High-Power Mountain Repeater Build (~$200)

⚠ **FCC COMPLIANCE WARNING — READ BEFORE BUILDING:** Under FCC Part 15 (47 CFR §15.247) the 902–928 MHz band has a hard **conducted-output ceiling of 1 W (30 dBm)** at the coax, referenced to an antenna of up to 6 dBi. This conducted limit applies *before* antenna gain is considered, and the derived EIRP ceiling is **36 dBm (4 W)** with a 6 dBi antenna (above 6 dBi, conducted power must be reduced 1 dB for every 1 dB of gain). An external RF amplifier almost always pushes conducted output over 30 dBm, which is **illegal for unlicensed Part 15 operation**. A "2 W" (33 dBm) amplifier exceeds the limit outright and must not be used unlicensed. Higher power is only lawful under an **amateur (Part 97) license** — and Part 97 **prohibits encryption** (47 CFR §97.113(a)(4)), so Meshtastic/MeshCore default AES channels must be **turned OFF**, and you must identify by callsign at least every 10 minutes (§97.119). **Measure your conducted output with a power meter before deploying.**

This build is designed for demanding deployments - mountain summits, ridge lines, or any site that needs extended range and the ability to survive winter conditions. It pairs a LilyGO T-Beam with a LiFePO4 battery bank and a robust MPPT charge controller. Note that any external RF amplifier option must be operated within the FCC limits described in the warning above — under Part 15 the total conducted output may not exceed 1 W (30 dBm), and most "1 W" amplifier modules will only be legal if the modem drive is reduced so the amplifier's *output* stays at or below 30 dBm conducted. A 2 W amplifier cannot be operated legally under Part 15.

Parts List

Prices are approximate and volatile (as of 2026-06-08); verify current pricing and component availability before ordering.

Part	Approx. Cost
LilyGO T-Beam v1.1 (ESP32 + SX1276/SX1262 + GPS + 18650 holder). Note: v1.1 has been largely superseded by v1.2; SX1276 variants max ~17-20 dBm vs SX1262 ~22 dBm.	~$35

Part	Approx. Cost
Documented LoRa power-amplifier module *(verify the datasheet — e.g. a RAKwireless 1 W LoRa booster or a documented E22-900M30S module). A 1 W (30 dBm) PA is the maximum that can be made Part-15-legal, and only if the modem drive is reduced so the PA output does not exceed 30 dBm conducted. Do NOT use a 2 W (33 dBm) module for unlicensed operation — it exceeds the FCC limit.)*	~$40 - 60
10W 12V monocrystalline solar panel	~$20
Genasun GVB-8 or Victron SmartSolar 75/10 MPPT charge controller (the ~$35 low end may be optimistic for a genuine MPPT unit)	~$35 - 90
LiFePO4 battery, 12V 10Ah	~$45
Inline fuse (3-5 A) for the battery positive lead, plus a battery disconnect/switch	~$5
Fibox TEMPO weatherproof polycarbonate enclosure (confirm the exact part number, dimensions, and stated IP rating — Fibox TEMPO is rated IP65/IP66/IP67 depending on the listing)	~$30
LMR-200 low-loss coax, 1m + N-type connectors (crimped or soldered)	~$15
6 dBi fiberglass omni antenna, N-type, 915 MHz (real gain must be at or below 6 dBi to stay within 36 dBm EIRP at full legal conducted power)	~$25
Mounting hardware (J-pipe mount, stainless U-bolts, mast)	~$20
Total	**~$200 - 250**

Key Design Considerations

Power Amplifier & Heat Management

A LoRa power-amplifier module requires a supply rail (typically 12V, taken from the LiFePO4 battery or a regulated bus — check the specific module's input voltage and current spec). At ~1W RF output with a typical class-AB PA efficiency around 25%, the amplifier draws ~4W DC and dissipates roughly 3W as heat (actual figure depends on the module's efficiency, typically 2-4W). Mount the amplifier board against an aluminum bracket that contacts the enclosure wall, or add a small heatsink with thermal paste. Without adequate thermal management, output power will derate and long-term reliability will suffer.

EIRP & Regulatory Compliance

Under FCC Part 15 at 902-928 MHz (47 CFR §15.247) the limit is **30 dBm (1 W) conducted** at the coax with an antenna of up to 6 dBi gain. For antennas above 6 dBi, conducted power must be reduced 1 dB for every 1 dB of gain above 6 dBi. Combining a true 1W (30 dBm) conducted output with a 6 dBi antenna yields 36 dBm EIRP — and that 36 dBm EIRP figure is the derived ceiling *only* with a 6 dBi antenna at full legal conducted power; it is not a universal fixed limit. Confirm the antenna gain rating is measured (not marketing-inflated), and treat 36 dBm EIRP as a target to stay *under* (with margin), accounting for feedline and connector loss. Verify by measurement rather than trusting nameplate numbers. **The conducted limit governs first**: an external amplifier that produces more than 30 dBm at the coax is non-compliant regardless of antenna gain.

If you hold an amateur radio license (Technician or above), you may operate at higher power under Part 97, but with important conditions: (1) you must **DISABLE all encryption** — Meshtastic/MeshCore default AES channels are prohibited under 47 CFR §97.113(a)(4); use an unencrypted/open channel; (2) you must transmit station identification by callsign at least every 10 minutes per §97.119; (3) the 33 cm band is secondary for amateurs and automatic-control and content rules apply; and (4) you must perform an RF-exposure (MPE) evaluation per FCC §1.1310, as a high-power amplifier at antenna height creates an exposure zone requiring a keep-away/safe-distance assessment. Do not operate default-encrypted mesh firmware at amateur power levels. See the regulatory guidance page before transmitting at amateur power levels.

LiFePO4 Chemistry for Cold Deployments

LiPo (Li-ion) cells can lose roughly 20-30% of usable capacity near 0°C and **must NOT be charged below freezing (0°C / 32°F)** — charging below 0°C causes lithium plating, which permanently damages the cell and creates a fire risk. LiFePO4 cells discharge to about -20°C with reduced capacity, but **should not be charged below 0°C at normal rates either**. Some BMS-equipped or self-heating LiFePO4 packs permit charging below freezing only at drastically reduced current (≈0.1C below 0°C, then ≈0.05C below -10°C). Critically, a LiFePO4 pack must be paired with a LiFePO4-appropriate charger/controller (3.6 V/cell charge profile) *and* a low-temperature charge cutoff; charging LiFePO4 on a standard 4.2 V Li-ion charge profile will overcharge it. The single safe rule to remember: **do not charge any lithium chemistry below 0°C.** For any deployment above 1500m elevation or at latitudes above 40°N, LiFePO4 (with a correct charger and low-temp cutoff) is strongly recommended over LiPo.

Winter Solar Harvest

A 10W panel mounted at a 30° south-facing tilt at 45°N latitude may deliver on the order of 15 - 20 Wh/day at winter solstice under clear skies, but this is a rough estimate — actual yield is highly site- and weather-dependent and should be modeled for your specific location with a tool such as PVWatts or PVGIS. Note that 30° tilt is suboptimal for winter at 45°N (≈60° captures more low-angle winter sun), and on overcast winter days small panels in low-sun regions (e.g. the Pacific Northwest "Big Dark") can produce only ~3-5 Wh/day. The system draws roughly 5W peak during transmit (≈1W RF plus PA inefficiency + ESP32 + GPS) and far less on average with duty-cycling; produce a measured, itemized peak and average power budget rather than relying on the estimate.

Whether this harvest sustains a 24/7 repeater with multi-day overcast reserves depends entirely on the verified site-specific harvest figure and the real average load. Tie the conclusion to a measured days-of-autonomy calculation; in low-sun regions deployed builders use larger or multiple panels precisely because small panels underperform in overcast winters, so a single 10W panel may be insufficient — size the panel and the 10Ah battery to your modeled worst case.

Coax Loss at 915 MHz

At ~915 MHz, RG-58 loses approximately **0.5 dB/m** (~16.5 dB/100 ft) and LMR-200 about **0.33 dB/m** (~9.9 dB/100 ft). Over a short 1 m run the difference between the two is only about 0.2 dB (~5% more radiated power) — effectively negligible. Coax choice matters on longer runs: at ~10 m the difference grows to roughly 2 dB, so use LMR-240/LMR-400 for runs of several meters or more. Keep the feedline run as short as practical. **Important EIRP note:** recovering coax loss increases EIRP — if the build is already near the 30 dBm conducted / 36 dBm EIRP ceiling, reducing feedline loss can push EIRP over the legal limit unless conducted power is correspondingly reduced.

Safety: Grounding, Lightning & Working at Height

Summit and ridge sites are high lightning-exposure locations and elevated-mast installs carry serious physical hazards. Before and during installation:

- **Lightning/grounding:** Bond the mast, enclosure, and the antenna's ground rod to the site grounding system, and bond that ground rod to the building grounding electrode system where one exists (NEC 810.21 / 250). Install a coax surge arrestor on the feedline. Never install during approaching weather.
- **Power-line clearance:** Keep the mast's full fall-radius clear of overhead power lines — contact with lines is the leading cause of installer fatalities.
- **Working at height:** Use fall protection for any elevated mast or tower work (OSHA height triggers are 4 ft in general industry, 6 ft in construction). Tower climbing requires training, certified anchors, 100% tie-off, and a spotter.
- **RF exposure:** At amplifier power levels, maintain a keep-away/safe distance per the MPE evaluation (FCC §1.1310) on rooftop/tower mounts.

Assembly Overview

1. Mount the MPPT controller and LiFePO4 battery in the lower half of the Fibox enclosure using DIN rail or bracket mounts.
2. Connect the solar panel input to the MPPT controller following the manufacturer's polarity labeling. Connect the battery output terminals.
3. **Install an inline fuse (sized to the wiring, typically 3-5 A) at the battery positive terminal**, ahead of the MPPT load/amplifier wiring, plus a battery disconnect/switch. The fuse must be at the battery, protecting the whole run. Never wire a LiFePO4 battery to the amplifier without overcurrent protection. Then wire a regulated output (per the amplifier's input-voltage spec) from the MPPT load terminals to the amplifier input and to a 5V step-down converter powering the T-Beam.
4. Connect the amplifier to the T-Beam following the amplifier module's documentation. Note this is the most demanding part of the build: the T-Beam's onboard SX1262/SX1276 normally feeds the board's own antenna port, so the radio's RF output must be redirected into the amplifier's RF input (the correct cable, connector, and any required board modification are specified in the amplifier module's docs — follow them). Drive the modem only to the level the PA datasheet specifies as its input (often ~10-17 dBm — the SX1262 maxes at +22 dBm and cannot itself reach 27-30 dBm). Thermal-pad the amplifier to the enclosure wall.
5. Run LMR-200 from the amplifier RF output through a weatherproof N-type bulkhead in the enclosure wall. Terminate with an N-type connector - do not use SMA at this power level.
6. Attach the 6 dBi fiberglass antenna to the external N-type bulkhead. Wrap the connector joint with self-amalgamating tape.
7. Flash and configure firmware (see below), then seal the enclosure with silicone RTV on all penetrations.
8. Mount the enclosure on the J-pipe mast with stainless U-bolts. Orient the solar panel to true south at the appropriate tilt angle for your latitude (a steeper, near-60° tilt favors winter harvest at higher latitudes).

Firmware Configuration

Flash the T-Beam with either **Meshtastic** (broader community compatibility) or **MeshCore repeater firmware** depending on your network's protocol stack. The T-Beam is an ESP32 board — flash it with esptool or a web flasher (it is not flashed via meshcore-cli, which only connects to an already-running node).

- **Set the modem TX power so the amplifier's CONDUCTED OUTPUT (at the coax) does not exceed 30 dBm / 1 W.** The Part 15 conducted limit is independent of, and additional to, the EIRP limit. Set the T-Beam modem TX power to the level the amplifier module specifies as its input (often ~10-17 dBm — check the PA datasheet); the SX1262 maxes at +22 dBm and cannot itself produce 27-30 dBm. The amplifier provides the final ~1 W output — size the modem drive to the PA input spec, then **measure the**

conducted output with a power meter and verify total EIRP before deployment. Operating an amplifier "with its gain on top" of a 27-30 dBm modem is not legal under Part 15 and would also overdrive most PA modules.
- **Disable the OLED display** after configuration to save roughly 10-20 mA continuously (depending on displayed content).
- **Disable Bluetooth** after initial setup (reduces attack surface and saves ~5 mA).
- **Set a fixed GPS position** manually once the site coordinates are known, then disable live GPS polling to save ~20 mA and extend GPS module life. Use a smartphone app on-site to capture precise coordinates before sealing.
- Set the node role to *Repeater* (or *Router*) and configure the hop limit appropriately so the node forwards distant packets. (Note: the ROUTER_CLIENT role was retired in firmware 2.3.15.)

Revision #3
Created 2026-05-03 05:28:10 UTC by Mesh America Admin
Updated 2026-06-08 23:28:17 UTC by Mesh America Admin