# Integration with Existing Systems

# Mesh and Amateur Radio (ARES/RACES)

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LoRa mesh and traditional amateur radio serve complementary roles in emergency communications. Understanding how they fit together helps you deploy each where it is most effective.

## What ARES and RACES Are

**ARES (Amateur Radio Emergency Service)** is an ARRL program where licensed amateur radio operators provide emergency communications for served agencies (Red Cross, hospitals, government agencies). **RACES (Radio Amateur Civil Emergency Service)** is authorized under 47 CFR §97.407, sponsored by FEMA, and activated only by the responsible state or local emergency-management (civil-defense) authority.

Both programs have established protocols, training requirements, and communication plans. They operate on licensed amateur radio frequencies with trained operators. Note: the LoRa mesh described on this page operates on the 915 MHz ISM band under FCC Part 15, **not** on the amateur frequencies used by ARES and RACES. Default-encrypted Meshtastic traffic cannot lawfully be moved onto amateur bands — 47 CFR §97.113(a)(4) prohibits messages encoded to obscure their meaning — so mesh does not simply join the amateur allocation.

## Where Mesh Fits In

| Capability | Amateur Radio | LoRa Mesh |
|---|---|---|
| Voice communications | Yes - primary strength | No - text/data only |

| Capability | Amateur Radio | LoRa Mesh |
|---|---|---|
| License required | Yes - FCC license required | No, when operated under Part 15 on the 915 MHz ISM band — using FCC-certified equipment at up to 1 W (30 dBm) conducted, on a non-interference, must-accept-interference basis* |
| Served agencies | Hospitals, Red Cross, EOC | Neighborhoods, community groups |
| Long-range links | HF (worldwide), VHF/UHF regional | LoRa: up to ~20 - 50+ km only in ideal hilltop-to-hilltop line of sight; typically far less (often <5 km) between handhelds in real terrain† |
| Text messaging | Winlink, APRS, packet | Native; all nodes capable |
| Deployment cost | $100 - $1,000+ per station | $20 - $60 per node |
| Deployment speed | Requires trained operator | Any community member, once the network and presets are pre-configured |

*915 MHz mesh is unlicensed under Part 15 (1 W conducted, EIRP-capped, FCC-certified equipment). Running mesh on amateur bands instead requires a license and caps spread spectrum at 10 W PEP with no encryption.
†The 20–50+ km figure is a best-case clear-line-of-sight hilltop-to-hilltop direct link, not typical operational coverage; all delivery is best-effort. Treat these as ceilings, not planning numbers — see Realistic Range and Coverage Expectations.

# Practical Integration Model

A realistic combined deployment:

- **Neighborhood layer (LoRa mesh):** Blocks to ~1-3 miles, more with elevated repeaters - coordination among neighbors, location sharing, welfare checks. No amateur license required when operated under Part 15 (FCC-certified equipment, 1 W conducted, EIRP-capped); any resident can deploy a node.
- **Regional layer (VHF/UHF amateur):** Repeater-linked coverage across a county or metro area. Requires licensed operators; handles voice coordination between neighborhoods and EOC.
- **State/national layer (HF amateur):** Winlink gateways and HF nets for long-distance traffic when regional infrastructure is compromised.

# For Amateur Radio Operators

If you hold an amateur radio license, consider:

- Deploying LoRa mesh alongside your existing radio setup to provide text/data capability for neighbors who don't have radio licenses. **Keep LoRa mesh on unlicensed Part 15 (902-928 MHz) frequencies. Do NOT run encrypted Meshtastic/MeshCore traffic on amateur bands** — 47 CFR §97.113(a)(4) prohibits messages encoded to obscure their meaning, and unlicensed neighbors may not transmit on amateur spectrum at all.
- Using LoRa mesh for neighborhood coordination while using your radio for ARES/RACES served agency traffic
- Advocating for LoRa mesh within your ARES group as a force multiplier for neighborhood-level coverage

# Realistic Range and Coverage Expectations

## Realistic Range and Coverage Expectations

Understanding realistic range helps you plan deployments, set expectations with community members, and know when a link will or won't work. The figures below are drawn from real-world community mesh experience and represent **best-case, line-of-sight (LOS) conditions** with good antenna placement. They are *not* guarantees — actual range varies widely with terrain, foliage, and node placement. For planning purposes, use the conservative "Planning Conservatively" figures lower on this page, not the upper end of the tables below.

## Direct Link Range (No Repeaters)

The ranges below assume reasonable line-of-sight clearance. They are best-case figures; obstructions, foliage, and ground-level placement will pull the low end down further.

| Environment | Typical Range (LOS, best case) | Limiting Factor |
|---|---|---|
| **Urban (street level)** | 1 - 3 km typical (up to ~5 km with favorable LOS) | Buildings blocking line of sight; multipath interference. Dense cores often closer to ~1-2 km. |
| **Suburban (rooftop-to-rooftop)** | 5 - 15 km (requires clear LOS between elevated antennas) | House heights, trees; rooftop placement and clear LOS dramatically improve range |
| **Rural (ground level)** | 5 - 15 km (with reasonable clearance) | Terrain, vegetation; dense vegetation or rolling terrain can reduce the low end well below 5 km |
| **Rural (hilltop-to-hilltop)** | 20 - 50+ km (ideal case only) | Primarily limited by earth curvature and Fresnel zone clearance. The 50+ km figure is a rare ideal-case top end requiring full clear LOS and Fresnel clearance — plan below it routinely. |

| Environment | Typical Range (LOS, best case) | Limiting Factor |
|---|---|---|
| **Flat terrain (North Dakota, Great Plains)** | 15 - 30+ km even at modest height (estimate) | Minimal obstructions; earth curvature/Fresnel clearance, not obstructions, dominate over open flat ground |

# With Mesh Hops

Each repeater hop extends coverage. In ideal hilltop-to-hilltop conditions, a chain of three repeaters spaced ~30 km apart can reach ~90+ km — but only if *each* link has clear line of sight and Fresnel clearance, which is a best case rather than a typical result. Note also that Meshtastic caps routing at a maximum of 7 hops (default 3). The mesh topology means messages can route around failed nodes only when an alternative path with adequate RF connectivity exists.

# Key Factors Affecting Range

- **Antenna height:** The single most impactful variable. As a rule of thumb, going from ground level to a 10-meter rooftop can roughly double or triple range by clearing Fresnel-zone obstructions.
- **Antenna gain:** A 5 dBi external antenna vs. a PCB trace antenna provides a significant range improvement (often roughly 2-3x in line-of-sight conditions; the exact gain is nonlinear and environment-dependent).
- **Spreading factor:** Higher SF (e.g., SF12 vs. SF7) adds roughly 15-18 dB of link budget — a meaningful range gain whose multiplier depends on terrain (free-space ~3x; less in obstructed paths) — while drastically cutting data rate and multiplying time-on-air (roughly 20x+ from SF7 to SF12). Treat the range gain as significant but environment-dependent, not a fixed multiple.
- **Terrain:** Line-of-sight clearance is critical. As an illustrative example, even a small hill between two nodes can collapse range dramatically (e.g., from ~20 km to ~2 km) through knife-edge diffraction loss.
- **Vegetation:** Dense forest canopy attenuates 915 MHz signals significantly. Summer foliage can reduce range compared to winter.
- **Buildings:** Each wall the signal passes through attenuates the signal. Inside-to-inside through multiple walls can reduce range to under 1 km.

# Planning Conservatively

For emergency planning, use these conservative estimates rather than the best-case table figures above:

- Inside a building: assume 300 - 500 m reliable range
- Outside in urban area: assume 1 - 2 km reliable range

- Rooftop with external antenna: assume 5 - 10 km reliable range (with clear LOS)

Actual coverage may be better, but plan for the conservative case. Use MeshMapper wardriving to measure actual coverage once deployed - real measurements beat estimates every time.

# Use Coverage Planning Tools

Before deploying, model your site with the tools below. Tool availability as of mid-2026; some are community- or region-specific and may move or go offline — verify each link resolves before relying on it.

- heywhatsthat.com - radio horizon from a specific location
- nodakmesh.org/tools/node-planner - topo + satellite with live node visibility (region-specific community tool; verify it is still maintained)
- radiomobile.pe1mew.nl - advanced RF propagation modeling