following section provides a brief overview of the project's primary investigator, intent, and outcome

2.1 *Assessing Gazex Avalanche Control Effectiveness with Terrestrial Laser Scanning (Jeff Deems- University of Colorado)*

This project aims to use terrestrial laser scanning (TLS) technology to create snow depth maps in avalanche starting zones for an effectiveness assessment of the new Gazex systems in reducing avalanche hazard in the Loveland Pass (Seven Sisters) and Berthoud Pass (Stanley) highway corridors. Snow depth maps created prior and post Gazex activation will allow the quantification of avalanche areas and volumes, as well as the mapping of snow slabs remaining after control operations.

The spatial distribution of snow depth exerts a strong influence on avalanche occurrence, triggering, character, and potential size. Snow depth also affects snow density, hardness, and weak layer failure. Extreme snow depth heterogeneity is common, especially in wind-affected environments. Avalanche control efforts are often more successful when shallow trigger point areas next to deeper slabs can be targeted with explosives or ski cutting. Control results from permanent installations such as Gazex are optimized when sufficient snow slab has accumulated to create a sizeable release, but before extensive accumulations threaten infrastructure. High resolution snow depth and snow depth change maps from repeat TLS scans can provide quantitative information on snow accumulation patterns for use in avalanche control planning, targeting of explosives, and especially post-control results assessment, and could be used to assess optimal control timing for new operations or installations.

2.2 Infrasound Avalanche Detection (HP Marshall- Boise State University)

Infrasound has been used operationally for avalanche detection, and for verifying avalanche control work at two U.S. locations: Teton Pass, Wyoming and Little Cottonwood Canyon, Utah and several locations in Europe The U.S. systems in use are outdated and will require replacement in the near future. The cost of infrasound avalanche detection systems is currently too high to allow expansion of this approach at a large scale.

The research team at Boise State University is evaluating several different approaches to infrasound avalanche detection by performing side-by-side tests with 3 unique and potentially less expensive infrasound systems for avalanche detection. These tests will inform future decisions for replacement and expansion of operational infrasound detection systems for highway operations. Their work leverages the development of 3 new infrasound systems by recent Ph.D. students in Electrical Engineering and Geophysics, and the development of a powerful avalanche detection algorithm developed by a Masters student in Computer Science at BSU.

2.3 O'BellX Analysis (Vilem Petr- Colorado School of Mines)

The use of gas-blast remote avalanche control systems has proven to be a safe and effective way to reduce avalanche hazard in fixed locations. The final performance of these RACS is affected by height of burst, elevation, and physical properties of snow. Identifying and evaluating their influence on control results presents a challenge for the implementation of gas exploders. A research study lead by the Advance Explosives Processing Research Group (AXPRO) at The Colorado School of Mines is underway to analyze the variables in order to maximize the successful implementation of these devices.

The study will evaluate the following:

- Influence of atmospheric conditions on the detonability of the hydrogen-oxygen mixtures
- Influence of atmospheric conditions on the air blast
- Effects of terrain feature on blast wave propagation
- Influence of the height of blast
- Time sequencing using multiple exploders
- Physical properties of the snow pack
- Evaluation of ground vibration

2.4 Detecting Avalanches and Differentiating Type and Size of Avalanches Using Radar (Nicolaus Moller-Niivatech)

In this project 16GHz (Ku-band) radar will be used to detect and classify avalanches of varying sizes. Size classification will be calculated using range, azimuth, and intensity measurements from the radar. The type of avalanche will also be estimated based on the shape of the footprint of the radar data. The radar data will be used to describe avalanches following the *Snow, Weather, and Avalanches: Observation Guidelines for Avalanche Programs in the United States*, while also providing additional information measured by the radar.

Overall radar have significantly decreased in size and price. The lack of a cost effective commercial radar in today's market with the proper design criteria has required the need to design and a build a custom radar system that not only detects avalanches but reports them clearly, and exhibits a very low error rate. Since 2015, Niivatech has been experimenting with the viability of radar for real-time avalanche detection. Radar have been installed at 3 locations and successfully detected over a dozen avalanches. Building from this experience, Niivatech looks to install radar at several locations in the Western United States in a variety of snow climates. Installations are expected during the 2018-2019 Northern Hemisphere winter.

3. CONCLUSIONS

The advantages of a pooled research fund has already been demonstrated by the current efforts, none of which would have been accomplished on an individual agency basis. The pool team anticipates further significant research developments relevant to the field internationally.

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