TESTING OF DRONE AVALANCHE CONTROL IN JASPER NATIONAL PARK

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ABSTRACT: Recent technological and regulatory advances in drones have enabled the technology to become a new avalanche control tool. The flexible use of drones has the potential to allow for more geographic versatility than Remote Avalanche Control Systems (RACS) and to reduce human exposure to flight hazards from helicopter-based missions.

In August 2025, Transport Canada issued a Special Flight Operations Certificate to AVSS, allowing for the Canadian-owned, designed, and manufactured Precision Avalanche Management System (PAMS) to move into testing with explosives. Missions were conducted in Jasper National Park in February and March 2026. The Canadian regulatory framework is evolving with the technology and at the time of testing also required compliance with or approvals from Natural Resources Canada, provincial occupational health and safety, and Parks Canada.

The first mission focused on validating flight capabilities and the ignition system in a mountain environment. The drone proved to be a reliable tool for avalanche control from valley bottom, utilizing less than half of the battery's capacity per flight. The second mission assessed operational efficiency, yielding one shot every 15 minutes. Mountain and 'lab' testing of over 300 drops demonstrated a reliable system, with a >99% initiation rate, a >98% drop rate and a >99% target accuracy. One misfire occurred due to the breaking of the crimped pull wires. The pilot was able to utilize the drone to deploy a secondary charge that destroyed the misfire. The hazard was mitigated right away, avoiding human exposure from approaching the charge and bypassing the standard one hour wait time.

Industry feedback from the trials indicates that widespread adoption depends on operational efficiency. The majority of the time during these missions was spent in the air, flying from staging to targets. A multi-charge payload would reduce operational time. Furthermore, the industry has requested the ability to deploy larger explosive charges, such as ANFO bags over the 5lb cast boosters.

KEYWORDS: Drone, Avalanche control, RPAS, UAS

1. INTRODUCTION

Drone avalanche control systems offer an alternative to traditional methods, bringing more geographic versatility than RACS and removing human exposure to flight hazards from helicopter missions. By using commercial delivery drone technology, avalanche control systems can deliver explosive chargers directly into start zones. PAMS was tested throughout the winter 2025-2026 season in Jasper National Park and Ontario, demonstrating it's reliability and efficacity as an avalanche control tool.

2. SYSTEM DESCRIPTION

The PAMS integration is a Canadian owned, designed and manufactured drone avalanche control suite.

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PAMS encompasses both the hardware and software required to complete drone-based avalanche control. During the winter 2025-2026 season, PAMS was used in conjunction with the DJI FlyCart 30.

2.1 Hardwear

The PAMS hardware consists of a drop system and a fuse puller. A 5lb cast booster, 2 safety fuse assemblies and 2 Comet pull wires make up the explosive charge used with PAMS (Figure 1: 2026 PAMS Flight in Jasper, Alberta, Canada). The explosive charge is housed in a SnowDart™, a biodegradable enclosure with the purpose of stabilizing the decent and keeping the cast booster on the surface of the snowpack. The SnowDart™ is secured to the dropper by a nylon strap. Once on the drone, the user crimps the 2 Comet pull wires to the safety fuse and inserts them onto the fuse puller. The fuse puller is situated beneath the drone's camera to allow monitoring during flight.

The DJI FlyCart 30 is a commercial delivery drone capable of operating in high altitude environments up to 6000m, in cold weather down to -20°C, in winds up to 12m/s (43.2km/h) and is rated for use in precipitation of up to 24mm per 24 hours. To ensure practical operational ranges in the mountain environment, flights were conducted using dual-battery configuration.

Figure 1: 2026 PAMS Flight in Jasper, Alberta, Canada

2.2 Software

The Ground Station is a desktop program that facilitates preflight mission planning. The user designates a target waypoint, establishes an allowable drop radius around that target and programs a safe takeoff location and emergency landing zone. This mission is then named and uploaded to the PAMS drop system.

The PAMS software is integrated into the remote controller for field operations. A multilayered safety system ensures that explosives can only be deployed on the designated target and from a safe distance. A status message window displays confirmation of correctly installed fuse, system readiness and that the drone is in the safe take off location, prior to flight. Once in flight this window provides the pilot with directions towards the drop zone. The user cannot deploy the charge while outside the drop zone. Once at the target, the user toggles the arm switch 'on', then they must press and hold the drop button for 3 seconds prior to the explosive being released. Only at this point does the fuse puller lock into position, allowing the pull wires to ignite the fuse. If the charge were to drop prematurely, it would fall free from the drone without igniting. In the event of an in-flight anomaly, the user may emergency jettison the charge, without it being ignited. The user may also force the drone to autonomously fly and land at the preprogrammed emergency landing location.

3. REGULATORY REQUIREMENTS

Testing of the PAMS system in Jasper National Park required approvals from multiple federal authorities, including Parks Canada, Natural Resources Canada and Transport Canada. The regulatory framework governing drone-based avalanche control is evolving rapidly alongside the technology. The team operating PAMS held Transport Canada advanced drone pilot licenses and provincial blasting licenses.

Transport Canada regulations mandated that the drone be operated within visual line of sight. This requirement meant that the team was staged on roads near the avalanche paths and allowed for constant visual contact. At this time, regulations do not allow drone operations to be conducted remotely, where the drone is out of sight.

4. MISSION 1: FEBRUARY 2026

The first mountain field testing occurred on February 2-3rd 2026 with the goal of validating flight capabilities and the ignition system in a mountain environment. A staging area was established at the Medicine Lake Lookout (52.872887, -117.804772) at an elevation of 1460m, with target start zones up to 2415m (Figure 2: AVSS's February 3rd, 2026 testing location at Medicine Lake Slabs, Jasper, Canada).

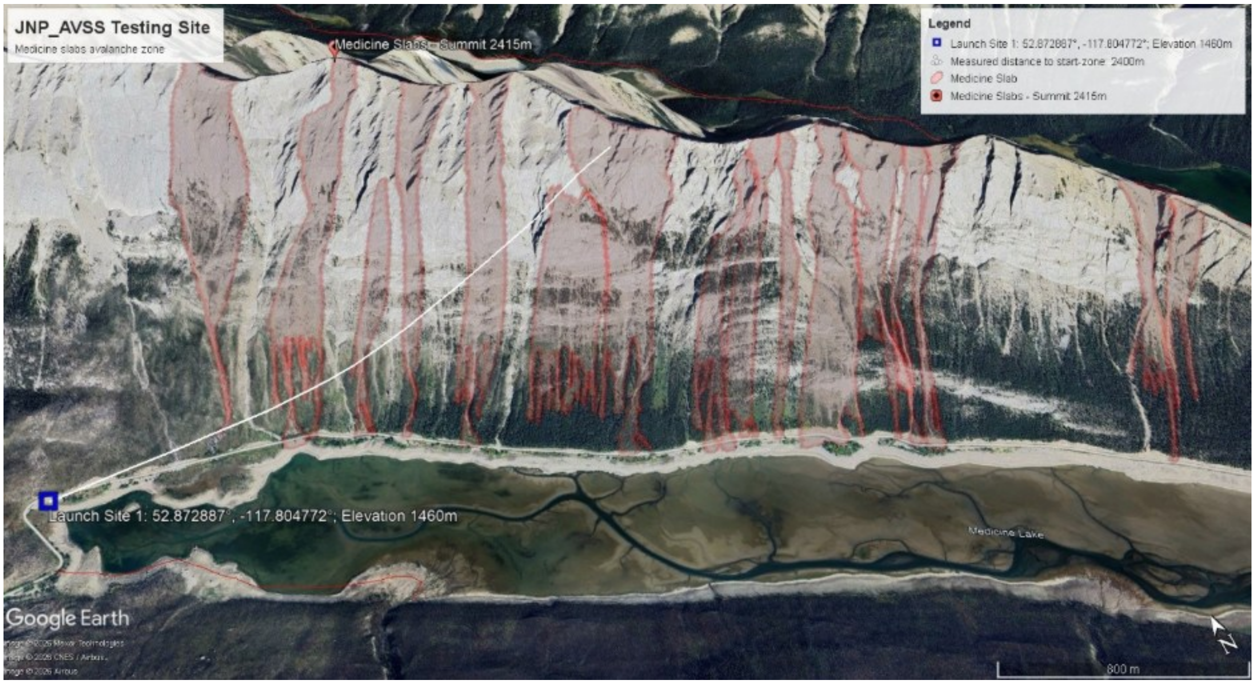

Figure 2: AVSS's February 3rd, 2026 testing location at Medicine Lake Slabs, Jasper, Canada.

Initial flights on February 2nd 2026 were completed with inert payloads to verify the drone's capacity to reach the start zone and measure power consumption. A flight to the start zone covering 1.4km with 850m of elevation gain took 15 minutes and consumed 50% of the drone's dual battery capacity.

Testing on February 3rd transitioned to explosive payloads, consisting of three missions utilizing 5lb cast boosters. Round trip flight times averaged 15 minutes and consumed 45-55% of available battery power. Notably, these flight times were longer than typical operations, as extra time was used for observation and recording.

Both days had light winds from the south and temperatures of -1°C. Avalanche hazard for Jasper National Park was rated Mod/Mod/Low with wind slab and deep persistent slab problems. Recent high temperatures had formed a surface crust. No avalanche results were observed or expected. The hard surface caused 2 of the cast boosters to separate from the SnowDart™ upon landing (dropped from 30 and 70m) and slide down the path. The third drop (from 20m) stuck in the snow as desired.

5. MISSION 2: MARCH 2026

Two additional days of testing occurred in March 2026, with a focus on operational efficiency. March 3rd operations were staged at 52.800503°N 117.688399°W at an elevation of 1570m. The target start zones were situated up to 300m away and 200m above the takeoff point. March 3rd avalanche hazard was rated Con/Con/Mod with persistent slab and wind slab problems. Temperature was 1°C with light SW winds, although drone software measured strong gusts. A total of eight 5lb cast boosters were deployed over a two hour period, resulting in persistent slab avalanches up to size one. Transit time from takeoff to explosive deployment took between 2 and 3 minutes. The team averaged one shot every 15 minutes.

March 4th operations were staged at 52.780412°N 117.689572°W at an elevation of 1600m. The target start zones were situated up to 1.2km away and 450m above the take off point. March 4th avalanche hazard was rated Con/Con/Mod with wind slab and persistent slab problems. Temperature was -2°C with light S winds, although once again the drone recorded strong gusts. Once again, eight 5lb cast boosters were deployed over a two hour window, averaging one shot per 15 minutes. Avalanche results were up to size 1 persistent slabs.

5.2 Misfire

Upon releasing the 6th charge on March 3rd, 2026, the pilot observed that the pull wires remained attached to the drone, despite the SnowDart™ releasing. After landing it was observed that both pull wires had broken at the top of the crimps and a mislight had occurred. The team discussed using the drone to destroy the charge. This would bypass the standard 60-minute wait time, as no human was required to approach the area. The pilot aimed a second charge on top of the first and was able to destroy the misfire. Consultation with the supplier afterwards led to a change in protocols from using 3 crimps to secure the pull wires to the safety fuse assembly to 2 crimps.

Figure 3: Broken pull wires resulting in a mislight.

6. RELIABILITY

While field trials in Jasper National Park provided critical operational validation, four days of mountain testing alone are insufficient to draw conclusions about reliability. To establish more robust performance metrics, larger scale testing of PAMS was conducted throughout the winter in Ontario, cumulating in a total of 305 test drops.

Throughout the 305 tests there were 5 instances where the SnowDart™ failed to release, all a result of user error. These incidences highlight the importance of prominent on-screen warning systems to alert the pilot of abnormalities prior to deployment.

Target accuracy was tracked across all completed drops. The aim was to achieve a shot placement within 1 horizontal meter of the target for every 5m of height above the snowpack from which the payload was dropped (a 1:5 allowance). 300 of the 301 completed drops landed within this designated accuracy range. Furthermore, the majority of drops landed within an much tighter range.

Of the 301 completed drop, 299 successfully initiated the safety fuse in a manner compatible with anticipated detonation. One limitation of Ontario testing venue was that full safety fuse assemblies could not be utilized. Instead, the team used safety fuse without a detonating cap, and spliced a small piece of fuse onto the longer section. This allowed the small spliced piece to light (verified via smoke) while preserving the longer section due to supply chain limitations and avoiding unnecessary burning. Only two mislights occurred across the entire dataset: the mislight in Jasper, caused by broken pull wires at the crimps; and a failure of the splicing mechanism which separated during deployment.

7. INDUSTRY FEEDBACK AND FUTURE STEPS

While testing in Jasper, the team invited observers from ski resorts, industrial avalanche operations and Parks Canada to observe the system. Feedback from these stakeholders highlighted several key areas for future developments. Observers suggested removing the SnowDart™ to expedite charge building in the field and mitigate the tendency of the SnowDart™ to slide on hard surfaces. SnowDart™ construction required the use of tape, which did not stick well in the cold. Between the two Jasper testing trips the SnowDart™ design was modified to remove the need for tape.

A frequent request from operations was the capability to deploy larger explosive charges, such as ANFO bags. As the DJI FlyCart30 has a payload capacity of 30kg, this is possible with the drone and would only require modifications to the drop system. Operators also emphasized that introducing a multi charge system would increase efficiency by reducing the need to return to the staging area between drops. Operational efficiency is paramount, as closure times are costly.

Furthermore, feedback recommended altering the ignition system so that the safety fuse assemblies are not being pulled on during deployment. Finally, operators discussed the need for fully automated missions to reduce the potential for human error. A high reliability automated system may one day open the door for regulations allowing beyond visual line of sight operations.

8. CONCLUSION

The field testing of PAMS demonstrated that drone systems offer a viable alternative or compliment to traditional avalanche control methods. PAMS successfully delivered explosive charges into start zones without exposing workers to avalanche or helicopter hazards. Testing in both Jasper National Park and Ontario demonstrated system reliability. While four days of mountain trials provided crucial initial validation, further mountain use will refine the system. Future development priorities include scaling explosive capacity to accommodate both more and larger charges to increase operational efficiency.