

# Ski Patrol and Mountain Safety

## Why Ski Resorts Are a Communications Challenge

A modern ski resort is one of the most punishing RF environments imaginable. Hundreds of vertical metres of complex terrain create deep shadow zones behind ridgelines, cliff bands, and the thick concrete-and-steel patrol huts scattered across the mountain. Existing patrol radios - typically VHF or UHF handheld units - work well on open slopes but fail predictably in terrain hollows, inside buildings, and in lift corridors where metal towers and cables absorb signal. Add -20 °C ambient temperatures, high winds, and the need for rapid one-handed operation while wearing thick gloves, and you have a scenario purpose-built to expose every weakness in a comms system.

LoRa mesh does not replace the ski patrol radio. What it does is fill the gaps: delivering position awareness, automatic check-ins, and short-message coordination in the very zones where voice radio fails.

“ **Mesh is a supplemental coordination tool, not a dispatch or rescue system.** LoRa mesh is best-effort with no guaranteed delivery - messages may be delayed or dropped in the shadow zones, buildings, and lift corridors described above, and positions can be stale or missing. Patrol voice radio (and 911/SAR) remain the primary, life-safety comms channel. Mesh is a passive position-awareness and short-text layer that supplements, never replaces, that infrastructure.

## How Mesh Complements Existing Patrol Radio

# Filling Shadow Zones

A small solar-powered relay node mounted on a lift tower, patrol hut roof, or summit shack can bridge a shadow zone that defeats direct radio contact. LoRa operates at 915 MHz (US) or 868 MHz (EU). Its advantage is not better propagation - 915 MHz is a higher frequency than VHF and actually attenuates more through terrain and foliage - but its high spreading factor (processing gain), which lets the receiver decode signals far below the noise floor and hold a link where a voice radio is unusable. A relay node placed at a high point can provide two-hop coverage from the base lodge toward a remote patrol post with no change to patrol procedures, where line of sight and node spacing allow.

# Position Tracking for Patrol Sweep

At the end of the ski day, patrol sweeps the mountain top-to-bottom to clear all guests. With Meshtastic running on each patroller's device, the incident commander at the base can watch each patroller's last-reported GPS position on a shared map - updated periodically and subject to coverage gaps. When a patroller completes their assigned zone, their icon moves into the clear area - no radio call needed. Missed segments tend to appear visually before the lifts close, though a stale or missing position should be confirmed by voice.

# Automatic Check-In at Aid Rooms

Each first-aid room or patrol hut can host a fixed node acting as a named waypoint. As a patroller's device reports its own GPS position, the base map operator can see when that patroller is at the hut. Note that a packet merely routing *through* a relay node does not by itself report "I am at the hut" - position comes from the device's own GPS, and arrival detection is an inference (or geofencing logic) the map operator applies, not a native automatic node-proximity feature. Supervisors can still see arrivals without requiring the patroller to key up, which is especially useful during high-call-volume periods when radio channels are saturated.

# Cold Weather Node Operation

## The Battery Problem at $-20\text{ }^{\circ}\text{C}$

Lithium-ion cells lose capacity in the cold and can be permanently damaged by deep discharge when cold. At  $-20\text{ }^{\circ}\text{C}$  most Li-ion/LiPo cells deliver only about 50 % of their rated capacity (per Battery University BU-502); this loss is temporary and recovers once the cell warms up. **Critically,**

**never CHARGE a lithium cell (Li-ion, LiPo, or LiFePO4) below 0 °C (32 °F)** - cold charging causes lithium plating, permanent damage, and a latent internal-short fire risk (discharging in the cold is fine). For fixed relay nodes, keeping the battery warm restores most of that lost capacity, so insulated enclosures with a small self-heating element (a few milliwatts of deliberate idle current through a dummy load is one illustrative technique - sizing is engineering guidance, not a fixed figure) can hold the battery above  $-10\text{ °C}$ .

## Boot Batteries vs. Pocket Carry

For patrollers carrying personal devices, the simplest cold-weather solution is body heat. A node or phone running Meshtastic kept in an inner chest pocket or a dedicated battery-warming pouch helps keep the battery near body temperature in most conditions (though garment insulation, activity level, and extreme wind/cold can still pull it down). One suggested DIY approach is an insulated "battery boot" - a neoprene sleeve around the battery pack - worn against the body with only the antenna protruding. Keeping the battery warm this way can substantially extend runtime in extreme cold, since the cold-capacity loss recovers as the cell warms.

## Recommended Hardware for Cold Environments

- **LILYGO T-Echo:** E-ink display is readable in direct sunlight without powering a backlight, reducing battery drain. Compact and pocketable; it has an internal  $\sim 850\text{ mAh}$  Li-ion cell (USB-C charged, no removable/AAA battery) and weighs  $\sim 120 - 130\text{ g}$  cased. Remember the sub-0 °C charge cutoff above.
- **RAK WisBlock with custom enclosure:** For fixed relay nodes, a RAK4631-based build in an IP67 polycarbonate enclosure with 10 W of solar input and a heated battery compartment can support year-round operation *if* the solar sizing and heater budget are validated for the site's winter insolation - deep-winter, snow-covered, low-sun alpine conditions can starve a heated enclosure, so do not assume 10 W is sufficient without checking.
- **Heltec V3 (indoor nodes only):** The OLED display is convenient for indoor patrol huts but is not cold-rated for extended outdoor exposure.

## Specific Ski Patrol Use Cases

### Toboggan Tracking

Attaching a small Meshtastic node to each rescue toboggan provides passive tracking throughout the mountain. Patrol dispatch can see which toboggans are in use, where they are, and roughly how long a rescue is taking - without requiring patrollers to narrate their location over the radio during a technically demanding patient-care situation.

## Rope Line and Closure Zone Monitoring

Boundary rope lines demarcating out-of-bounds areas can host small fixed nodes - but note that a bare Meshtastic node cannot by itself detect that a zone is "unmanned" or that a boundary was crossed. That requires an external sensor and custom logic: for example, wiring a PIR sensor output to a GPIO pin on a RAK WisBlock can create a simple "boundary crossed" alert that sends a mesh message to all patrol devices. Without that added sensor and logic, the node only relays whatever traffic reaches it.

## Out-of-Bounds Alert Zones

Fixed nodes placed at the top of known out-of-bounds access points (gates, gaps in rope lines) can be configured as named waypoints. This only helps for a skier who is already running Meshtastic, on a channel patrol monitors, with position broadcasting enabled, and within RF range of a patrol node - a small minority of the public. For those few, patrol may see a last-known position if the device hops within range of that node. Do NOT treat mesh as a search-and-rescue locating method for the general public: most lost skiers will not carry a compatible node on the right channel, and a dedicated PLB/satellite messenger plus 911/patrol remain the means by which the public is actually found.

## Incident Reporting to Dispatch

When a patroller responds to an injury, the first action at the scene is reporting location and preliminary assessment to dispatch. A GPS pin plus short text can be sent to other patrollers and the patrol room over mesh, usually within seconds where coverage is good - but in shadow zones, buildings, and lift corridors delivery may be delayed or fail. Keep voice radio as the primary incident-reporting channel; treat mesh as a convenient supplement, not the system you rely on for first-on-scene reporting.

## Approaching Resort Management

Ski resorts operate under strict RF licencing conditions and have existing radio infrastructure to protect. When proposing a mesh pilot to resort management, frame it as an *overlay* system that does not interfere with existing channels, not a replacement. Key talking points:

- LoRa operates in the unlicensed ISM band (915 MHz in North America) and cannot legally interfere with licensed patrol radios on VHF/UHF.
- Mesh is a passive position-awareness layer; patrollers keep their radios as primary voice comms.
- A small pilot of three to five devices covering one shadow zone costs under \$200 and produces measurable results in a single patrol day.
- Data stays on-mountain; the mesh does not require internet connectivity to function.

Starting with the patrol director's buy-in on a single-day pilot - rather than a resort-wide proposal - dramatically improves adoption chances. Let the technology prove itself.

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