

PRACTICAL EXPERIENCE WITH AERIAL DETONATION OF EXPLOSIVES FOR AVALANCHE CONTROL<sup>1</sup>Joel Juergens<sup>2</sup>


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Studies indicate that aerial detonation of explosives for avalanche work may be more effective than hand thrown explosives that detonate on or in the snowpack. Our preliminary field work and observations tend to support the theory. Aerial delivery systems may have a place in North America's avalanche control programs.

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At the 1982 International Snow Science Workshop in Bozeman, Montana, Rand Decker, snow and avalanche research assistant at Montana State University reported on the concept of aerial detonation of explosives for avalanche control via tramway systems. These tramways are specifically designed to transport explosives to avalanche starting zones. The concept is not new to avalanche control work but is relatively unknown in North America. In Europe tramways for the delivery of explosives for aerial detonation have been in use for many years. These installations protect ski areas, highways, and railroads (fig. 1 and 2)



Figure 1.-- Doppelmayr bomb tram in Europe.

<sup>1</sup>Paper presented at the International Snow Science Workshop, Aspen, Colorado, October 24-27, 1984.

<sup>2</sup>Joel Juergens is the Director of the Ski Patrol at Bridger Bowl Ski Area, Bozeman, Montana.

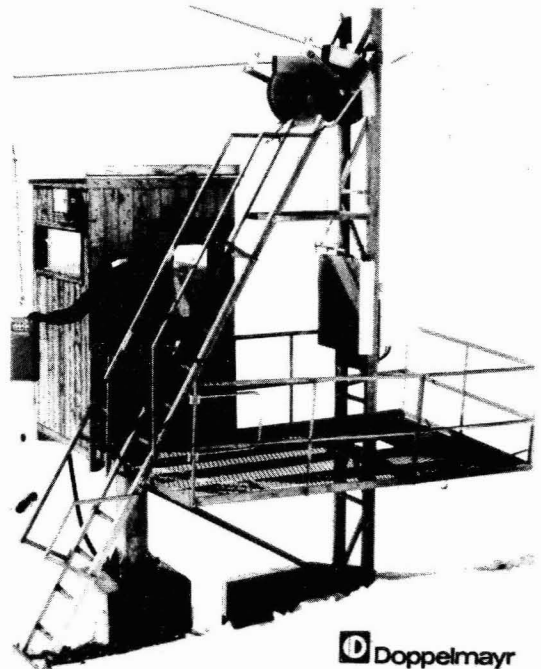


Figure 2.-- Doppelmayr bomb tram. Note the carrier at the left of the picture.

In certain limited situations the use of aerial detonations could be beneficial to many avalanche control programs. The advantage to detonating a charge in the air (one to two meters) is the blast has a greater zone of influence on the areas of weakness in any given starting zone. According to studies done by Hans Gubler of the Swiss Federal Institute for Snow and Avalanche Research the zone of influence for a detonation in the air has a radius of 50-100 meters. (Gubler

and Armstrong 1981 ) This measurement compares with 20-40 meters for well placed charges on the snow surface. Charges within the snowpack have a significantly reduced zone of influence. Figure 3 shows the influence of the location of the detonation on the radius of influence for a dry seasonal snowcover.

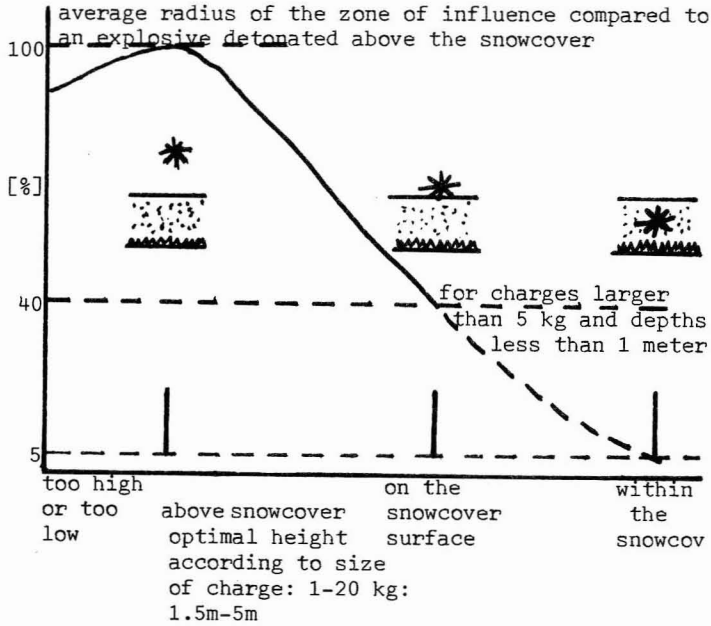


Figure 3.--Zone of influence, total snow depth 1-3 meters. (Gubler and Armstrong 1981)

In 1981, Rand Decker and Dr. Robert Brown with the Montana State University Department of Civil Engineering and Engineering Mechanics, completed a short hand cranked tramway at the Bridger Bowl Ski Area. Technical and design assistance was provided by Eduardo Garreaud, Director of Snow Safety at La Plagne ski area in France. Eduardo Garreaud was on a cooperative scientific exchange at Montana State University supported by the MSU Engineering Department and the French agency A.N.E.N.A. (National Association for the Study of Snow and Avalanches) Materials for construction are old chairlift parts and salvage from the ski area boneyard. The use of this tramway was incorporated into Bridger's normal control program. This tramway covers two small avalanches paths (Fingers One and Two). Since that time delivery systems have been built over eight other paths. These others are fixed cables with a retrievable pully as the delivery method. All of the systems are used regularly.

After a few years of use and practice with our delivery systems we began last season to attempt a crude analysis of the results of the aerial detonations. These are strictly field observations by the Bridger Bowl control teams during control work. All the patrollers were involved giving us a wide range of opinion as to the effectiveness of the detonations. For the purpose of analysis on each control day when aerial blasts were used we also detonated a hand thrown charge in an adjacent slidepath as an on

the spot comparison. We have a comparison of 65 aerial charges and 90 hand thrown charges. Records of avalanche size and percent of slidepath that slid were recorded on the standard Forest Service forms. Figure 4 and 5 summarize this past season's activity and observations

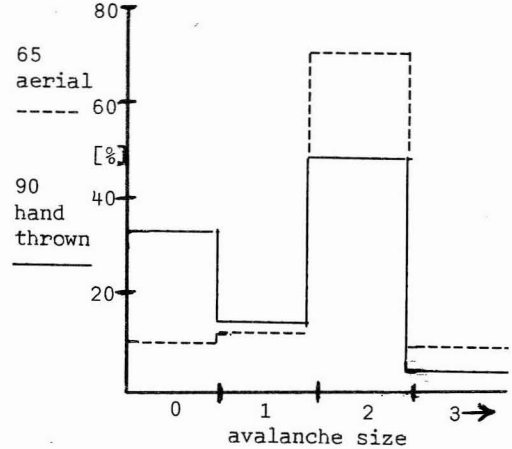


Figure 4

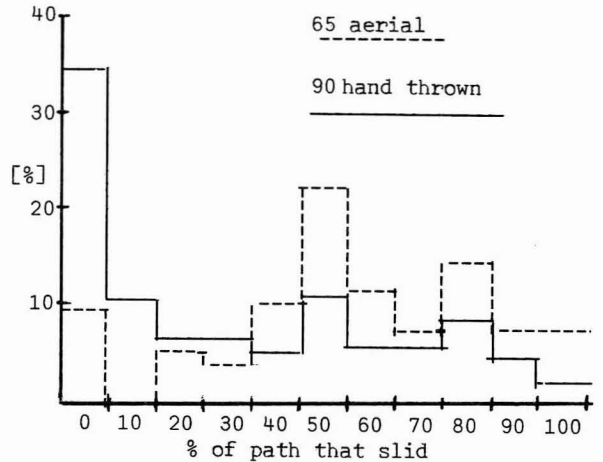


Figure 5

It would appear that a greater percentage of the aerial detonations are moving a larger volume of snow. This might indicate that on any given control day the aerial detonations are reaching more areas of weakness in the snowpack. Figure 6 summarizes the past years statistics.

Because of the cost of construction and maintenance, extensive aerial delivery systems will probably not be used in North America for some time. Small inexpensive systems can be hung from convenient trees to cover isolated areas or hard to reach areas. Most of the materials for our bombtrams have come from the ski areas boneyard. This has kept the cost to a minimum.

## LITERATURE CITED

- A total of 82 aerial detonations were used. (Bridger uses approximately 1800 charges per year)
- On 23 control days charges were detonated in the air as well as on or in the snowpack in adjacent slidepaths.
- Larger slides were produced on 17 days with aerial detonations, 6 days with hand thrown explosives.
- At this point we can find no apparent pattern in regard to new snow depth or new snow density and larger slide produced.
- New snow depths ranged from 2" to 17" on the 23 control days.
- New snow densities ranged from 3% to 18%.

Figure 6.--Some statistics from the 83-84 season.

These delivery systems are good for isolated difficult to reach areas. Cliffs are prime places to hang a fixed line over. The concept is interesting to experiment with and can be some good fun and good humor while you are learning to use the systems.

- Decker, Rand and Brown, Dr. R. L. 1982. Bomb Trams and Aerial Detonation: A New Method of Avalanche Control at Bridger Bowl, Bozeman, Montana.
- Gubler, Hans (Author) and Armstrong, Richard L. (Translator) 1981. Translation from the original German text. Artificial Release of Avalanches by Explosives: An introduction for the Field Person.