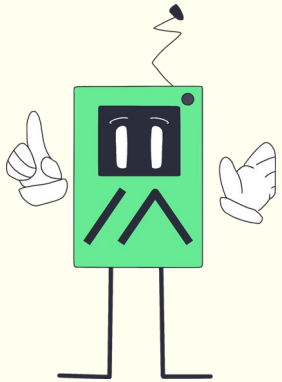
# Meshtastic is Hamtastic

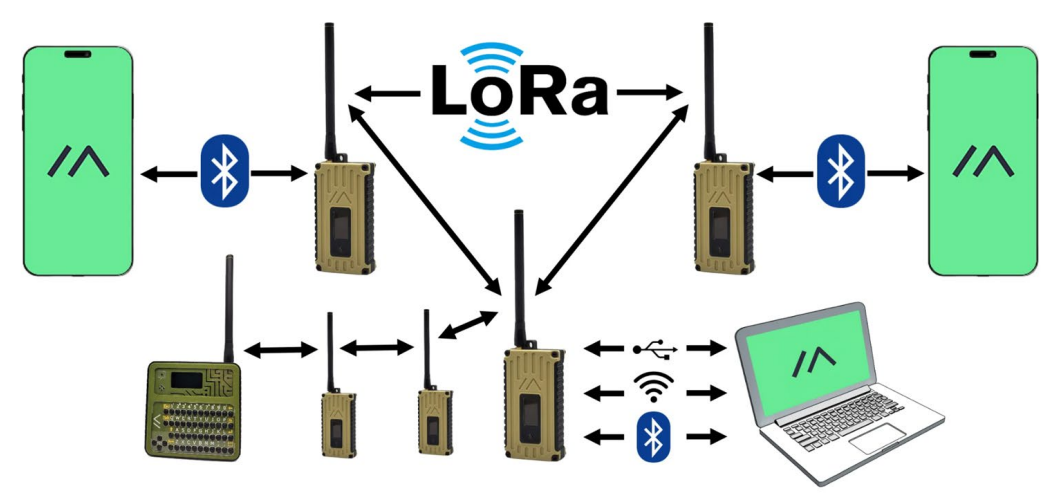
Presented to the SARA Club March 17, 2026
By Alex Matula – KO6HPZ



# What is Meshtastic?

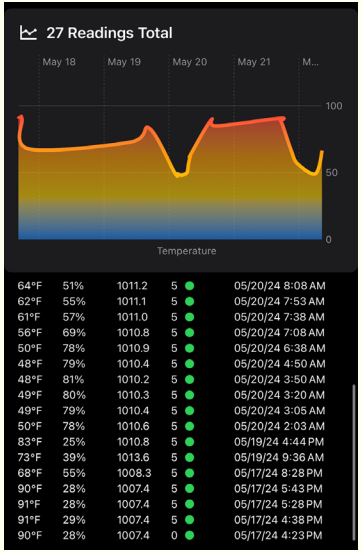
An open source, off-grid, decentralized mesh network built to run on affordable, low-power (~160mW) to (1W) devices

No license required
(Can be used in Ham Mode)



# Use cases for Meshtastic

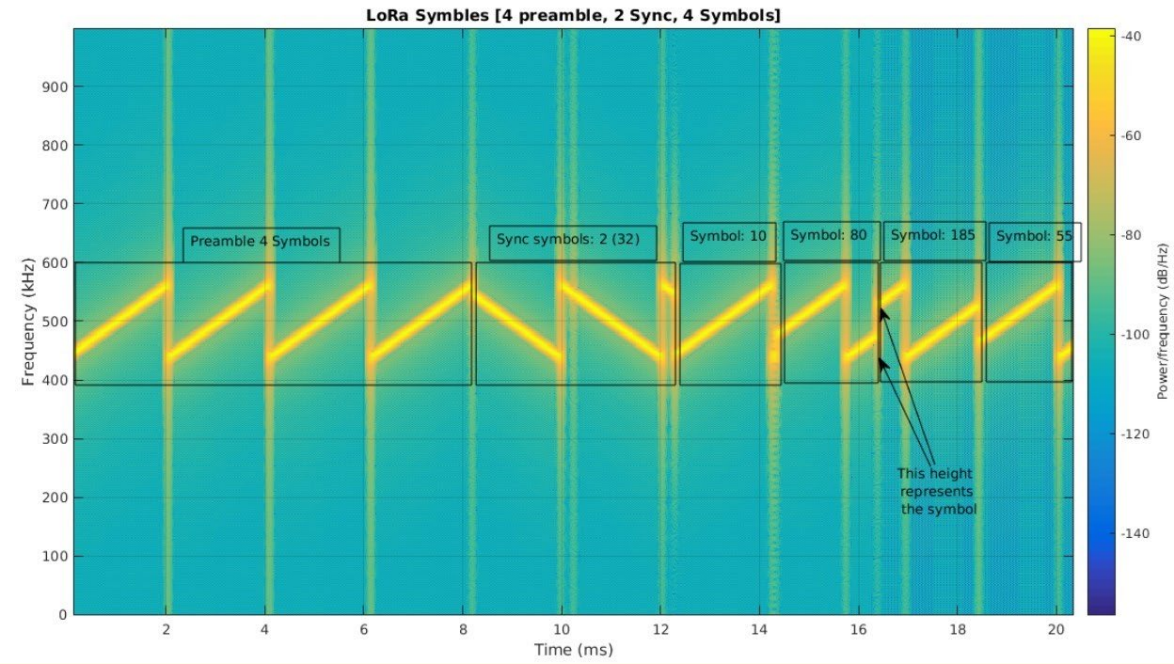
- Texting off-grid and without reliance on cellular networks
- Using live GPS data to monitor the locations of people (and pets)
- Off grid weather/sensor stations
- Learning about RF

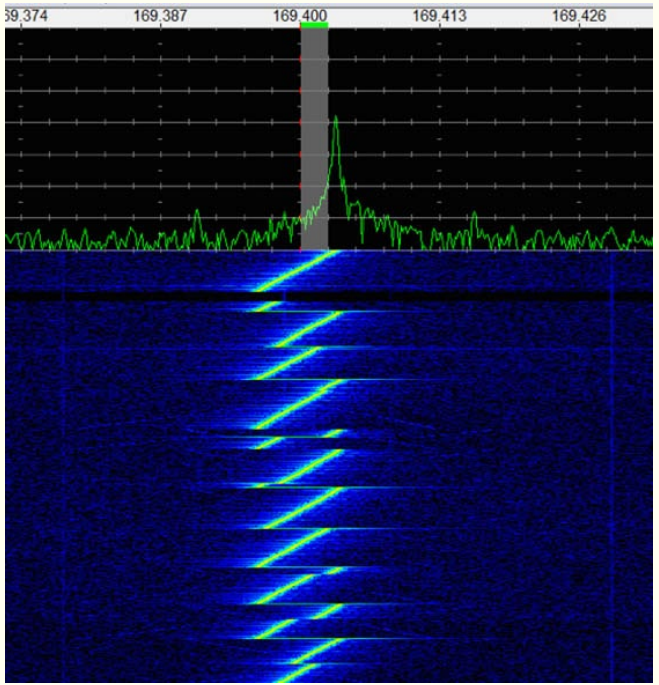


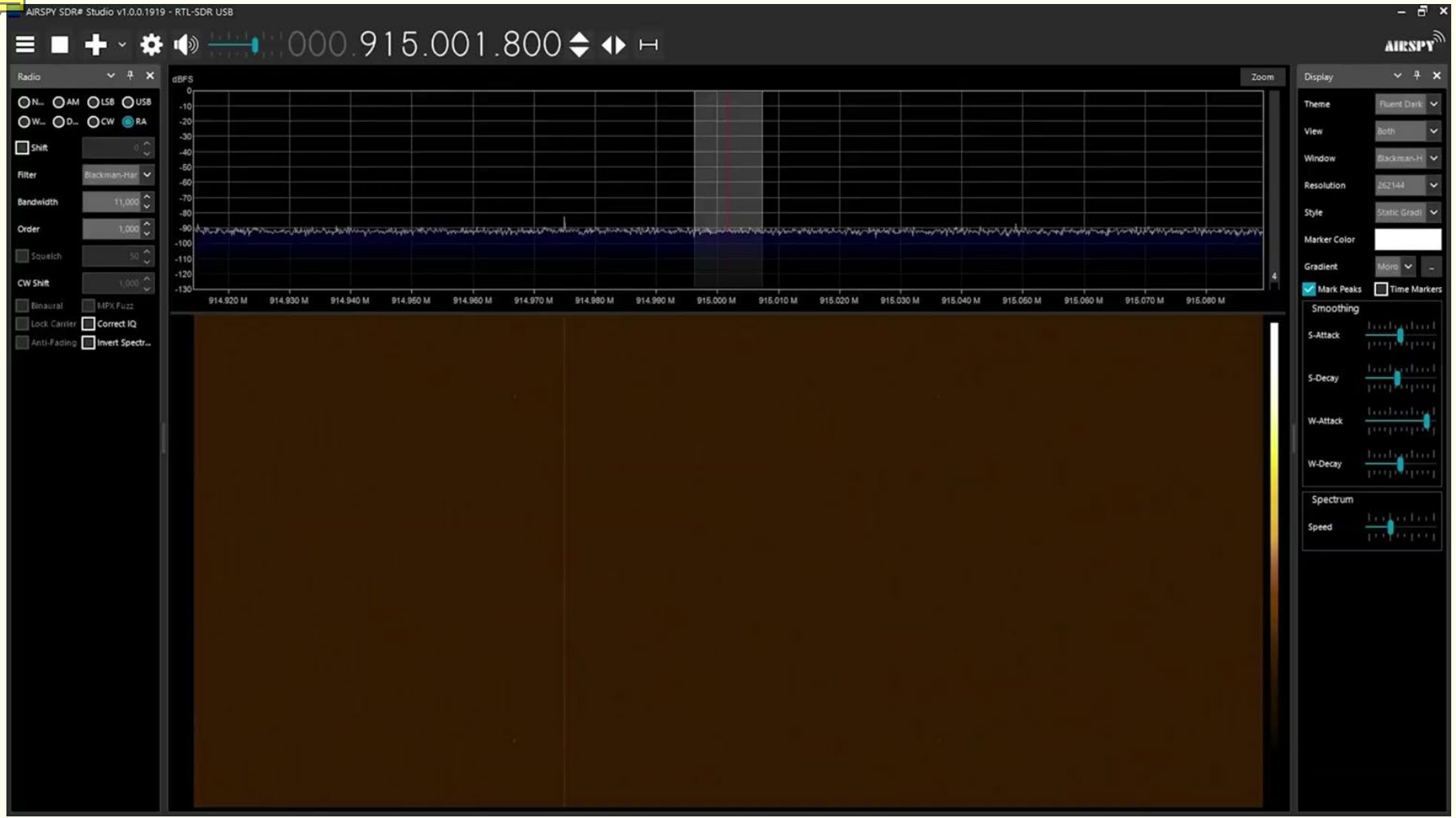

| | | | | |
|---|---|---|---|---|
| 64°F | 51% | 1011.2 | 5 | 05/20/24 8:08 AM |
| 62°F | 55% | 1011.1 | 5 | 05/20/24 7:53 AM |
| 61°F | 57% | 1011.0 | 5 | 05/20/24 7:38 AM |
| 56°F | 69% | 1010.8 | 5 | 05/20/24 7:08 AM |
| 50°F | 78% | 1010.9 | 5 | 05/20/24 6:38 AM |
| 48°F | 79% | 1010.4 | 5 | 05/20/24 4:50 AM |
| 48°F | 81% | 1010.2 | 5 | 05/20/24 3:50 AM |
| 49°F | 80% | 1010.3 | 5 | 05/20/24 3:20 AM |
| 49°F | 79% | 1010.4 | 5 | 05/20/24 3:05 AM |
| 50°F | 78% | 1010.6 | 5 | 05/20/24 2:03 AM |
| 83°F | 25% | 1010.8 | 5 | 05/19/24 4:44 PM |
| 73°F | 39% | 1013.6 | 5 | 05/19/24 9:36 AM |
| 68°F | 55% | 1008.3 | 5 | 05/17/24 8:28 PM |
| 90°F | 28% | 1007.4 | 5 | 05/17/24 5:43 PM |
| 91°F | 28% | 1007.4 | 5 | 05/17/24 5:28 PM |
| 91°F | 29% | 1007.4 | 5 | 05/17/24 4:38 PM |
| 90°F | 28% | 1007.4 | 0 | 05/17/24 4:23 PM |

# Technology Behind Meshtastic

- LoRa (Which stands for Long Range) is a modulation technique that utilizes Chirp Spread Spectrum Technology
- LoRa transmits small chunks of data with low bit rate
- LoRa is used for Iot (Internet of things) devices to transmit data over long distances with low power
    - Also used by some commercial satellites for telemetry downlink
- LoRa signals can propagate below the noise floor
- Ideal for sensors
- Message flooding of packets, somewhat “peer to peer”


LoRa Symbles [4 preamble, 2 Sync, 4 Symbols]
Preamble 4 Symbols
Sync symbols: 2 (32)
Symbol: 10
Symbol: 80
Symbol: 185
Symbol: 55
This height represents the symbol
Frequency (kHz)
Time (ms)
Power/frequency (dB/Hz)


169.374
169.387
169.400
169.413
169.426


AIRSPY SDR# Studio v1.0.0.1919 - RTL-SDR USB
000.915.001.800
AIRSPY
Radio
N...
AM
LSB
USB
W...
D...
CW
RA
Shift
Filter
Blackman-Har
Bandwidth
11,000
Order
1,000
Squelch
50
CW Shift
1,000
Binaural
MPX Fuzz
Lock Carrier
Correct IQ
Anti-Fading
Invert Spectr...
dBFS
Zoom
0
-10
-20
-30
-40
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-60
-70
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-90
-100
-110
-120
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914.920 M
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914.980 M
914.990 M
915.000 M
915.010 M
915.020 M
915.030 M
915.040 M
915.050 M
915.060 M
915.070 M
915.080 M
Display
Theme
Fluent Dark
View
Both
Window
Blackman-H
Resolution
262144
Style
Static Gradi
Marker Color
Gradient
Mono
Mark Peaks
Time Markers
Smoothing
S-Attack
S-Decay
W-Attack
W-Decay
Spectrum
Speed

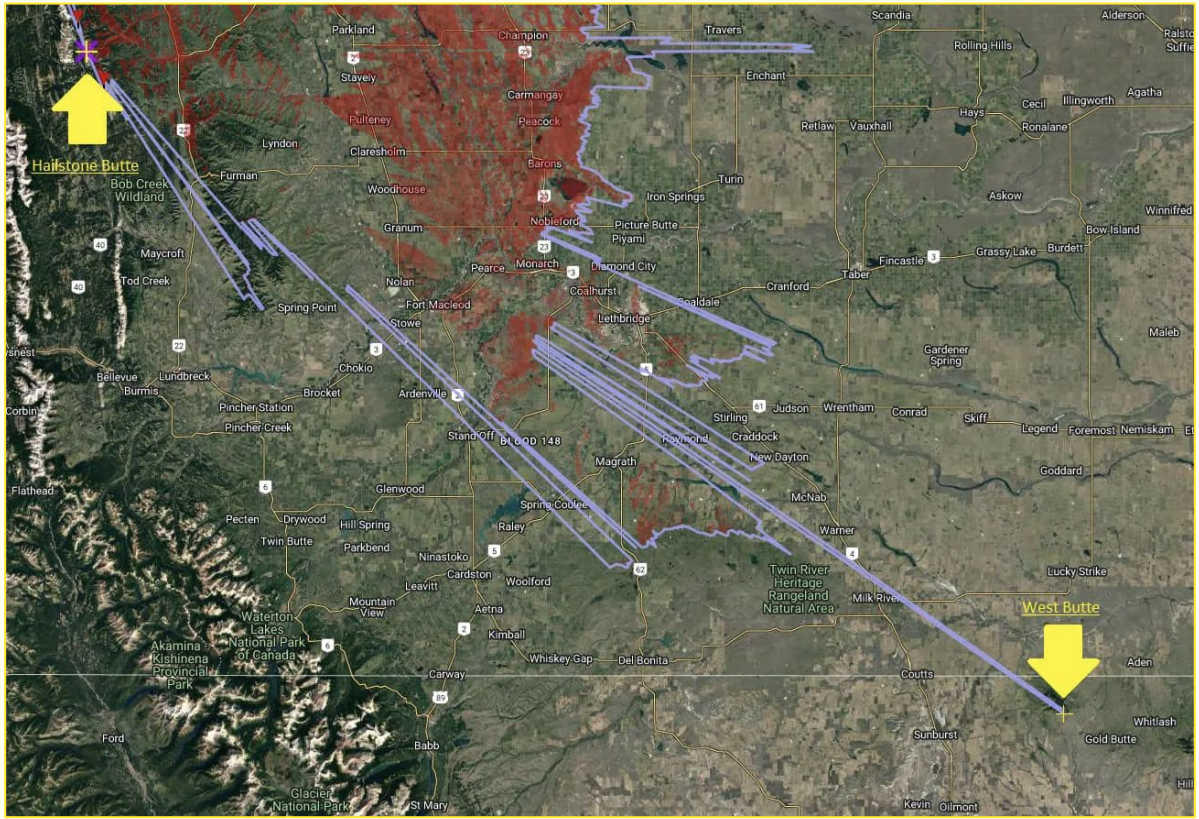
# Meshtastic terms to know

- Node - Synonymous with device, can send receive and retransmit messages
- Hops - amount of times the message is retransmitted
- Preset - a collection of parameters behind 1 easy setting
- Mesh - the nodes sharing a preset, frequency, and area
- Role - the mode a node can be in such as “router” or “client”.

# Technology Behind Meshtastic cont..

- Meshtastic in America operates on the 915 MHz ISM (Unlicensed band)
- Frequencies are selected automatically depending on the name of the primary channel (We are operating on default, 913.125 MHz) 250 khz bandwidth
- Mostly line of sight
- Most transceivers are outputting 22dBm/160mW or 30dBm/1W of power when in unlicensed mode
- Legal max output 30 dbm/1W unlicensed, but also encrypted
- The current ground-ground Meshtastic record is 158 miles with no hops
- AES 256 encryption
- Public/Private key encryption
- Channelized with 104 frequency slots in the ISM band
    - Freq + bw + spread = one compatible mesh

# Ground - Ground 158 miles



# Meshtastic Routing Algorithm

- Meshtastic uses a flooding algorithm to route non directed packets.
- When a node receives a packet with a non-zero hop count, it retransmits it with the hop count reduced by 1.
- A node **won't** retransmit a packet if:
  - It has already done so recently (tracked in buffer),
    or
  - Another node retransmits it (and we hear them doing so).
- Nodes wait a random amount of time before retransmitting to avoid collisions (CSMA like)
- Router nodes use sooner retransmit timers than regular nodes.

# Next Hop Routing

- This is only for directed packets, like direct messages
- **Next-Hop Basics:** Next-hop routing uses two spare bytes in the Meshtastic header to tag the current relayer and the next node to relay a message, reducing unnecessary relaying by directing packets to specific nodes.
- **How It Works:** Starts with managed flooding (all nodes relay); once a reliable relayer is confirmed (e.g., via a response), it’s set as the next-hop for future messages, but only for that specific hop.
- **Adapting to Real Life:** If a next-hop fails (e.g., due to movement, packet loss, or old firmware), the system switches back to managed flooding on the last retry to ensure delivery.

# Zero Hop Routing

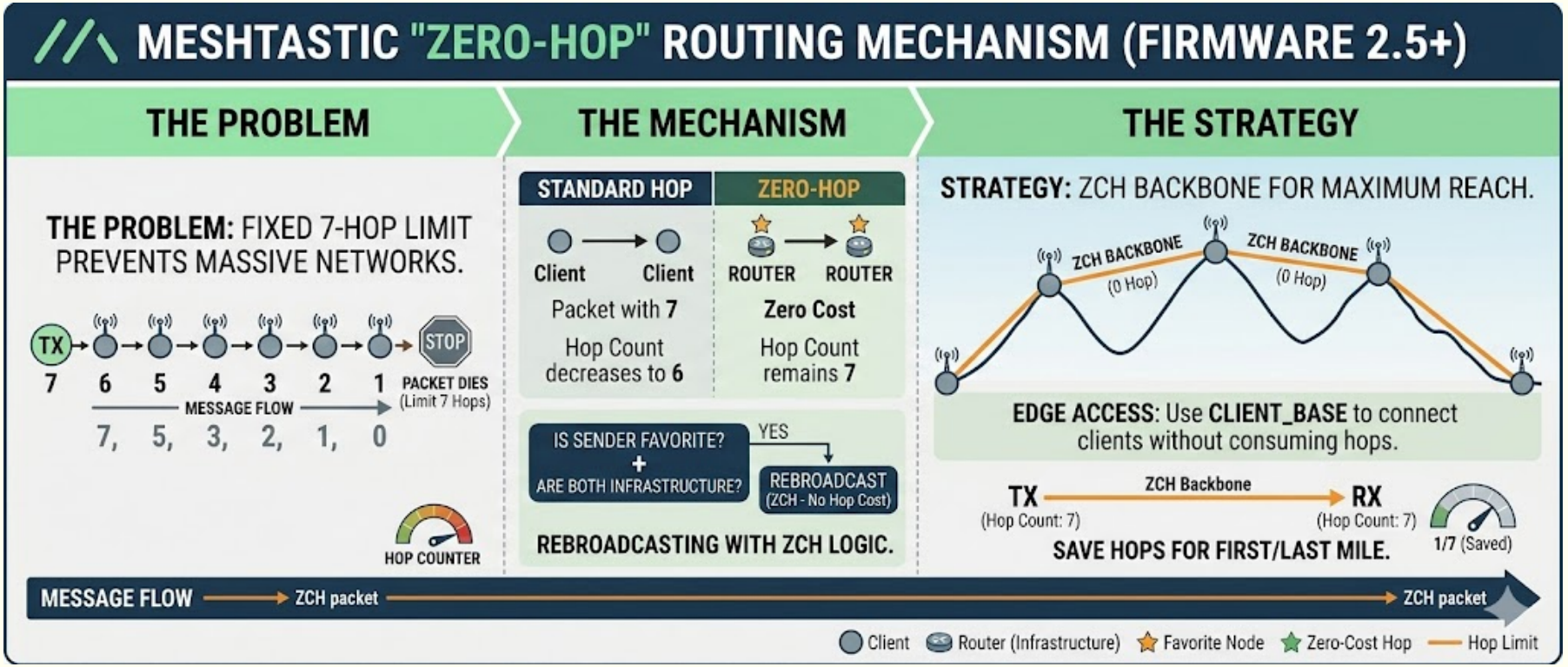
## How It Works

- **The Logic:** If a node receives a packet from a **Favorited** node and both are in infrastructure roles, the node rebroadcasts without subtracting from hop_limit.
- **The "Cheat":** A packet can travel through 10+ routers but still appear as "1 hop away" to the end user.
- **The Goal:** Reserve the 7-hop limit for reaching handhelds in "valleys" or "indoor" areas, while the high-altitude backbone handles the distance for "free."

## Requirements for 0-Cost Relay

1. **Role:** Both nodes must be ROUTER, ROUTER_LATE, or CLIENT_BASE.
2. **Trust:** The sender/previous relay must be in your **Favorites** list.
3. **Position:** Not valid for the very first hop (the initial transmit always costs 1)

# Zero Hop Routing



# Roles

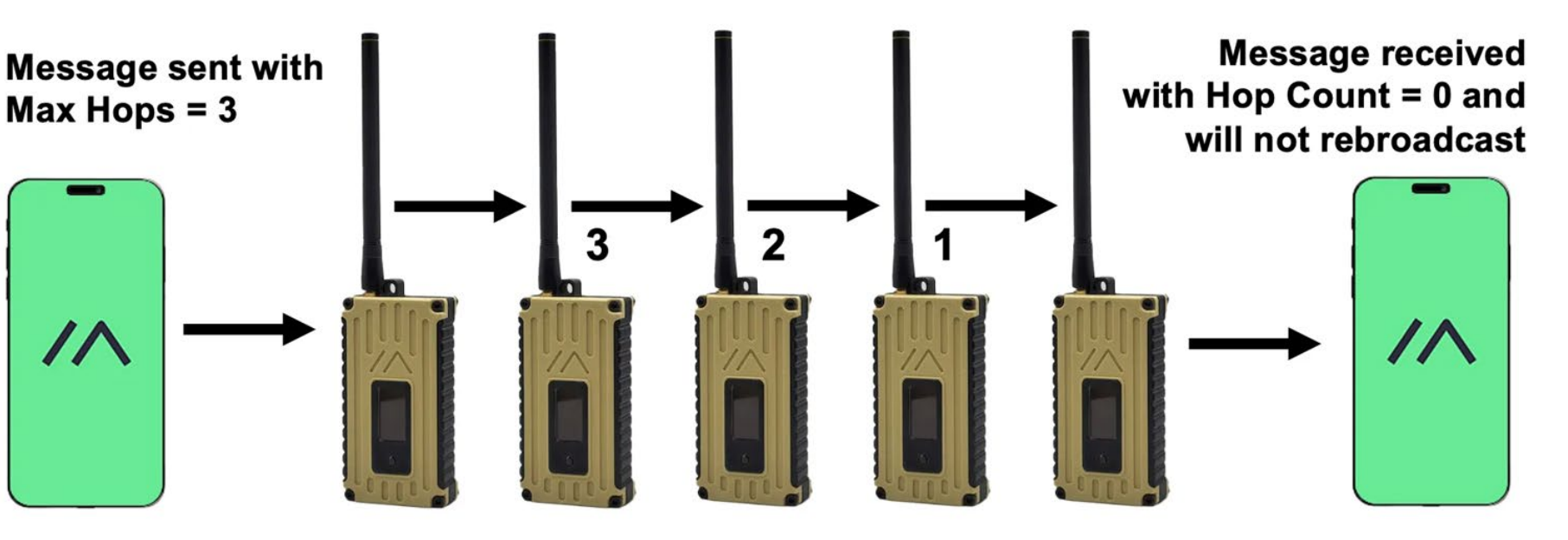
- Roles affect the behavior of a node, by default all nodes are client

| Device Role | Description | Best Uses |
|---|---|---|
| **CLIENT** | App connected or stand alone messaging device. Rebroadcasts packets when no other node has done so. | General use for individuals needing to communicate over the Meshtastic network with support for client applications. |
| **CLIENT_MUTE** | Device that does not forward packets from other devices. | Situations where a device needs to participate in the network without assisting in packet routing, reducing network load. |
| **CLIENT_BASE** | Personal base station: always rebroadcasts packets from or to its favorited nodes. Handles all other packets like CLIENT. | Use for stronger attic/roof “base station” nodes to distribute messages more widely from your own weaker, indoor, or less-well-positioned nodes. |
| **ROUTER** | Infrastructure node for extending network coverage by always rebroadcasting packets once. Visible in Nodes list. | Best positioned in strategic locations to maximize the network's overall coverage. Device is shown in topology. |
| **ROUTER_LATE** | Infrastructure node that always rebroadcasts packets once but only after all other modes, ensuring additional coverage for local clusters. Visible in Nodes list. More details in our blog: Demystifying Router Late | Ideal for covering dead spots or ensuring reliability for a cluster of nodes where placement doesn’t benefit the broader mesh. Device is shown in topology. |

# Presets

- Presets are set frequencies and packet settings that provide different use cases assuming 1 watt tx/rx

| Preset Name | Speed & Airtime | Range Profile | Primary Use Case |
|---|---|---|---|
| **LongFast** | Slow (~1 kbps) | 1mile to 80 miles | Rural back country, universal default setting, low data rate, low bandwidth small network size |
| **LongModerate** | Very Slow | 1 mile to 80 miles | Used in low-density rural areas where nodes are extremely far apart and reliability is more important than speed. |
| **LongSlow** | Extremely Slow | 1 mile to 80 miles | Distance Records. Highest possible range, but very long "hang time" on the air. Easily congested if more than 2-3 people use it. |
| **MediumSlow** | Moderate | 1 mile to 65 miles | Dense Regional Mesh. A popular alternative to LongFast for Regions & Cites with 50+ nodes to reduce "noise" and collisions. |
| **MediumFast** | Fast | 1 mile to 65 miles | Dense Regional Mesh. A popular alternative to LongFast for Regions & Cites with 50+ nodes to reduce "noise" and collisions. |
| **ShortFast** | Very Fast | 1 mile to 25 miles | Dense City mesh offering fastest data transfer, range is significantly decrease |
| **ShortTurbo** | Max Speed | 1 mile to 25 miles | Dense City mesh offering fastest data transfer, range is significantly decrease |


Message sent with
Max Hops = 3
3
2
1
Message received
with Hop Count = 0 and
will not rebroadcast

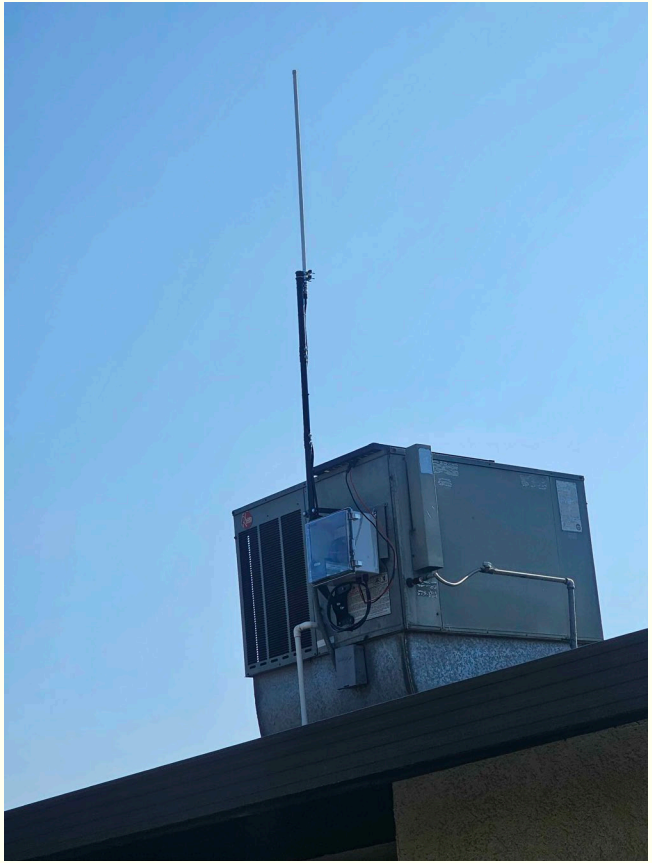
# Difference between ARDEN and Meshtastic

- **Meshtastic has a much lower data rate**
- **Built on top of totally different technologies**
- **Different Frequency**
- **Meshtastic nodes are usually more mobile and adhoc**
- **AREDN requires a ham radio license**

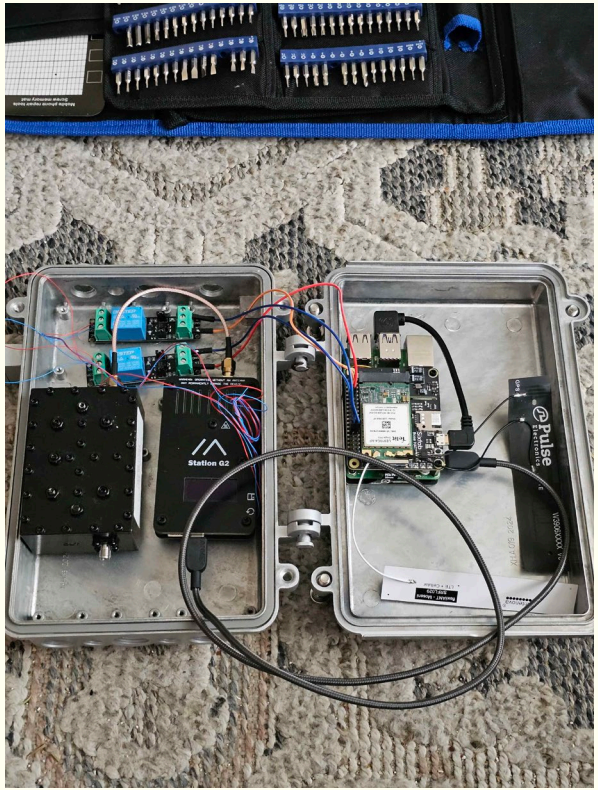
# Differences between APRS and Meshtastic

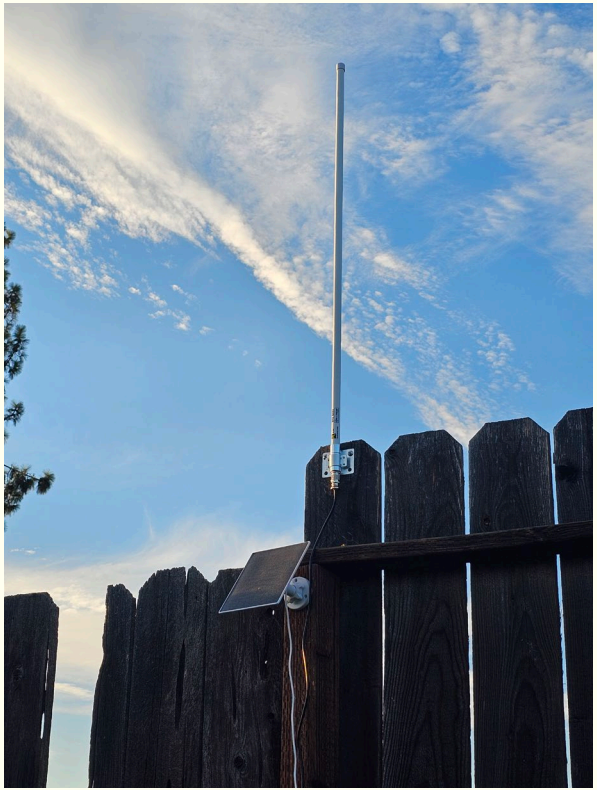
| Feature | Ham Radio APRS | LoRa Meshtastic |
|---|---|---|
| **License Required?** | Yes (Amateur Radio License) | No (Unlicensed ISM bands) |
| **Frequencies** | VHF / UHF (e.g., 144.390 MHz in US) | 900 MHz ISM (915 MHz US / 868 MHz EU) |
| **Encryption & Privacy** | Illegal (All traffic is public/plaintext) | Standard (AES-256 encryption) |
| **Network Topology** | Digipeaters & iGates (Hierarchical) | Peer-to-Peer Mesh (Every node is a repeater) |
| **Typical Power Output** | High (5W handhelds to 50W+ mobiles) | Very Low (Typically 0.1W to 1W) |
| **Range (Per Node/Hop)** | Long (10 to 50+ miles line-of-sight) | Short/Medium (1 to 65 miles, extends via mesh) |
| **Hardware Cost** | Moderate/High ($100 – $500+) | Very Low ($30 – $80) |
| **Internet Bridging** | iGates (connects to APRS-IS / aprs.fi) | MQTT Gateways (connects mesh to internet) |

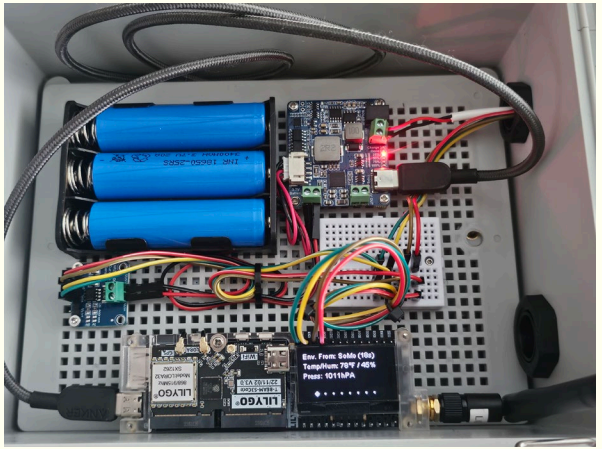
# My personal experiences with Meshtastic



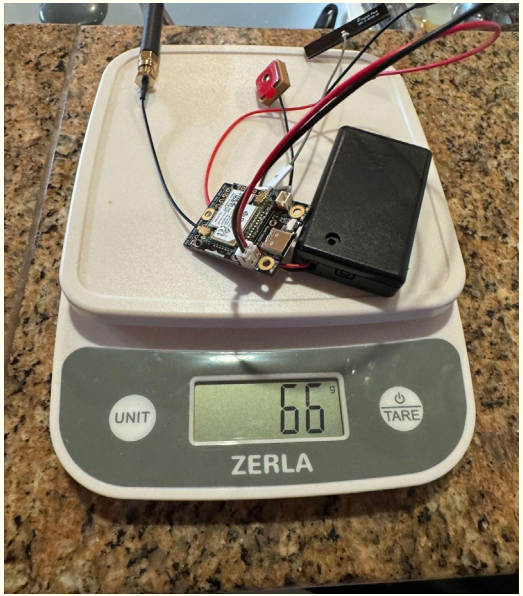
# My personal experiences with Meshtastic cont..





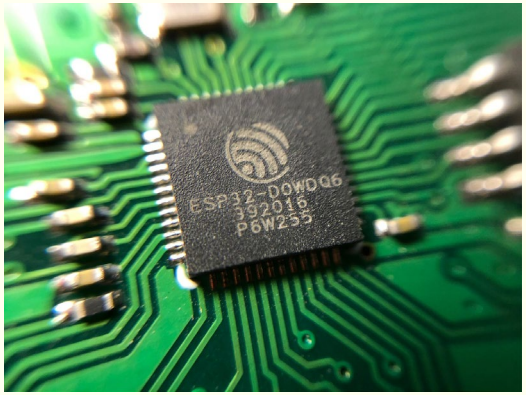
# My personal experiences with Meshtastic cont..



# Hardware

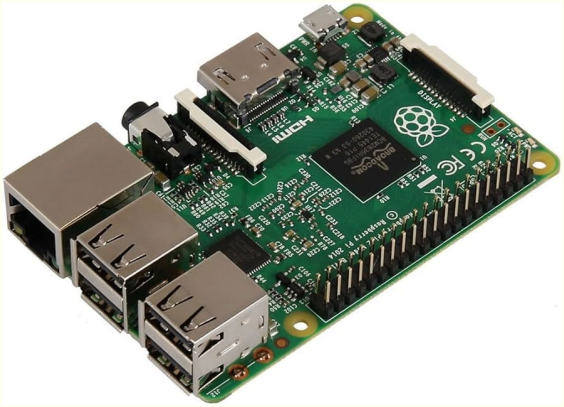
## Nrf52 based

- Power efficient
- Initially came 2017-2018




## ESP32 based

- Has wifi chip
- More RAM
- Initially came out in 2016
- Middle ground power efficiency



## Linux Native

- Almost unlimited RAM
- Can run scripts as well as Meshtastic

# Recommended Devices (By Me)

## Lilygo T beam 1 watt

### Pros

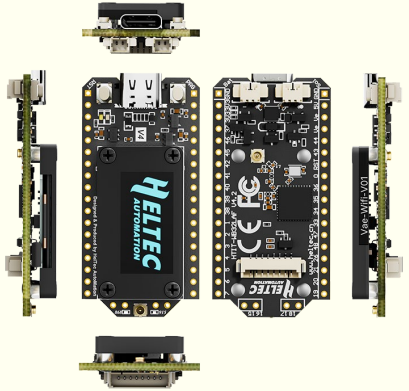
- 1 watt output 50-80 miles
- GPS included
- Dedicated on off switch

### Cons

- Requires external battery
- Always on Fan
- Needs housing

Order from
- ebay
- Rokland
- AliExpress
- Amazon

## Heltec V4



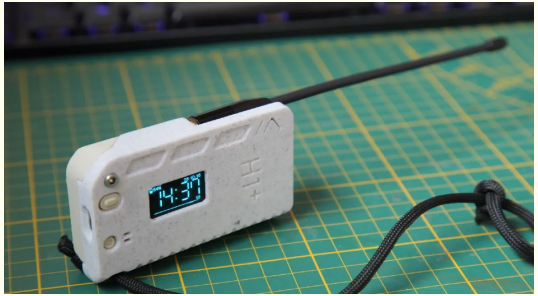

### Pros

- Modular
- Low power usage
- .5 watt power (25  -50 miles)
- Solar controller built in

### Cons

- Needs housing

Order from
- Amazon
- Rokland



# Recommended Devices (By Me) cont..

## Lilygo T beam supreme

### Pros

- Small form factor
- Cheap
- Already attached display and built in wifi and ble antenna
- Arduino compatible sensors
- Solar compatible
- 18650

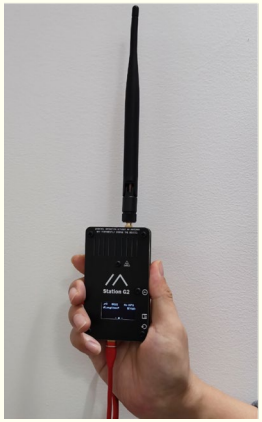
### Cons

- Low output 0.160 watts, 5 -10 miles or less
- Needs housing

### Order from

- Lilygo
- Rokland
- Amazon

## Station G2

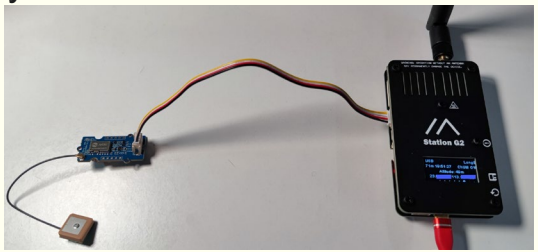


### Pros

- Industrial grade 1w to 5w output
- Modular
- Nicest form factor

### Cons

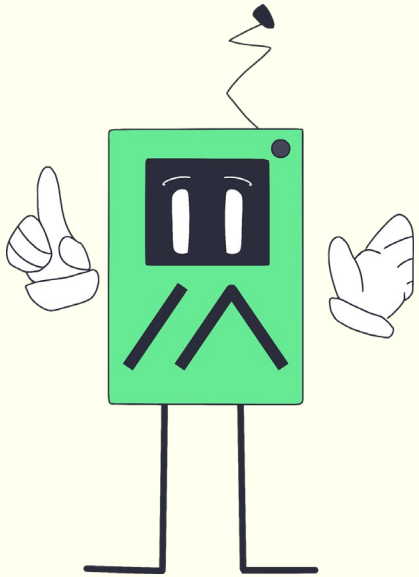
- USB C PD or 12V-19V input
- Expensive
- Hard to come by



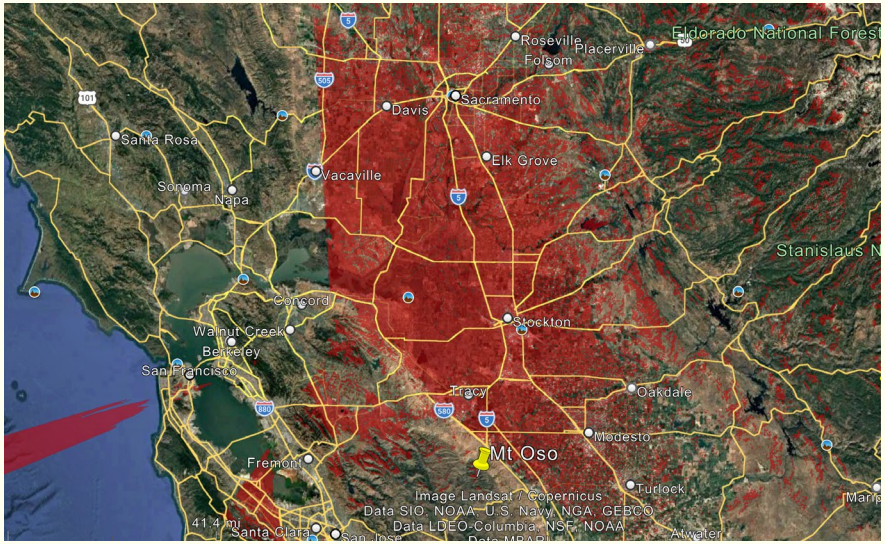
### Order from

- Ebay
- shop.uniteng.com

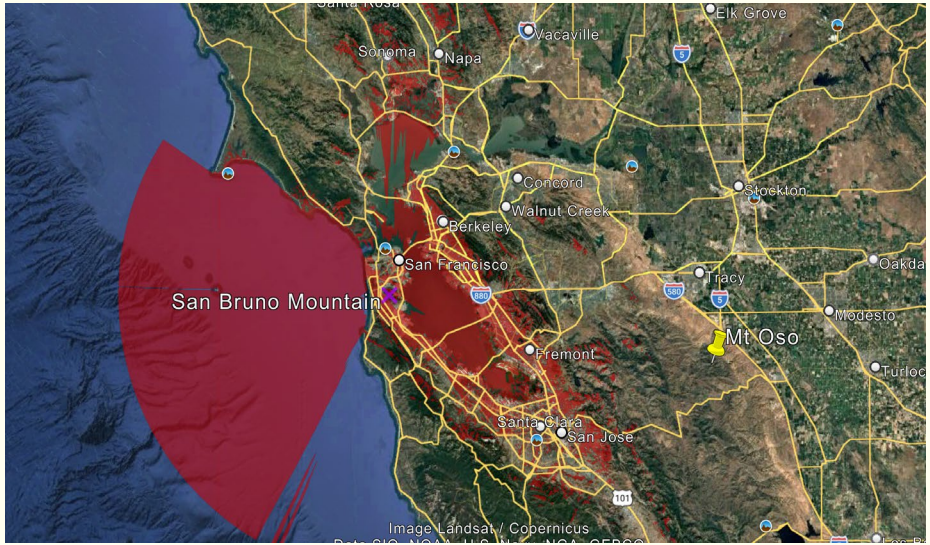
# Meshtastic Device Demo



# Meshtastic in California

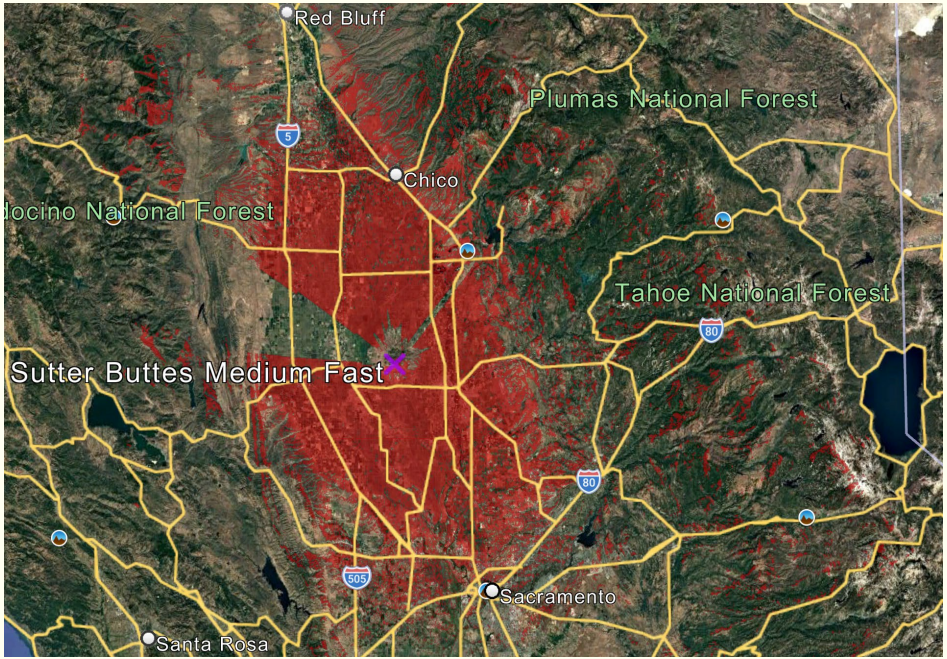



Diablo Coverage

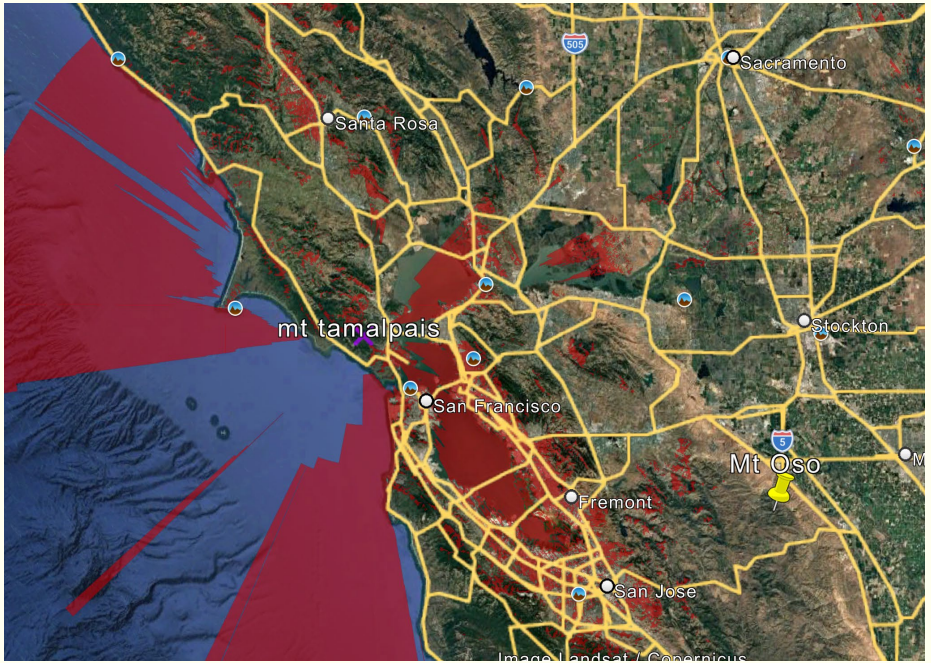



San Bruno Mountain

# Meshtastic in California

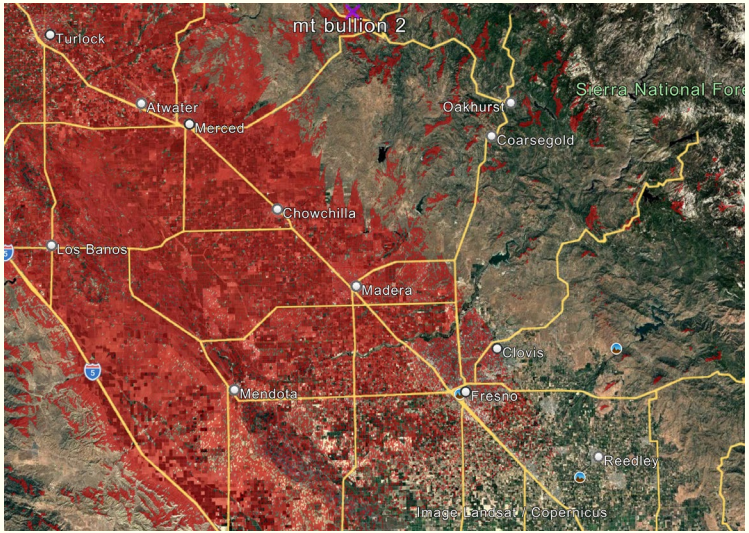



Sutter Buttes Coverage

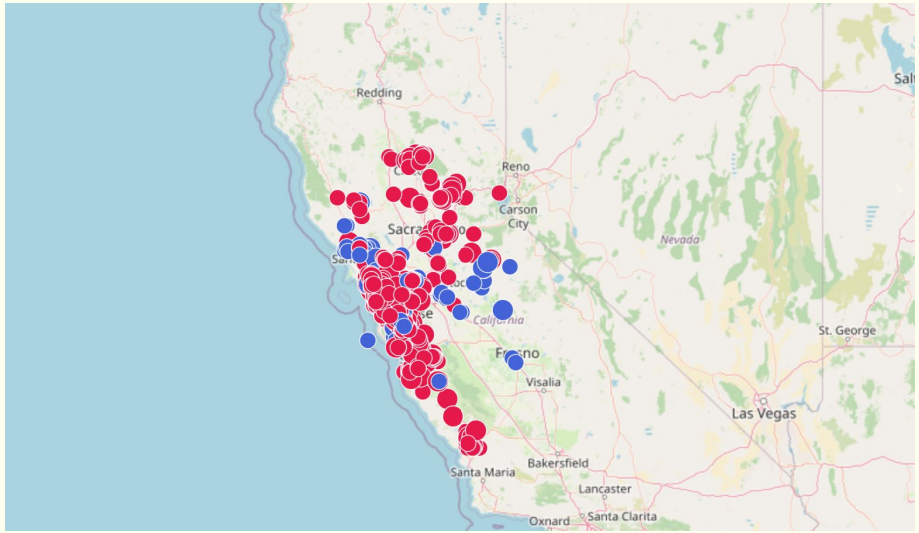



Mt Tamalpais coverage

# Meshtastic in California

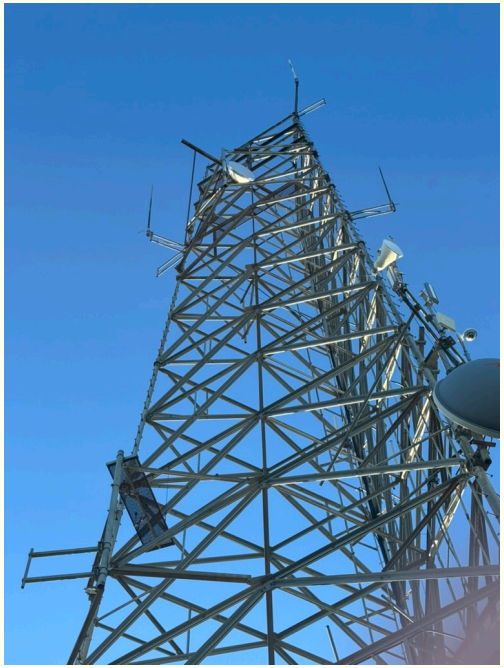



**Mt bullion Coverage**

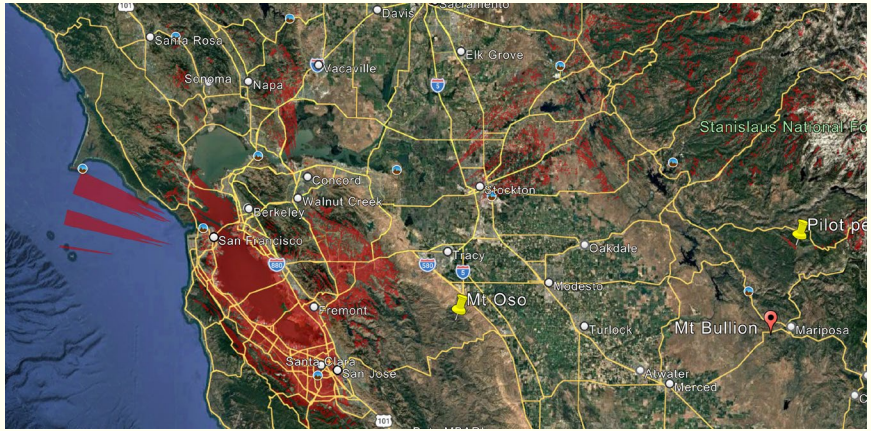



**Nodes logged on Baymesh**

# Meshtastic in California

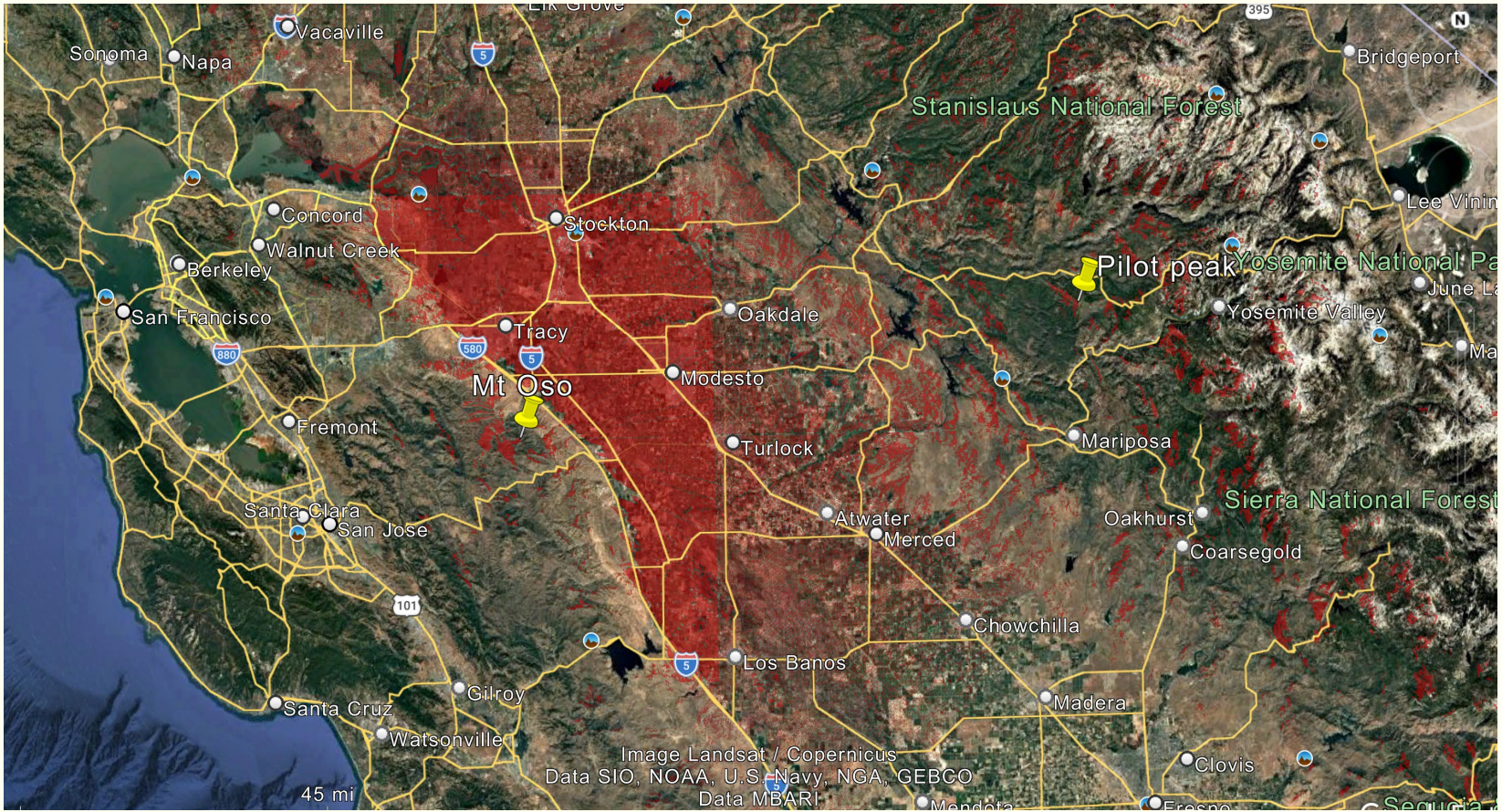


Sunol Tower

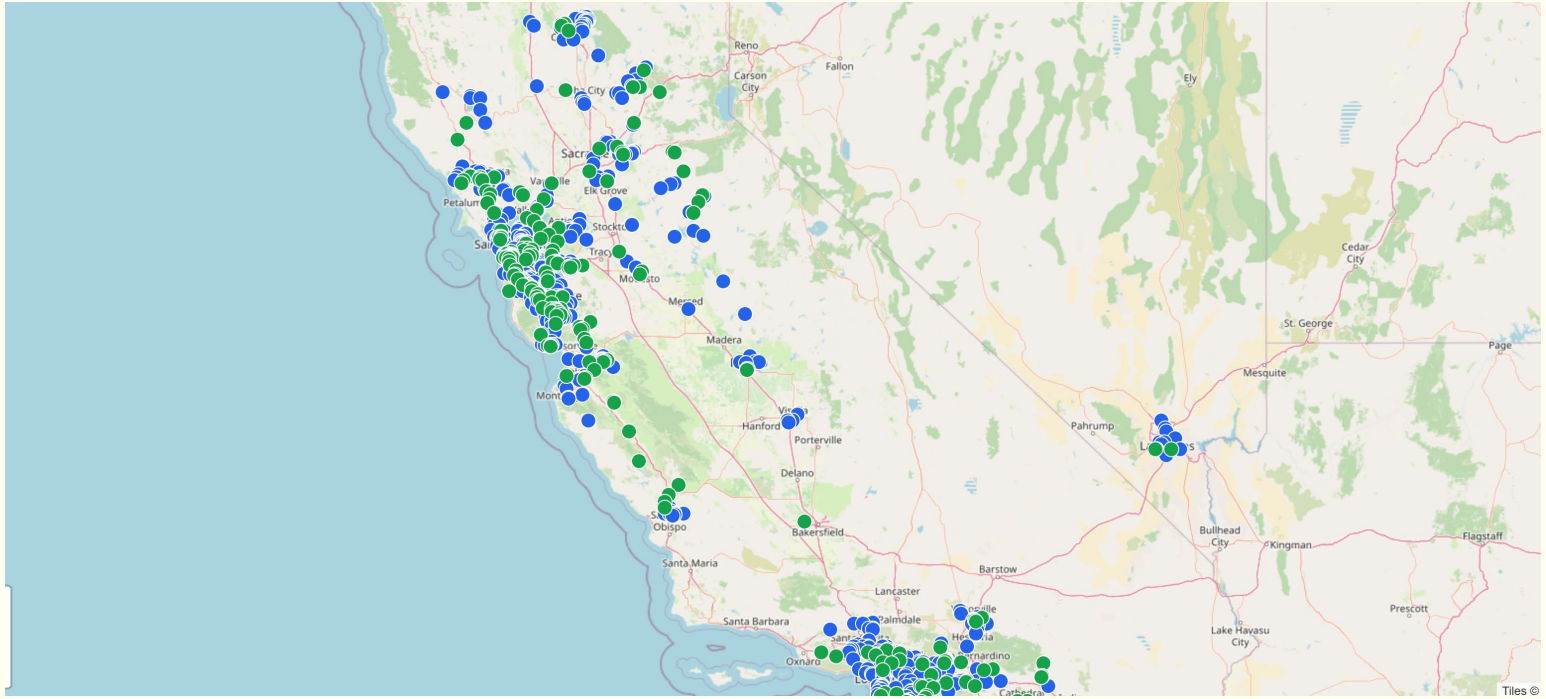



Sunol coverage

# Simulated Oso Coverage

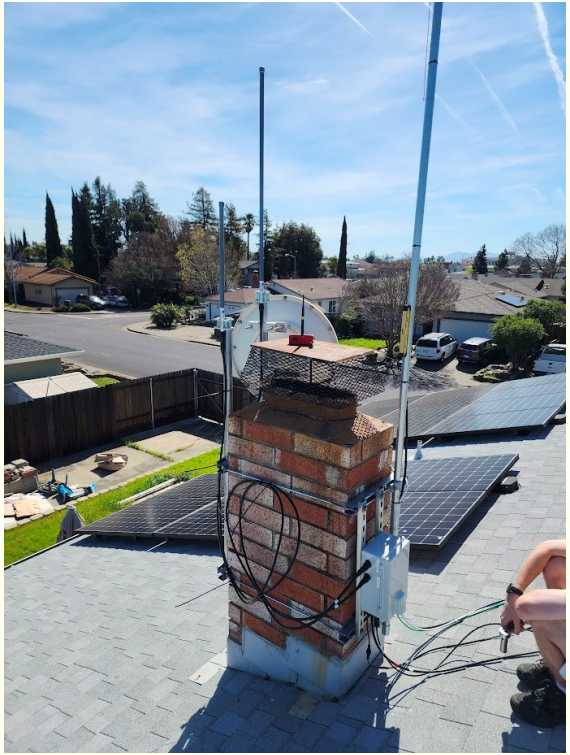


# Meshtastic in California




**These nodes are only nodes that have MQTT on, but there is likely another 50% more that don't have MQTT on. My current total node db is 2100 nodes and counting on the medium fast preset**

# Typical home roof nodes



# Basic Setup

1. Get a supported device
2. Wipe and flash firmware using the Meshtastic Flasher
3. Connect to the node via serial or bluetooth to a phone or computer
4. Set the region to US
5. Change the node Long and Short name

# Basic Setup

Home base node: mount high, use higher power nodes such as Heltec V4, Station G2, rakwireless WisMesh 1W

Mount above roof line, hight is might, power is foundation.

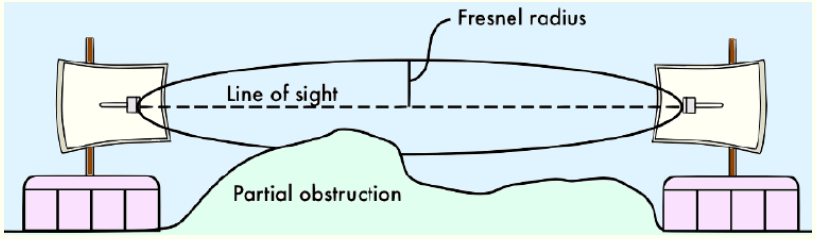
People run POE power or Solar, I personally run a offgrid Solar set up

Mobile/vehicle nodes: Heltec V4, Lilygo T beam 1 watt

For vehicle nodes ive used a window clip sma connector then and mounted it on my roof rack and ran a 3.5 dbi antenna. Antenna cable routed through door

# Things to look out for:

- Do not power on mesh devices without antenna
- Moisture is your enemy when planning roof or outdoor nodes, plan for it
- Line of sight, Meshtastic does not penetrate or pass through objects. Most instances of stable connection are usually made LOS. Online tools like scada core LOS calculator, or heywhatsthat.com help plan for coverage maps & LOS calculator
- As mentioned previously, external mounted antennas will significantly increase tx and rx.
- Understand the concept of Fresnel zone and partial obstruction can impede signal if within 45% of Fresnel zone



# Things to look out for:

**Tx Power Matters:** Avoid the "0.160W trap" found in common Lilygo and RAK models; their limited output often restricts urban range to under a few miles. (22 dbm labeled models)
**Antenna Myths:** High-gain (dB) antennas are ideal for roof nodes; the theoretical "cone of silence" is practically irrelevant, typically extending only 150 ft at standard residential heights.
**MQTT vs. LoRa:** Enabling "MQTT Uplink" only logs packets to a server; it does not route messages over the internet between nodes, as communication remains strictly over LoRa

# Regional Presets

- **Network Migration:** The NorCal/Bay Area/Central Coast regions transitioned from **LongFast** to **MediumSlow**, and finally to **MediumFast** to combat increasing network congestion.
- **Data Rate Improvements:** These shifts provided significant throughput gains: **LongFast** (1.07 kbps) to **MediumSlow** (1.95 kbps / +82%), then to **MediumFast** (3.52 kbps / +81%).
- **Geographic Strategy:** While the Central Valley (Merced/Fresno) remains on **LongFast** due to isolation, a node at **Oso** would act as a **MediumFast** gateway to link the Valley with the Northern California mesh.
- **Current Reach:** Mount Diablo (DBMF) currently maintains a range extending as far south as **Turlock**.

# Ham Mode

**Pros**

- Up to 10W transmit power
- Higher gain antennas

**Improvements coming soon including:**

- Remote administration through signing and not encryption
- Ham mode presets

**Cons**

- Can’t join the default Mesh (You will not see others if you use this mode)
- No encryption

# How to join the Bay Area Mesh and Central Valley Mesh

- Follow settings on https://bayme.sh/docs/getting-started/recommended-settings
- Medium Fast, Default encryption, and blank channel name (913.125 mhz)

(You can go out and make your own mesh on a different frequency for specific purposes but this is the easiest way to mesh with others)

## Join Our Discord

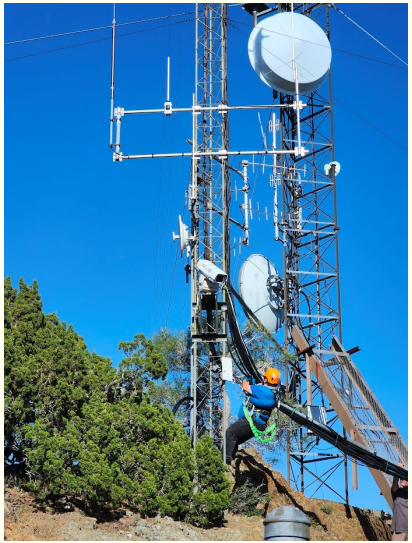
BayMe.sh

CVMe.sh

# Meshtastic.org

# Routers

We use high level sites to expand the mesh network coverage. Some of the most notable being on Sunol ridge and a few scattered throughout the mountains. (Mt Vaca, Mt Tamalpais, Mt Thayer, Sutter Butte, Mt Bullion, San Bruno Mountain…



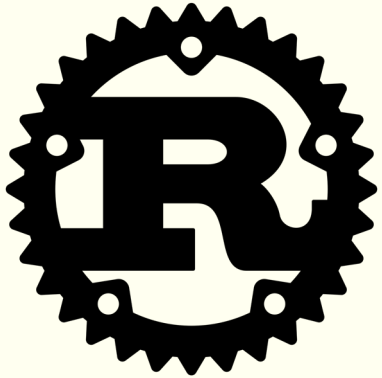
Mt. Diablo

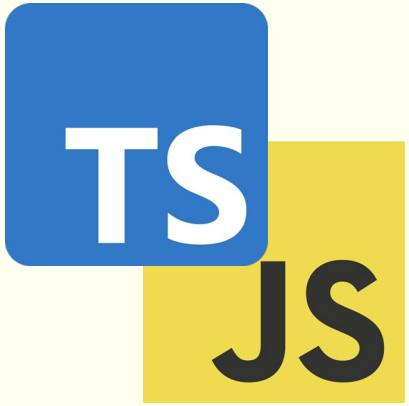
Stanford

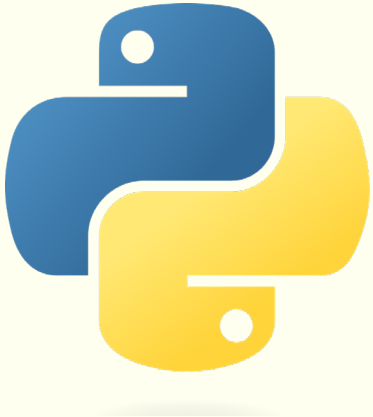
SJSU

Patterson Pass

# Info for Developers





# Further Resources

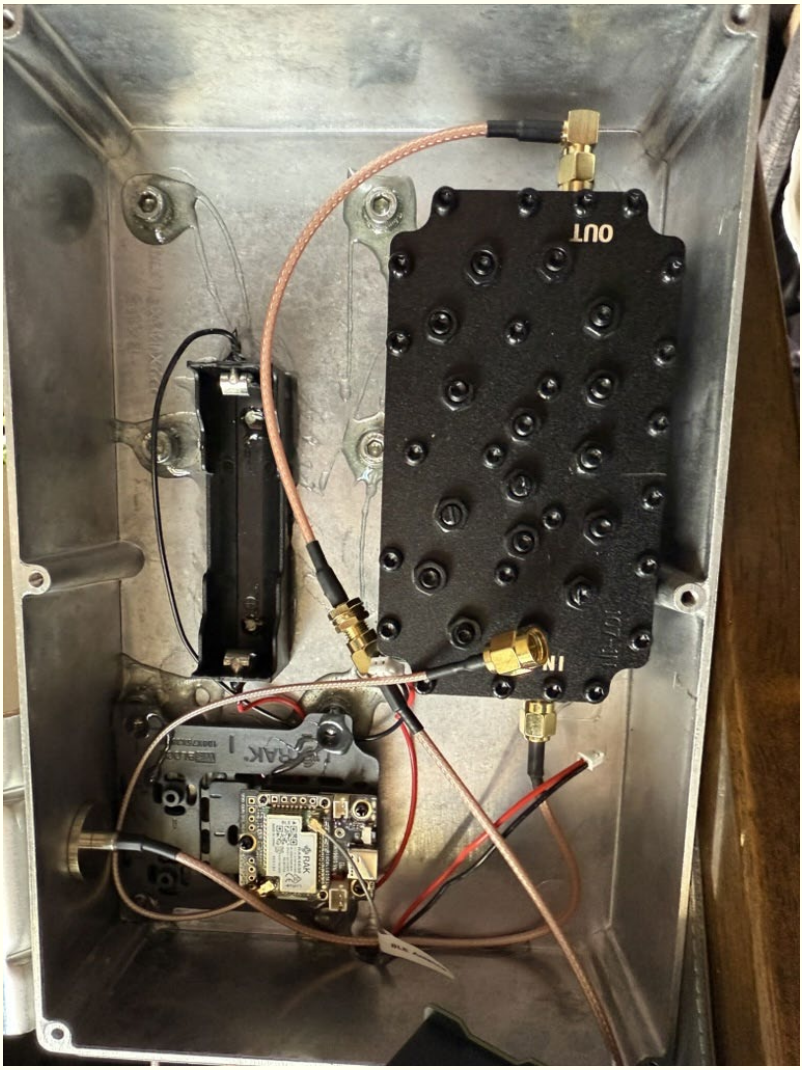
- Meshtastic.org (Official Docs)
- youtube.com/watch?v=boKh_0FjW-c (HRCC Livestream with Meshtastic admins)
- https://www.heywhatsthat.com/ LOS/Signal coverage mapping software
- https://meshinfo.cvme.sh/map Central Valley Mesh info
- https://meshview.bayme.sh/map Bay Area Mesh info

# Cvme.sh

# BayMe.sh

# Have fun Meshing Around!

Thank you


OUT

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