LOW COST EXPLOSIVE DELIVERY SYSTEMS FOR AVALANCHE CONTROL

By Lee Redden[I]

ABSTRACT

Avalanche controllers in Snoqualmie Pass's maritime climate are currently using up to 25 kg bombs on routine missions. Over the past few years, three low-cost systems to deploy bombs of this size have evolved. The use of and the methods for delivering the large bombs for aerial detonation are presented.

INTRODUCTION

The Washington State Department of Transportation maintains an active avalanche control program involved with the slide paths affecting approximately 20 kilometers of Interstate 90 in the Snoqualmie Pass area. Three kilometers north of the pass is Alpental which can be considered one of the most avalanche active ski areas in the country. Many of the slide paths controlled by the ski area or the highway crew have cliffs and/or very steep starting zones.

In recent years, three aerial blasting delivery systems have been developed in the Snoqualmie Pass area. Two of these systems lower bombs out over vertical cliffs which have difficult or hazardous access to the edge. The other is a overhead cable system which services convex sloped starting zones above cliff bands. It is a modification of the typical "jiffy wire" installation introduced at previous ISSW presentations by Bridger Bowl personnel. All of these systems were built and installed with a minimum of expense.

LARGE BOMBS

Achieving desired placement of 10 to 25 kg bombs in these areas had been a problem. This size payload has been demonstrated to be effective for Alpental's needs and for highway protection in the respective slide paths. Alpental's use of large bombs has triggered potentially unstable slopes in broad areas up to 500 meters wide. Department of Transportation crews seldom have the opportunity to redo a control route. Timing the period of maximum instability is not as critical when larger bombs are used. Also, after several hundred of these tests, the only postcontrol releases observed have been associated with rapid warming or major snow pack structure change.

When using large bombs, it is important to maintain comprehensive communication with all of the other control teams. Everyone must be in a safe location at the time of detonation to prevent accidents from sympathetically released slides.

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EAST SNOWSHED AREA

The highest priority area for the Department of Transportation in the Snoqualmie Pass corridor is East Shed-4 which slides with virtually every new snowfall. Inspired by Bridger Bowl's practical "jiffy wire" results (Juergens 1984), a similar installation was tested here. R. Dombromski pointed out (Dombronski 1986) that a tightly hung cable serving slopes which drop off steeply from the operating area works best. Unfortunately, the East Shed-4 starting zone starts off nearly flat, proceeds to a convex slope, then drops off steeply over cliffs. This topographic feature is not conducive to simple "jiffy wire" installation because the bombs auger into the snow before they get past the apex of the convexity. Our other high priority area also has a convex sloped starting zone above a cliff band. The drop release carrier and the "Banjo" carrier systems were considered, but we were not sure if they could handle 12 kg bombs without considerable modifications. We wanted an alternative to belaying a controller down into the starting zone to set up a large stick bomb, a method which would get the bomb past the terrain obstruction and still be simple to operate.

VARIABLE TENSION CABLE INSTALLATIONS

The height of the cable in the resulting delivery system is much higher but can be adjusted from the base of the upper terminal tree. The cable is lowered to ground level to attach the bomb and then raised high enough to slide the bomb down the cable over the apex of the convexity to the desired shot placement (see Figure 1). The height adjustment of the cable is achieved by regulating the tension of the cable. The cable originates on a hand-cranked spool which allows adjustment of the cable tension. From the spool, the cable runs vertically through a pulley near the top of the tree and then runs down slope to the lower terminal tree. A stopper on the cable prevents the carrier and bomb from reaching the bottom tree. To operate, the cable is unwound off of the hand-cranked spool. By slacking enough cable off the spool, the down slope segment of the cable lowers into the operating area at the base of the upper terminal tree. The operator then ties the dangle line from the bomb to a simple carrier on the cable. The cable is now cranked back onto the spool which raises the down slope segment of the cable and lifts the carrier and the bomb out of the snow in the operating area. Det cord, laced into the bomb, is reeled out as the bomb is deployed. Gravity pulls the bomb and the carrier down slope, and when sufficient tension is applied to the cable, the bomb is elevated enough to pass over the terrain obstruction enroute to the starting zone. Once the bomb arrives at the target area, the cable tension can be adjusted to raise or lower the bomb to the desired elevation above the snow surface.

Two convenience options that we have found to be helpful are a spool mount and a tag line to the cable. The spool mount is a perforated steel post 2.5 meters in length, lag bolted vertically to the upper terminal tree. As the snow depth increases, the spool can easily be raised to a comfortable working height. A tag line from the operating area to the cable provides quick recovery of the slack cable.

At East Shed-4, we installed a pair of these cable systems to spread out the placement of two 12 kg bombs. We feel that 24 kg of explosives is what we should use here. In the years before the cables were installed, we

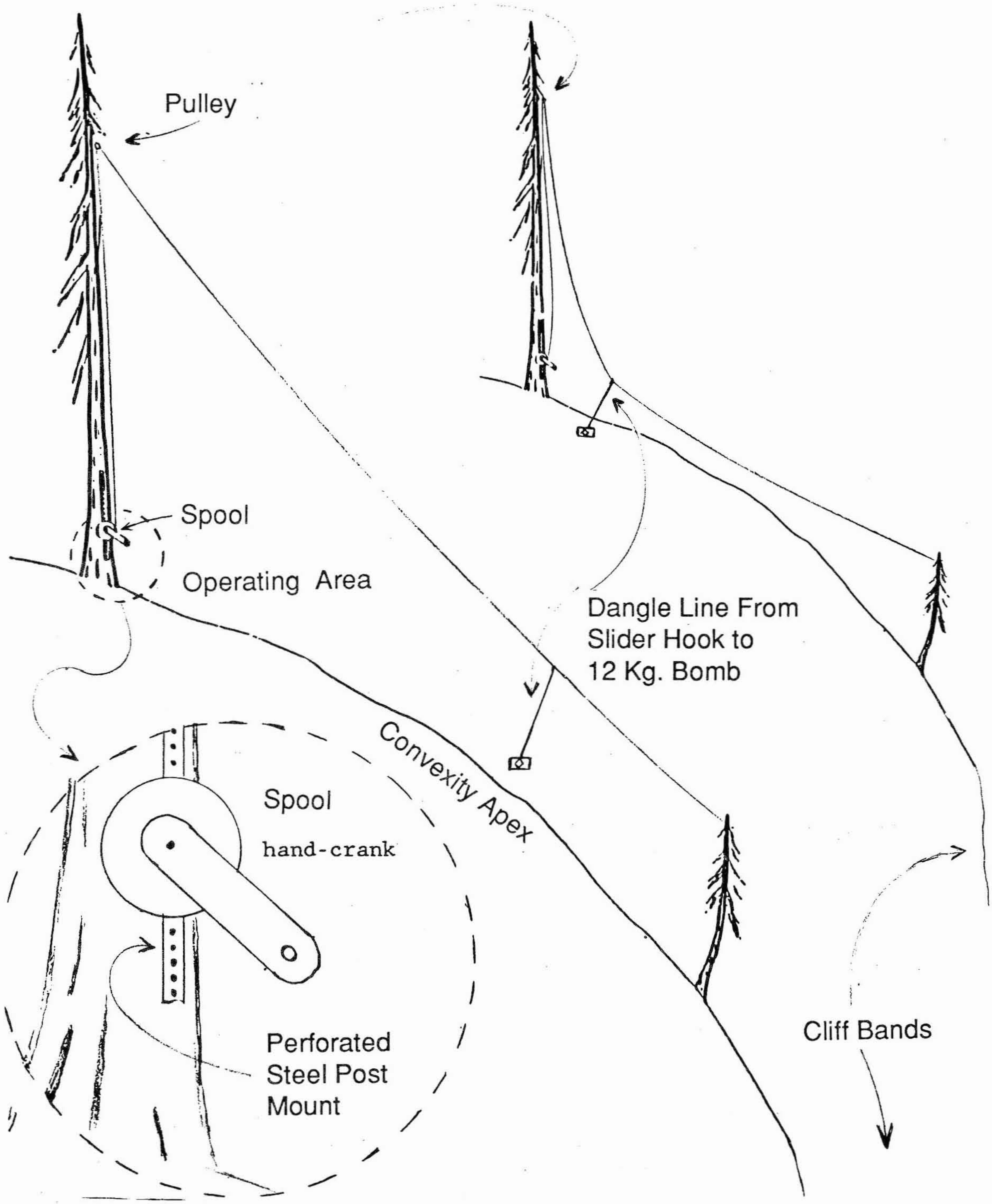

Figure 1.--Variable Tension Cable system (top right) in lowered position for loading bomb carrier and (center) in raised position to deliver bomb past the apex of the convexity. Detail of operating area (lower left).

had observed better results when two 12 kg stick bombs, connected together with E cord, were placed approximately 30 meters apart. One bomb was placed on the east flank and the other slightly west of the center area. The cable to the east flank is almost 40 meters in length, the west cable just over 30 meters. When the bombs each arrive at their desired target area, they are spread out nearly 45 meters apart. Our tests have had even better results triggering the far reaches of the starting zone, especially the difficult far west flank when the 12 kg bombs are elevated relatively high, approximately 3 to 4 meters. This provides a more direct blast angle to those far reaches and minimizes the impact to vegetation in the target area.

We have had problems from our dangle line or retrieve line for the carrier getting snagged on the cable after the explosion. Another problem was the unauthorized person who untied the retrieve line and sent the carrier on a one way trip to the lower terminal. Our solution has been to replace the simple carrier with a disposable slider hook or a split link of chain. The hooks or links travel down the cable almost as smoothly, and no retrieve line is needed. One additional concern we have is that a heavy ice build-up would prevent operation of the system. In the only iced cable launch we have had so far, the slider hook managed to peel all the ice off the cable as it was lowered into place.

Another variable tension cable was installed at the upper Airplane Curve-1 (Bald Knob) starting zone. This cable is only 20 meters in length and took only one day to set up. It has greatly reduced the time consumed and improved the control results when this area is controlled with explosives.

The most recent installation, at East Shed-3, is over 100 meters in length. The one control mission since completion was successful, but some debugging will be necessary.

THE WEST SHED-2 DELIVERY TUBE

An old gas cannon from East Shed-4 was in our gun room, and I started to look for somewhere to store it. I recalled what I assumed was a whimsical suggestion that pneumatic tube delivery systems from drive-up banking operations could be used for shot placement in avalanche control. I wanted to try the 6 meter long, 20 centimeter diameter tube of the cannon for a less complex application more similar to a laundry chute. Since the edge of the cliff above the West Shed-2 path is impossible to get close to with skis on, we hung the tube from trees with one end extended over the edge of the cliff (see Figure 2). The tube is sloped so bombs will slide right down it and out over the cliff. We lower the bomb about 25 meters with a rope which places the bomb about 2 meters above the snow surface in the starting zone. The result is we can now ski directly to the upper end of the tube, deliver the bomb to the starting zone, get the desired aerial detonation, and be on our way in under 5 minutes.

Some convenience features include a spool for easy rope handling, a plug to keep snow out of the tube between control missions, and height adjustment systems for the tube and the spool to move them up or down as the depth of the snowpack changes.

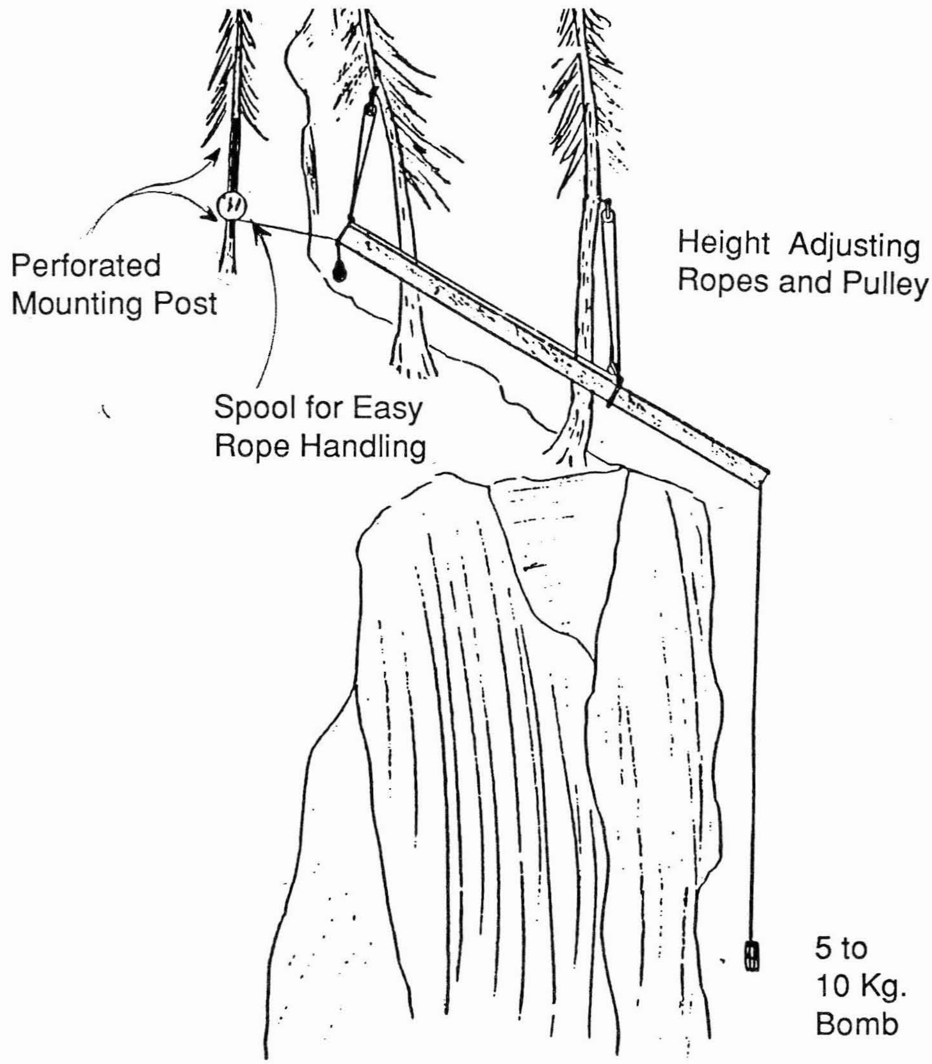

Figure 2.--The West Shed-2 delivery tube.

This system has worked well for us and we are considering additional delivery tubes which will service distances greater than 6 meters. Rigid metal tubing or plastic water pipe is being looked into for these future installations.

THE PIVOTING BOOMS AT ALPENTAL

Several years ago, Alpental Ski Area began experimenting with methods to replace or reduce their dependence on 75mm recoilless artillery. Avalaunchers do not have the range or accuracy needed to control the multiple and complex starting zones in the International Cliffs area. Hand charges, thrown or launched from the top of the cliffs, were not very effective either. The best results were achieved by lowering 22.7 kg (50 lb.) bags of ANFO from the top of the cliffs by rope. Det cord laced into a cast primer inside the bag is spooled out from the top as the bag is lowered. These large air blasts were effective in cleaning out most of the starting zones in a sizable portion of the cliffs. However, the ANFO bags sometimes ended up detonating close to or right against the rock cliffs resulting in rock fragments ending up all over the ski runs below. Ski Patrol Director Mark Matanich alleviated this problem by constructing pivoting booms which suspend the bags further out from the rock cliffs (see Figure 3). This produced a more direct blast angle to the snow in the starting zones improving the triggering performance of the explosion. It also made placement of the bags safer and easier as well as eliminating the rocks on the run. Using the boom and bag system reduced artillery use in the International Cliffs area at Alpental by over 75 percent in the 1987-88 winter. The cost for a 22.7 kg (50 lb.) bag of ANFO plus the booster and nearly 15 meters of E cord used to detonate it is less than $20. The price breakdown for the 1987-88 season was $8/22.7 kg bag ANFO; $3 to $5 depending on if gelatin dynamite or a cast primer is used; $5/det cord; $1 includes cap, fuse, and ignitor. Residents of the area have made a few comments about the loud noise but have, for the most part, grown accustomed to the sound.

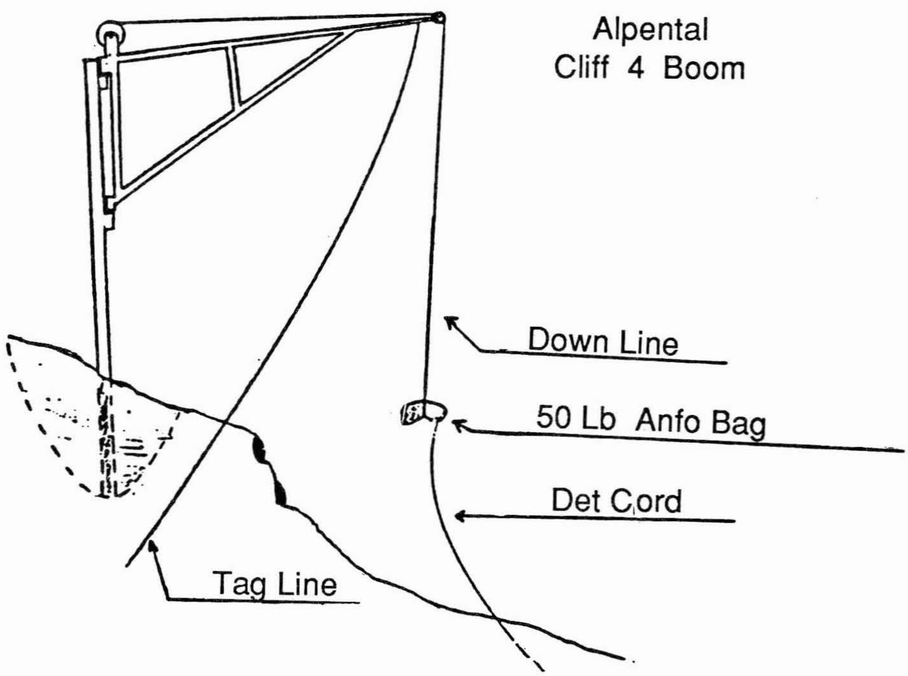

Figure 3.--Typical pivoting boom at Alpental Ski Area.

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