Deployment and Operations

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Deploying Mesh Networks in Disaster Scenarios

Overview

Deploying a LoRa mesh network during an active disaster differs significantly from a planned exercise. Speed, improvisation, and integration with an active ICS structure are paramount. This page walks through the complete deployment sequence from pre-event staging through live operations.

Pre-Event Staging

The most effective disaster mesh deployments begin well before the event. Pre-staging includes:

- **Fixed relay nodes at key sites**: EOC, hospitals, Red Cross shelters, CERT caches, and strategic high-elevation points (water towers, fire stations) should have permanently installed relay nodes maintained on standby power.
- **Go kit pre-positioning**: Portable node kits stored at ARES/RACES deployment caches, pre-configured with the operational channel and node names.
- **Firmware and configuration freeze**: Two weeks before a forecast event (hurricane, wildfire season), freeze firmware versions and push final channel configurations. Do not update during an active event.
- **Battery maintenance**: Charge all battery systems to 100%. LiFePO4 cells should be stored at approximately 50% if not in active standby; bring to 100% 24-48 hours before expected deployment.

Rapid Deployment Sequence

1. **Receive activation order** from COML or ARES EC. Confirm assigned tactical node name, channel plan, and check-in frequency and interval.
2. **Travel to assigned position** with go kit. Log departure time in ICS 214.
3. **Conduct site survey**: Identify best antenna elevation point. Note any obstructions (buildings, terrain, foliage).
4. **Deploy antenna**: Elevate to maximum practical height. Secure coax and weatherproof connections.

5. **Power up node**: Allow 2-5 minutes for GPS cold fix. Confirm node name and channel in Meshtastic app.
6. **Test connectivity**: Send a check-in message to EOC-MAIN. Confirm receipt acknowledgment (green checkmark in Meshtastic).
7. **Report to COML**: Via voice radio or mesh message - node name, location (GPS coordinates or address), battery level, estimated endurance, node count visible.
8. **Begin ICS 214 log**: Record activation time, location, initial node count, and all subsequent events.

Antenna Elevation Strategies

In disaster environments, traditional antenna mounting points may be unavailable or unsafe. Practical options:

- **Vehicle rooftop**: Magnetic mount antenna on a metal vehicle roof is fast to deploy and provides 2-4 meters of elevation above grade. Most effective in flat terrain or when working in a parking lot staging area.
- **Temporary mast**: A 3-6 meter telescoping fiberglass push-up mast (e.g., MFJ-1910 or equivalent) with a ground stake can be deployed in under 5 minutes by one person. Provides significant elevation advantage.
- **Existing structure attachment**: In urban rubble environments, attaching a whip antenna to any surviving elevated structure (fence post, utility pole stub, intact second-floor window frame) can provide 3-6 meters of elevation with minimal equipment.
- **Balloon lift**: For extended fixed relay in flat terrain, a helium balloon can lift a lightweight node and antenna to 10-30 meters. Requires tether management and calm wind conditions.

Frequency Coordination with Served Agency

Confirm that your LoRa channel center frequency does not conflict with LoRaWAN sensors already deployed by the served agency (e.g., flood sensors on 915.2 MHz). The Meshtastic default US channel preset should be checked against the agency sensor inventory. Document the agreed channel in ICS 205.

Mesh Topology for Disaster Environments

Topology	Description	When to Use
Star (hub-and-spoke)	All field nodes communicate directly to a central elevated relay. No inter-node routing.	Open flat terrain; EOC has excellent elevation; small node count (fewer than 10).
Mesh (peer-to-peer)	Every node routes for every other node. Messages hop through multiple nodes to reach destination.	Urban rubble; blocked line-of-sight; large geographic area; many nodes.
Chain (linear relay)	Nodes placed in a line to extend range along a corridor (road, valley, ridge).	Evacuation corridor monitoring; search teams moving along a defined route.

Key insight: In rubble environments, more hops equals more coverage. A message that travels through 3 intermediate nodes to reach a buried receiver can succeed where a direct link cannot, because the signal is re-transmitted at full power at each hop. Meshtastic supports up to 7 hops by default (configurable). Do not reduce max hop count below 3 in disaster deployments.

Interface with ICS Structure

The mesh network is a resource managed by the Communications Unit within the Logistics Section. All operational changes (channel reassignment, node redeployment, shutdown) require authorization from the COML. Field mesh operators report to the COML, not directly to Operations. When Operations Section needs to reach a field team via mesh, the request flows: Operations Chief to COML to mesh operator to field node. This chain maintains ICS unity of command and ensures communications changes are coordinated.

Net Control Operations for Mesh Networks

Mesh vs. Voice Net Control: A Fundamental Difference

In a traditional amateur radio voice net, the Net Control Station (NCS) is the technical and operational hub of all communications - every transmission must be directed through or acknowledged by NCS. LoRa mesh networks operate on a fundamentally different principle: they are peer-to-peer systems where any node can transmit at any time, and the mesh protocol automatically routes messages to their destination without a central controller.

Despite this, the operational role of a net control function remains valuable and is recommended for any mesh network supporting an ICS activation. The difference is that mesh net control is a human coordination role, not a technical gatekeeping role.

Responsibilities of Mesh Net Control

- **Node inventory management**: Maintain a current list of all active nodes (name, operator, location, battery endurance). Update at each operational period change and whenever a node is added or goes offline.
- **Coverage verification**: Confirm that all assigned positions have mesh connectivity, either directly or via relayed path. Nodes that cannot reach any other node are isolated and may need repositioning.
- **Channel discipline**: Monitor for excessive traffic (bulk test messages, repeated retransmissions) that degrades bandwidth for others. Coordinate with the COML to address violations.
- **Liaison to COML**: Translate mesh network status into ICS-compatible status reports for inclusion in the Incident Action Plan.
- **Escalation to voice radio**: When mesh connectivity fails between critical nodes, immediately escalate to the voice radio net for the affected link. Do not wait for the mesh to self-heal if the message is time-sensitive.

Structured Check-In Procedure

At the start of each operational period (typically every 12 hours in ICS), mesh net control should conduct a structured check-in:

1. Net control sends a broadcast message to all nodes: [OPPERIOD-2 CHECK-IN] All nodes reply with status. EOC-MAIN standing by.
2. Each node replies with a short status message: SHELTER-A: ONLINE, 85% battery, 4 nodes visible, 12 persons checked in.
3. Net control logs each reply in the ICS 214 activity log, noting time of receipt and node status.
4. Nodes that do not reply within 5 minutes are flagged as missing. Net control attempts contact via voice radio before declaring the node offline in the ICS 217A.

Tracking Node Count and Coverage

Meshtastic provides a node list in the app showing all nodes heard (directly or via mesh). Net control should maintain a separate paper or spreadsheet log that includes:

Node Name	Operator	Location	Last Heard	Battery %	Status
EOC-MAIN	W6XYZ	City EOC Rooftop	Continuous	AC Power	ONLINE
SHELTER-A	KD9ABC	Franklin HS Gym	14:32	78%	ONLINE
DIV-B-RELAY	N7DEF	Oak Ave Water Tower	14:28	62%	ONLINE
SEARCH-1	KG5GHI	Mobile (Grid 4)	14:05	45%	MONITOR

Handling Message Relay Requests

Although the mesh automatically routes messages, operators at field positions may request manual relay assistance when:

- A message requires confirmation of delivery (the mesh protocol delivers best-effort; a human relay provides certainty).
- The message contains sensitive information not suitable for broadcast (use the DM/direct message channel in Meshtastic).
- An ICS 213 form needs to be transcribed to paper at the EOC.

Net control should acknowledge all relay requests and confirm delivery to the originating node when the message has been received by the intended party.

Escalation to Voice Radio

Mesh net control must be prepared to escalate to voice radio immediately when:

- A node has been offline for more than 10 minutes without explanation.
- A critical message (MCI report, EOC request, shelter closure) has not been acknowledged within 5 minutes.
- The mesh channel appears to be experiencing congestion or RF interference (excessive retransmissions, failed acknowledgments).
- Any node reports battery below 20% without a relief operator on the way.

The voice radio escalation path should be pre-coordinated: establish the tactical frequency and call sign of the COML before the operational period begins, and ensure mesh net control has a radio capable of reaching EOC.

Log Keeping

Net control must maintain a continuous ICS 214 activity log throughout the operational period. Minimum entries:

- Activation and deactivation times for each node.
- All check-in responses and any non-responding nodes.
- Channel changes, configuration updates, or firmware actions taken.
- All message relay confirmations for ICS 213 traffic.
- Battery status at each check-in interval.
- All voice radio escalations and outcomes.

At the end of each operational period, the ICS 214 is submitted to the Documentation Unit in the Planning Section for inclusion in the incident file.

Integration with Winlink and APRS

The Complementary Stack

No single communications technology is sufficient for all emergency communications scenarios. The most resilient deployments combine multiple systems that complement each other's strengths. The three-layer stack of LoRa mesh plus Winlink plus APRS provides digital messaging, store-and-forward email, and position tracking - covering the primary data needs of an ICS-integrated emergency communications response.

Winlink Overview

Winlink is a worldwide radio email system that allows licensed amateur operators (and, under certain authorizations, non-amateur stations) to send and receive email messages via radio. Key components:

- **Winlink Common Message Server (CMS)**: The cloud-based message store operated by the Winlink Development Team. Messages are held until retrieved by the recipient.
- **Radio Message Server (RMS)**: A gateway station (typically a licensed operator's station with a TNC and radio) that provides radio access to the CMS. RMS gateways exist on HF (Pactor, VARA HF), VHF/UHF (Packet, VARA FM), and experimental LoRa modes.
- **Client software**: Winlink Express (Windows) or Pat Winlink (cross-platform, open source) are used by operators to compose messages and connect to RMS gateways.

Building a Winlink Gateway for ICS Form Delivery

A Winlink RMS gateway co-located with a mesh EOC node creates a powerful hybrid: field operators compose ICS 213 messages on a mesh-connected device, and those messages are forwarded to the EOC node which relays them into the Winlink system for delivery to served agency email addresses.

Hardware Required for a VHF/VARA FM Gateway

- VHF FM transceiver (e.g., Icom IC-7100, Kenwood TM-D710)
- Sound card interface or VARA FM modem (e.g., Digirig Mobile)
- Windows PC or Raspberry Pi running Winlink Express or Pat
- Internet connection to CMS (for a full gateway); or peer-to-peer mode for offline operation

Configuration Steps (VARA FM)

1. Install VARA FM modem software and configure audio levels to the transceiver.
2. Install Winlink Express. Configure station call sign, grid square, and VARA FM as the primary radio mode.
3. Enable RMS Relay mode in Winlink Express to accept connections from client stations.
4. Register the gateway with the Winlink network (requires licensed callsign and internet access at least once for initial registration).
5. Test by connecting with a second station using Pat or Winlink Express in client mode.

ICS 213 forms composed in Winlink Express are transmitted as structured email attachments. Served agencies with standard email can receive these forms without any special software.

APRS as a Parallel Position Tracking Layer

Automatic Packet Reporting System (APRS) operates on 144.390 MHz (North America) and provides real-time position reporting, weather data, and short messaging via a nationwide network of digipeaters and I-gates (internet gateways). APRS complements Meshtastic mesh in the following ways:

Feature	Meshtastic Mesh	APRS
Position tracking	Yes (GPS, within mesh coverage)	Yes (GPS, nationwide via digipeaters)
Text messaging	Yes (encrypted, multi-hop)	Limited (unencrypted, short messages)
Internet connectivity required	No (self-contained mesh)	No for local; yes for APRS-IS
License required	No (ISM band)	Yes (Technician or higher)
Nationwide coverage	Only where mesh nodes exist	Yes (existing infrastructure)
Typical range per hop	2-15 km	10-100 km via digipeater

A field operator equipped with both a Meshtastic device and a VHF APRS tracker (e.g., Mobilinkd TNC with a handheld radio, or a Kenwood TH-D74) provides redundant position visibility: the EOC can track them on the local mesh map AND on aprs.fi via APRS-IS.

Mesh + Winlink + APRS: The Complete Stack

When all three systems are operational, the complementary roles are:

- **LoRa Mesh (Meshtastic)**: Short-range encrypted text messaging, welfare check-ins, ICS 213 relay within the incident area, GPS position sharing among mesh-equipped operators.
- **Winlink**: Store-and-forward email delivery for ICS forms to served agency recipients, long-haul message delivery via HF when VHF infrastructure is unavailable, formal record of messages (timestamped, archived).
- **APRS**: Nationwide position tracking for mobile operators outside mesh coverage, real-time map display on aprs.fi for remote coordination, weather object broadcasting.

Tools and Software

Tool	Platform	Purpose
Meshtastic app	iOS / Android / Web	Mesh node control, messaging, map view
Winlink Express	Windows	Winlink client and gateway software; ICS form templates included
Pat Winlink	Linux / macOS / Windows / Raspberry Pi	Open-source Winlink client; CLI and web UI; ideal for headless gateway builds
Direwolf	Linux / Windows	Software TNC for APRS and Winlink Packet; runs on Raspberry Pi
YAAC / APRSdroid	Java (desktop) / Android	APRS client for tracking and messaging
atak-forwarder	Android (ATAK plugin)	Forwards Meshtastic positions into ATAK/WinTAK for ICS TAK server integration

Practical Integration Workflow

1. Pre-event: Configure all mesh nodes on the agreed channel. Pre-load ICS 213 message templates on devices used by served agency liaisons.

2. At EOC: Stand up Winlink gateway on VHF. Confirm Pat or Winlink Express can reach a CMS. Test ICS 213 form delivery to served agency email.
3. At EOC: Enable APRS I-gate (via Direwolf and VHF radio) to provide internet-visible position tracking for all APRS-equipped operators.
4. Operations: Field operators use Meshtastic for local comms. When a message must reach a served agency email (hospital, county OES), it is forwarded to the EOC mesh node and injected into Winlink for delivery.
5. Position tracking: EOC staff monitor both the Meshtastic map (local, encrypted) and aprs.fi (wide area) to maintain situational awareness of all resources.