Realistic Range and Coverage Expectations

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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

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