# Marine and Aviation

- Recreational Boating and Marina Networks
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# Recreational Boating and Marina Networks

Open water offers clear line of sight, low horizon clutter, and the ability to elevate antennas on a mast - all of which favor long-range LoRa links. (Note: the water surface itself causes reflections/multipath rather than low attenuation.) As a best-case over-open-water line-of-sight figure, a modest 6 dBi antenna at 10m above waterline may reach 20-40 km to similarly-equipped vessels; typical results are often lower and depend on the antenna height at both ends, sea state, and transmit settings.

# Marina-to-Vessel Communications

Mesh networking could be used for dock communications where VHF radio is too public and cellular is unreliable when boats are in covered slips or channels.

- **Slip status boards** - Sensor nodes on dock pedestals reporting power usage or water connections
- **Fuel dock coordination** - Fuel dock attendant to harbormaster messaging without shouting or VHF
- **Guest notification** - Message guests in slips about marina events or maintenance shutdowns
- **Pump-out requests** - Environmental dock coordination

# Vessel-to-Vessel Applications

Cruising fleets, sailing clubs, and buddy-boat passages use mesh for fleet coordination:

- **Buddy boat position sharing** - Real-time GPS position of all fleet vessels on a shared map, without AIS equipment costs
- **Anchorage coordination** - Communicate with other vessels in an anchorage when cell service is absent
- **Race committee communications** - Start line to mark boats without dedicated radio infrastructure
- **Float plan check-ins** - Mesh position sharing can supplement a float plan only within mesh coverage, but must not be relied on as the safety mechanism: out-of-range and in-

distress look identical to a shore contact, and no rescue authority monitors the mesh. Mesh has no marine SOS function. For offshore safety use a registered EPIRB/PLB or a satellite messenger with true SOS, plus VHF Ch16/DSC.

# Antenna Installation on Vessels

Marine mesh antenna installation differs from land installations:

- **Masthead mount** - Ideal for sailboats: 15-20m height, 360-degree view. As a best-case open-water figure requiring elevation at both ends, this may reach 30-50 km; typical results are lower. Use marine-grade stainless mounts and UV-stable cable ties. Route coax inside the mast where possible.
- **T-top or hard top** - Powerboats typically mount antennas on T-tops at 3-4m height; best-case calm-water line-of-sight range is around 10-15 km, though real range is often less.
- **Pushpit or stern rail** - Lower but easy to access; use vertical polarization and ensure clear view forward and aft.
- **Connector weatherproofing** - Marine environment is extremely corrosive. Use only marine-rated N-type or sealed SMA connectors; apply self-amalgamating tape over all outdoor connections; inspect annually.

# Integration with Existing Marine Electronics

Using the serial module's NMEA mode, Meshtastic can output its own position (and other nodes' positions) as NMEA 0183 waypoints to a chartplotter, letting the boat's navigation display show mesh nodes alongside other targets. (Note: the node uses its own GPS module for its position; it does not source position from the boat's chartplotter GPS.)

# Search and Rescue Applications

Search and rescue (SAR) operations are one of the most compelling real-world applications for LoRa mesh networking. The combination of off-grid operation, long range, GPS position sharing, and low cost addresses several critical gaps in existing SAR communications infrastructure. Throughout, treat mesh as a supplemental coordination and position-reporting layer, not a guaranteed life-safety system: it is best-effort, low-bandwidth, and has no delivery guarantee, and it does not replace primary VHF/UHF voice. SAR and emergency-services agencies do not monitor Meshtastic by default unless your team has explicitly arranged it.

# Current SAR Communications Gaps

Existing SAR communications rely primarily on VHF/UHF amateur and commercial radio, which has well-known limitations in complex terrain:

- **Shadow zones** - VHF requires line-of-sight; a searcher in a valley cannot communicate with team members on the opposite ridge.
- **Simplex range limits** - Portable VHF often has a rough 1-5 km range in terrain (a rule of thumb only; actual range varies widely with terrain, transmit power, and antenna height); repeaters extend this but require fixed infrastructure.
- **No position reporting** - Standard radio doesn't transmit GPS coordinates; operators must report verbally.
- **Licensing requirements** - Two distinct regimes apply: organized SAR voice radio typically runs under agency/public-safety licensing or amateur Part 97 (which requires an individual license), while LoRa mesh operates under FCC Part 15 on unlicensed ISM spectrum (no operator license). Unlicensed ad-hoc volunteers cannot legally transmit on Part 97 amateur allocations, but they can carry Part 15 LoRa nodes.

# How Mesh Addresses These Gaps

A LoRa mesh deployed for a SAR operation provides:

- **Automatic GPS position sharing** - Every searcher with a mesh node appears on the operations map, with positions sent at configured intervals over best-effort mesh - so the

map shows last-known positions with some latency, not continuous real-time tracking. This only covers nodes on your team's own deployed mesh, not any external SAR infrastructure. It reduces, but does not entirely remove, the need for verbal position reports.
- **Multi-hop relay through terrain** - Mesh relays through intermediate nodes, bypassing terrain shadows that block direct radio. A searcher in a canyon relays through nodes on the ridge above to reach incident command.
- **No license required for ISM band operation** - Civilian volunteers can carry nodes without licensing (FCC Part 15, unlicensed ISM band).
- **Days of battery life** - An nRF52840 node can run on the order of days on a small LiPo, but actual runtime depends heavily on battery capacity and configuration (GPS interval, transmit rate, sleep settings). Specify the battery capacity and node config for your build, and carry spare power for multi-day operations rather than relying on a fixed runtime.
- **Reroutes around lost nodes where alternate paths exist** - Meshtastic's managed-flood routing will reroute around a lost or damaged node when another path is available, but this is not guaranteed self-healing: if a node was the only bridge across a stretch of terrain, losing it severs that path with no alternate. Deploy redundant relays so no single node is a single point of failure.

# SAR Deployment Architecture

1. **Incident Command (IC) node** - Laptop or tablet running Meshtastic app; receives all position reports and messages from field teams. The IC node can optionally be bridged via MQTT to a cloud map, but only do so if a specific agency has explicitly agreed to monitor it. County OES and SAR agencies do not monitor Meshtastic feeds by default - never assume external eyes are on your feed without a confirmed, pre-arranged agreement.
2. **Hilltop relay nodes** - 2-4 battery-powered repeater nodes placed on high terrain at the search area perimeter, creating mesh backbone coverage. Carried by support personnel or cached at ridge lines.
3. **Team leader nodes** - Each search team leader carries a dedicated mesh node for position reporting and messaging. A smartphone running the Meshtastic app is a usable interface for team leaders, but the phone alone cannot join the mesh - it must be paired over Bluetooth to a Meshtastic LoRa hardware node. The smartphone is the interface, not the radio.
4. **Subject detection consideration** - A mesh node left at the last known point (LKP) can serve as a reference beacon visible to all searchers on their maps.

# Coordination with Existing SAR Infrastructure

Mesh networking complements rather than replaces existing SAR radio systems. Plan for:

- Primary VHF/UHF team radio continues for voice coordination
- Mesh supplements with position data and text messaging
- Interoperability: IC node can have both mesh and VHF capability
- Pre-incident training: all team members should practice with mesh before an actual deployment (a general comms-training best practice, consistent with SAR training doctrine)

# Mountain and Wilderness SAR Specifics

For wilderness SAR in mountainous terrain, you can pre-deploy mesh infrastructure by caching solar repeater nodes at known high points (trailheads, summit areas, saddles). Pre-positioned nodes can speed initial coverage, but they do not guarantee "instant" coverage: cached nodes may be dead when activated months later (battery or solar failure, snow-covered panels, weather damage, theft), and coverage only exists where searchers fall within range of the pre-placed nodes - which a search, by definition, cannot guarantee. Verify that every cached node is live at activation, treat mesh as best-effort and as a supplement to primary VHF/UHF voice, and have field teams carry portable nodes as backup rather than relying on the cached backbone.