



Site Management During Avalanches

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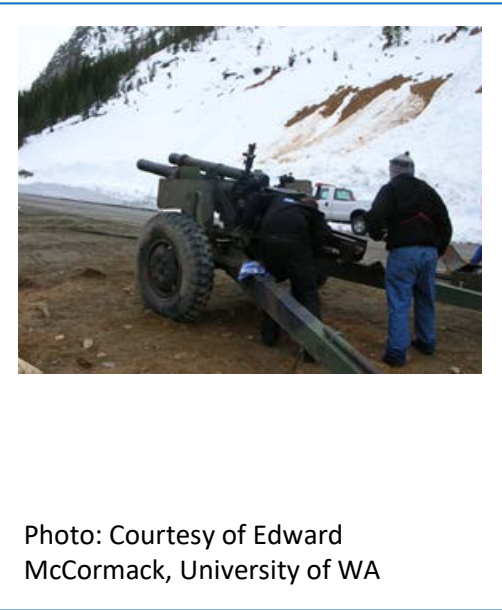


Photo: Courtesy of Edward McCormack, University of WA

Description: Intelligent transportation systems (ITS) in coordination with avalanche mitigation efforts (avalanche blasting) can work to keep an avalanche prone corridor safe and open for the public. ITS tools can be used to monitor conditions, close roads and activate warnings. Various sensors can be used to monitor snow pack condition and movement including environmental sensor stations, geophones, tilt sensors, or ultrasonic sensors. These sensors can detect the presence of an avalanche or identify that the risk of an avalanche is high, and then provide warning to an agency that a road needs to be closed or that maintenance staff may be required. Access control gates (see [#TM1](#)) can be activated so that the public cannot enter the area. Dynamic message signs (see [#TT13](#)) or static signs with flashing beacons can be used to inform the public of an avalanche and that the road is closed. Vehicle detection sensors (see [#TM5](#)) can be used as a vehicle enters and exits an avalanche prone area. These sensors will help an agency determine the number of vehicles that may be in the area if an avalanche were to occur.

Rural Transportation Critical Needs

- Crash Countermeasures
- Emergency Services
- Operations & Maintenance
- Rural Transit & Mobility
- Surface Transportation & Weather
- Tourism & Travel Information
- Traffic Management

Issues Addressed

- Resource Mapping and Monitoring
- Central Data Storage
- Icing of Roads
- Avalanches
- Maintaining Cameras
- Commercial Vehicles
- Prioritizing Snow Removal

Strategies Achieved

- Road User
- Road
- Vehicle
- Safety Culture
- Engineering
- Emergency Response
- Enforcement
- Education





Applicability

•ITS tools can be deployed in avalanche prone corridors in order to increase safety for both the traveling public and maintenance personnel. These tools work to alert the public of an avalanche or avalanche danger. Furthermore, these systems are extremely important as these corridors tend to be more remote in nature. Therefore, the sooner an agency is aware of an avalanche, the sooner it can alert the proper maintenance personnel or first responders (if necessary). This allows for quicker response times if a traveler is trapped and reduces the time necessary for the road to be closed, which can have a huge impact on local businesses (ski resorts, etc.).

Partnerships

- Applications benefit from collaboration among numerous agencies, which may include:
 - Departments of Transportation (Federal, State, Local)
 - Law Enforcement
 - First Responders
 - Local Ski Resorts/Recreation/Businesses
 - Weather Condition Services
 - US Forest Service

Key Components

- A combination of these tools can be used to detect the occurrence or the increased risk of an avalanche for increased safety on roadways in avalanche prone corridors.
 - Tilt Switch Sensors
 - Infrasonic Sensors
 - Geophones
 - Doppler Radar
 - Road Weather Information Systems
 - Dynamic Message Signs (DMS)
 - Alarm System
 - Vehicle Detection Sensors
 - Cameras
 - Traveler Information Systems
 - Social Media

Examples of Implementation

• Wyoming Department of Transportation (WYDOT) Avalanche Warning System

WYDOT installed an [avalanche warning system](#) to improve safety along an avalanche prone area of Highway 189. The system consisted of tilt switch sensors, warning signs with flashing beacons, and an alarm system. Tilt switch sensors are within steel pipes suspended along the roadside. During a slide, the snow triggers the switches, activating a siren and flashing beacons to warn motorists.

• Avalanche Monitoring System

Utah Department of Transportation (UDOT) installed infrasonic avalanche sensors and cameras in the Cottonwood Canyon to [monitor avalanche risk](#) during periods of low visibility. This system enhanced avalanche control operations; using the sensors along with cameras to verify conditions allowed UDOT to know whether control efforts were successful. This led to shorter road closures and safer conditions for maintenance personnel.

• WY-22 Teton Pass Closure Gates

Teton Pass on WY-22 is consistently closed for hazardous winter driving conditions and avalanches. To increase safety, [access control gates](#) were installed on Teton Pass as well as warning lights to allow Wyoming Department of Transportation to remotely close WY-22 during hazardous driving conditions.

• Colorado Department of Transportation (CDOT) Avalanche Control

CDOT has teamed up with the Colorado Avalanche Information Center. If the Center determines that there is a [high risk of an avalanche](#), CDOT will close the appropriate highways until avalanche control has been conducted. When a road is closed due to avalanche danger, CDOT posts messages on DMS, the state's traveler information website, and 511. The public can also sign up for text or email alerts.





Implementation Considerations (Pro)

- Improves safety in avalanche prone areas.
- Reduces road closure times.
- Reduces congestion on mountain passes.
- Can provide real-time alerts to travelers and maintenance personnel.
- Avalanche detection systems with automatic gates can automatically close roads that are affected by avalanches, reducing the number of drivers in the area.
- Reduces economic loss to nearby towns or recreation areas (ski areas, etc.).

Implementation Considerations (Con)

- The sensor system may detect an avalanche that does not reach the road, potentially causing an unnecessary road closure.

Opportunities for Future Expansion

- Vehicle to infrastructure (V2I) communications could alert drivers that an avalanche warning system has been triggered on their route. This would warn drivers that they may get stopped ahead on their route or that they should try to re-route if possible.

Additional Resources

- *Rural Intelligent Transportation System for Snow Avalanche Detection and Warning*, found here: <http://trrjournalonline.trb.org/doi/abs/10.3141/1700-04>
- *Rural Intelligent Transportation System Natural-Hazard Management on Low-Volume Roads*, found here: <http://trrjournalonline.trb.org/doi/pdf/10.3141/1819a-37>
- *Snow Avalanche Safety Measures for Highways Manual*, found here: http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/highway-bridge-maintenance/avalanche/snow_avalanche_safety_measures-hwys.pdf
- *Expanding the Road Weather Information System for Avalanche Support*, found here: <http://trrjournalonline.trb.org/doi/abs/10.3141/2551-05>





Useful Tip

An agency can use its available ITS to alert the public about an avalanche. When a road is closed due to avalanche danger, consider posting messages on DMS, integrated traveler information systems, or social media.

Cost Range

(Cost/financial information, where noted, is based on 2016 dollars (unless otherwise specified). Cost/financial information is estimated, and will vary based on size and scope of project, number of units, etc. In general, capital costs include initial purchase costs of hardware, software, and other required equipment. Maintenance and operations costs include staff time to operate, monitor and maintain systems; data collection; system upgrades; evaluation; etc.)



Capital Costs: The total capital costs for this tool are high (\$100,000 to \$250,000) or higher (above \$250,000). The cost estimate for a European avalanche warning system, including Doppler radar and geophones, that can record real-time avalanche data and communicate risk via warning lights and phone was \$250,880¹. The cost for CDOT to install 16 avalanche exploders and supporting infrastructure in order to allow maintenance personnel to remotely control avalanches on Berthoud Pass and Loveland Pass was \$1.5 million². The estimated cost to deploy a road weather information system was \$63,000. The cost to deploy access control gates was estimated to be \$16,354. The costs for a camera are estimated to be \$12,440. Social media is an effective, low cost way to get out information on avalanche conditions and possible road closures.



Operations Costs: The operations and maintenance costs for this tool are expected to be high (\$100,000 to \$250,000). These costs will include maintaining all avalanche condition sensors as well as testing the system to make sure that everything is in working order.

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