Credit:Höhenarbeit GmbH

Drones for Snow Avalanche Control in Austria

Snow avalanches are a major alpine natural hazard, capable of causing severe impacts on human safety, settlements and infrastructure. They can occur in mountainous regions around the globe when unstable snow releases and slides downslope. In the Alps, most avalanches release on slopes between 30 and 45°, though releases on steeper or slightly gentler slopes have also been reported. Avalanches are most likely during the winter months; in the Alps, avalanche activity typically peaks from December to April. Powder-snow avalanches can reach speeds of up to 300 km/h in steep terrain.

One of the most effective ways to mitigate avalanche risk is to trigger the avalanche deliberately. This prevents the snow from building up and, thus, reduces the potential for large, destructive avalanches. **Avalanche blasting**, also known as **avalanche control or mitigation**, reduces the chance of uncontrolled releases, thus, protecting lives, property, and critical infrastructure. Operational decisions on when and where to conduct avalanche control rely on meteorological forecasts, snowpack stratigraphy, and expert assessment. Common avalanche blasting methods include hand-charges, helicopter-based deployment, the use of military equipment or remote avalanche control systems, and - more recently - high-payload drones.

What is it, where and how is it used?

The system explored in this use case is a relatively new method using drones to ensure safe, reliable, cost-effective, and flexible avalanche blasting. It is a high-altitude drone system developed by the Austrian company Höhenarbeit GmbH, and geared towards avalanche mapping in cooperation with the Austrian Research Centre for Forests (BFW) within the project AvaDrone. The system was specifically developed for triggering avalanches and was first used in 2019 (since then approx. 100 deployments). It has been granted class 1, category C approval by Austro Control, Austria's aviation authority. Its long flight times and strong flight performance facilitate its high-alpine deployment.

The avalanche control process consists of two main stages: avalanche assessment and avalanche triggering. Avalanche assessment involves 3D scanning of the snow-covered terrain to assess the depth of the snowpack and potential blasting points. Avalanche triggering involves assessing the blasting points in accordance with the weather and snow conditions, the drone then navigating to these locations and detonating cartridges to trigger the avalanche.

Technical and organisational aspects

During the assessment stage, a wide range of safety checks are carried out to determine and check the avalanche danger area, using optical and thermal imaging cameras. The used drone is a custom-built high-altitude drone - a hexacopter with a payload of up to 20kg.

Max: 1
Min: -6C
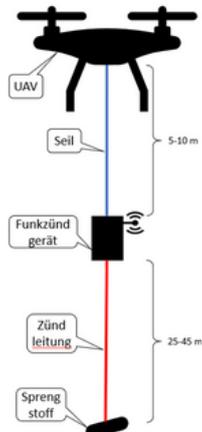*Credit:Höhenarbeit GmbH*

The blasting system is completely separated from the drone and can be cancelled at any time. The cartridges used in the triggering stage are industry standard Emulex AV cartridges which are attached to the drone with a long rope (40-60m). After the drone has flown to the pre-programmed blast point, the charge is detonated electronically by radio, and the next load can be mounted without the need to land in between. This method is shown in the following underline.
Clients using this avalanche control system include state and district authorities, local avalanche commissions, infrastructure providers, as well as avalanche blasting experts in ski areas.

Benefits and effectiveness

The main benefits of the system are: safety (no person needs to be in the danger zone), efficiency (optimal placement above the snowpack), flexibility (can be used anywhere as required), reliability and cost-effectiveness. Additional advantages include: certified solution (certified blasting company), unique integrated system, capacity for synchronous avalanche blasting on large terrain features with drone swarms, authorisation from Austro Control to carry out filming, photography and surveying in Austria, optimisation of the procedure and flexible location choice for blasting points. Compared to traditional methods (e.g., hand-charges, helicopter-based deployment), which are associated with high costs and danger, avalanche blasting via drones is safe, flexible and efficient.

Key challenges

Key challenges include potential constraints from severe environmental and/or weather conditions (e.g., high wind speeds, low temperatures, poor visibility), restricted battery endurance, technical limitations. Additional challenges include: changes and requirements for the approval procedure, ongoing equipment investments, maintenance, and training, as well as communication and navigation difficulties in remote, mountainous, or GNSS-limited areas.

Future potential

Future developments promise autonomous, AI-enabled drones to operate in swarms, beyond visual line-of-sight, and largely without requiring manual control - for a precise and safer remote deployment of explosives, real-time detailed site monitoring, and 3D mapping of snowpacks. These technologies combined with revised procedures and regulations may lead to more flexible and affordable alternatives, with more accurate risk assessments as well as faster and safer blasting operations.

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