Amateur Radio Emergency Communications in the Modern Era

Orv Beach, Amateur radio callsign W6BI

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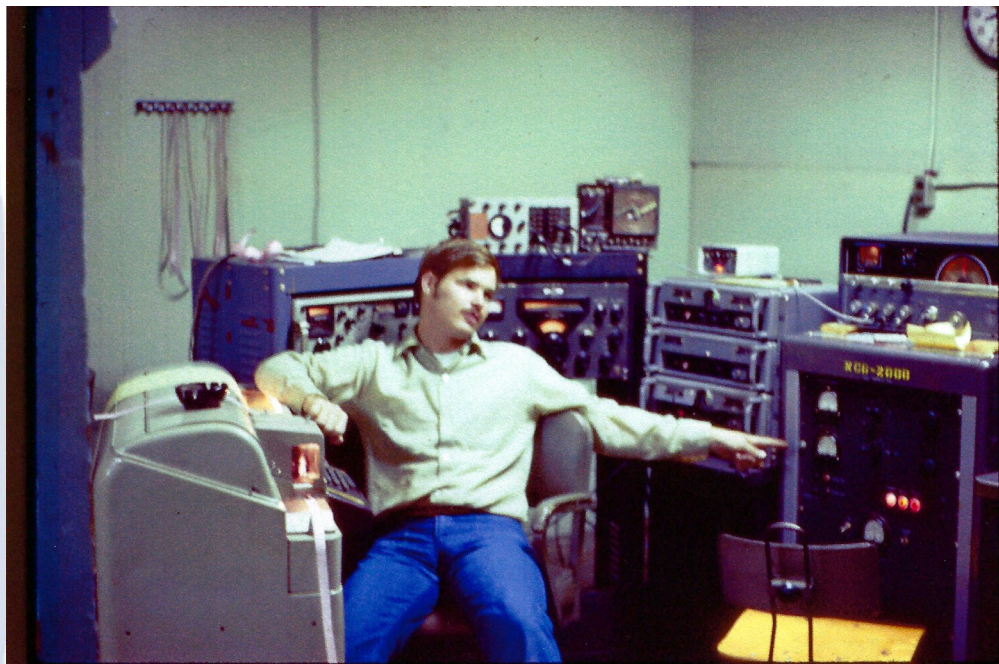
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In the Beginning…
Morse code, then voice

In the Beginning…
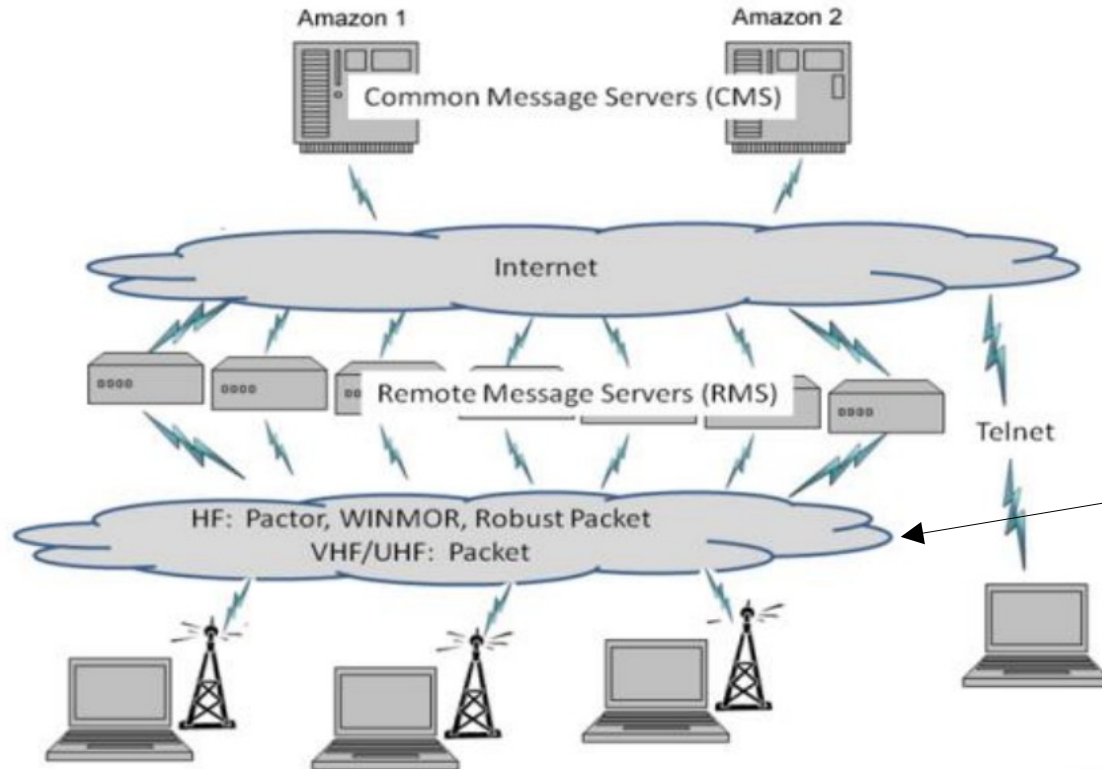## Radioteletype, then AX.25 packet radio

Winlink
(Winlink Global Radio Email)

A worldwide messaging system. Can use these relatively low speed modulations/protocols.
Data rates (not throughput) typically between 350 bits/second and 6 kilobits/second:

- ALE (Automatic Link Establishment)
- APRS (Automatic Packet Reporting System)
- AX.25 Packet Radio
- D-Star ("(Digital Smart Technologies for Amateur Radio)" – digital voice
- PACTOR, PACTOR-II, PACTOR-III, PACTOR-IV
- VARA FM, VARA HF
- Recently added support for: amateur radio IP networks
  - Significantly faster: data rates can be over 100 Megabits/second. Throughput between 5 and 10 Megabits/second

- Has a large set of standardized messaging templates: FEMA, ICS (Incident Command System), SATERN, various state-specific templates, and more

Winlink Architecture (Conventional Mode)

- CMS

- RMS (gateway)

- Client (you)

Amazon 1

Amazon 2

Common Message Servers (CMS)

Internet

Remote Message Servers (RMS)

Telnet

HF: Pactor, WINMOR, Robust Packet
VHF/UHF: Packet

Ham IP networking goes here

Winlink Express (Client). Like email but considerably more complex to configure, depending on protocol and route specified

Ham Radio Networking

Uses stock outdoor wireless access points – few hardware mods

- Ham radio network links can be more than 100 Megabits/second
    - (That's modulation rate, not throughput)

- Access points are loaded with custom software

- Together, they create a ham radio TCP/IP network

Amateur Radio Emergency Data Network (AREDN) Software

Derived from OpenWrt open source router software

Supports:

- Ubiquiti, TP-Link, Mikrotik and GL.Inet brands - 70+ different models
- Four ham radio bands
- Internet tunneling between nodes
- **Allows operations in Part 97-only channels***
- **MIMO/802.11n operation***
- **Provides DNS & DHCP services, route discovery and routing information***
- *These three combined make ham radio networks easy to construct!

The Digital Networking Bands supported by AREDN Software

- 902-928 MHz
  - not used much: only one 5 MHz wide channel, very noisy in urban and suburban areas, we're secondary on that band, and the gear is relatively expensive

- 2.4 GHz – 2300-2450 MHz
  - Only one usable 10 MHz wide Part 97 channel (Channel -2); Channel -1 may work OK away from cities.
  - Noisy due to splatter from poorly designed Part 15 wireless gear

- 3 GHz – 3300-3500 MHz
  - The good news: it's all ours! No U.S. Part 15 in this band
  - The bad news: we have to buy export equipment and it's almost double the price of 2 or 5 GHz equipment
  - The worse news: in November of 2020, the FCC took away this band and gave it to the 5G carriers; we'll have one to two years of grandfathered use before being required to vacate.

- 5 GHz Band – 5650-5925 MHz
  - Lots of channels.
  - The Part 97 band overlaps a lot of Part 15 channels, which can be useful for spreading traffic out.
  - We're secondary in this band. In October of 2020 the FCC took away primary occupancy of this band from the DOT (Department of Transportation). They'll be allowing Part 15 users to spread into the entire band in the near future.

Networking is a modern ham radio activity

But it's just infrastructure.

It doesn't accomplish anything…

It's all about the "Services"

Networking Services

Services = things you can actually use

- Keyboard to keyboard (text)
- Voice
- Video
- Email
- Document editing/management

- Dropboxes
- Web servers
- Repeater linking
- *Anything else you can think of subject to the Part 97 regulations*

Applications
(Services)
Some examples

Team Communications Tools

- E.g., Slack, Mattermost, RocketChat

- Text & pictures

- Multiple channels available

- Web access + Windows, IOS, MacOS, and Android apps available

Mattermost

VOIP (Voice Over IP w/Phones)

- VOIP PBX installed in mountaintop repeater building (WD6EBY – Sulphur Mountain, Ojai, California)
- Voice mail, conference calls, etc

VOIP Phones

- Showing a missed phone call
- Showing one or more voice messages waiting

Another VOIP PBX

W6BI–SFV–PBX

- Raspberry Pi 3 running FreePBX
- Deployed to the adjacent valley; trunked to first PBX
- Offers extensions, voice mail, conference bridges, etc.

Collaboration Servers

- Like the gamers use to coordinate their teams

- Voice and/or video chat. Very useful – and fun!

- Like the gamers use to coordinate their teams

- TeamSpeak, Mumble, TeamTalk, etc.

- Teamtalk provides these features:
  - One to one chats
  - Many to many (chat rooms)
  - Can set up as many channels as necessary
  - Multiple, **simultaneous** conversations possible – all **full duplex** (you can interrupt whomever's speaking :-D)
  - Speaker/microphone or headset (**HIGH quality audio**; not limited to 300-3,000 Hz like regular ham radio)

- PTT, VOX or open mic (each audio stream uses about 30 kbps – minimal load on a healthy network)

- File sharing and desktop sharing are also available

- The Teamtalk server runs nicely on a Raspberry Pi (RPI 3: typically < 10-15% CPU utilization)

- Clients available for Windows, Debian Linux, MacOS, IOS, and Android

Teamtalk Weekly Net – Call of person talking has green background; when they unkey it turns yellow

Teamtalk Net
Video can be bandwidth-heavy. It's optional

Aux channels; switch to one by double-clicking
Green – who's talking
Yellow – who talked last
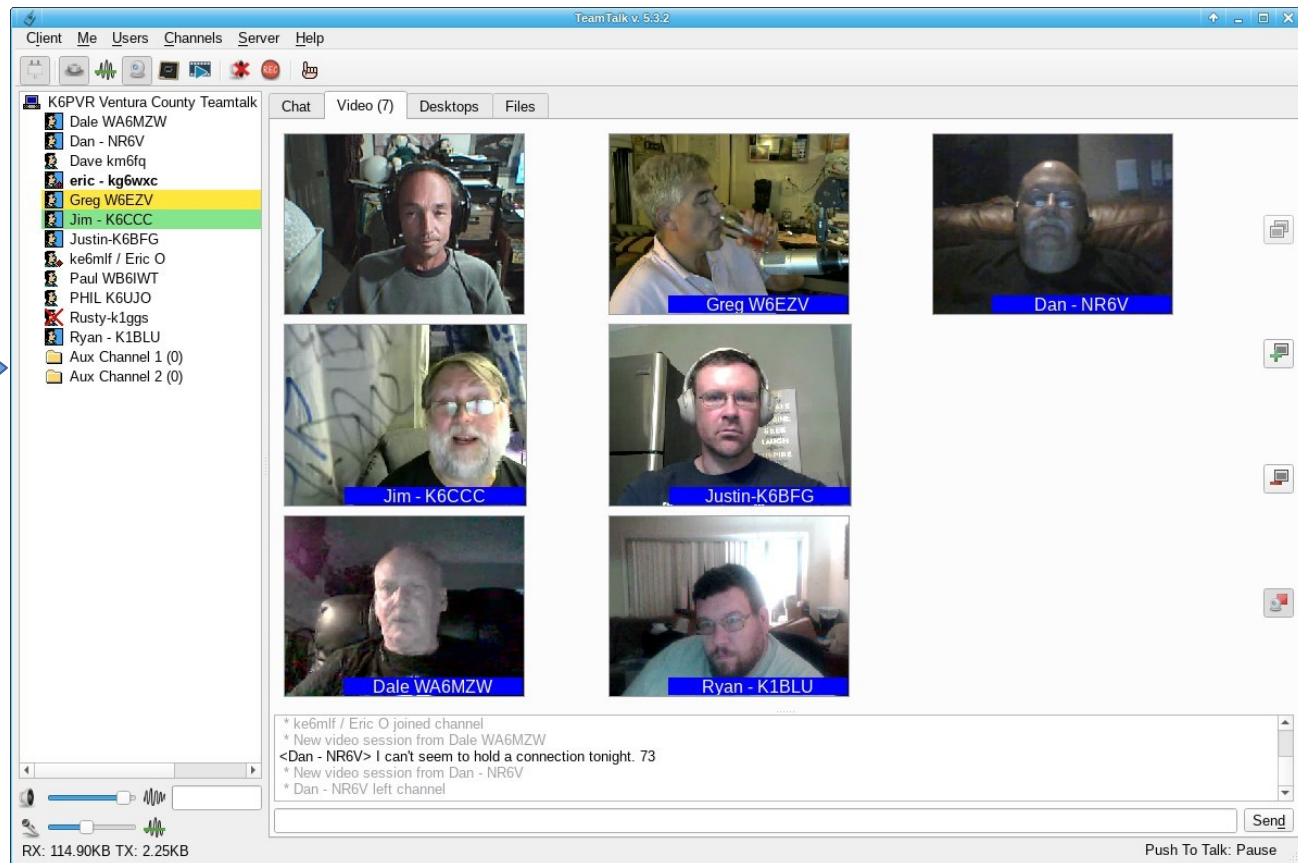
EmComm

Network nodes are deployed to EOCs, hospitals, etc., alongside existing amateur radio installations.

- Computer is equipped with
    - Teamtalk app
    - Winlink Express app
- Also equipped with VOIP phone

The Thomas Fire – Ventura, CA Dec 2017.
Streamed to from ham network to YouTube for wide viewing

The Woolsey Fire – Thousand Oaks, CA 11/2018
Also streamed to YouTube

Network map – Yakima, WA
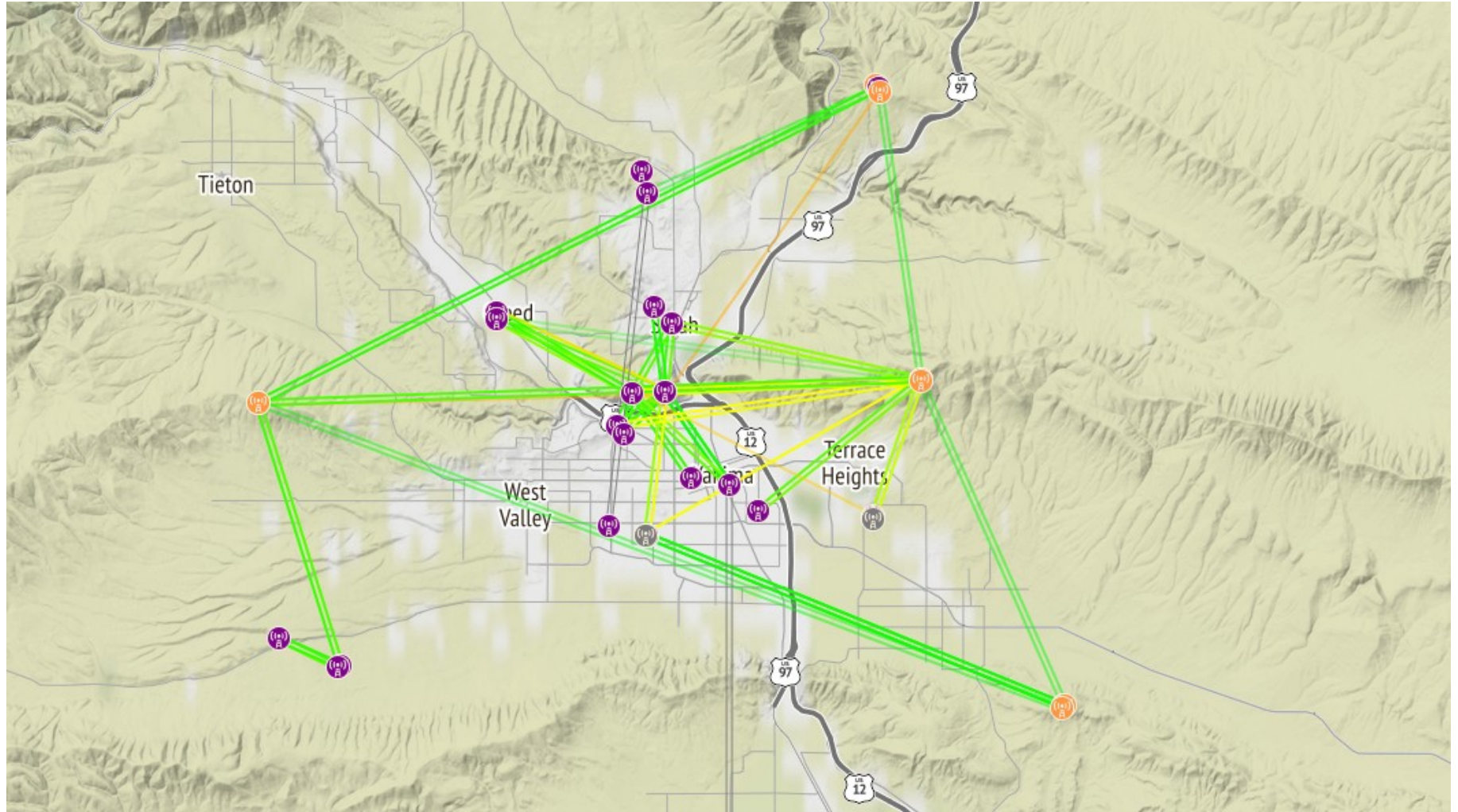
Network map – San Francisco, CA
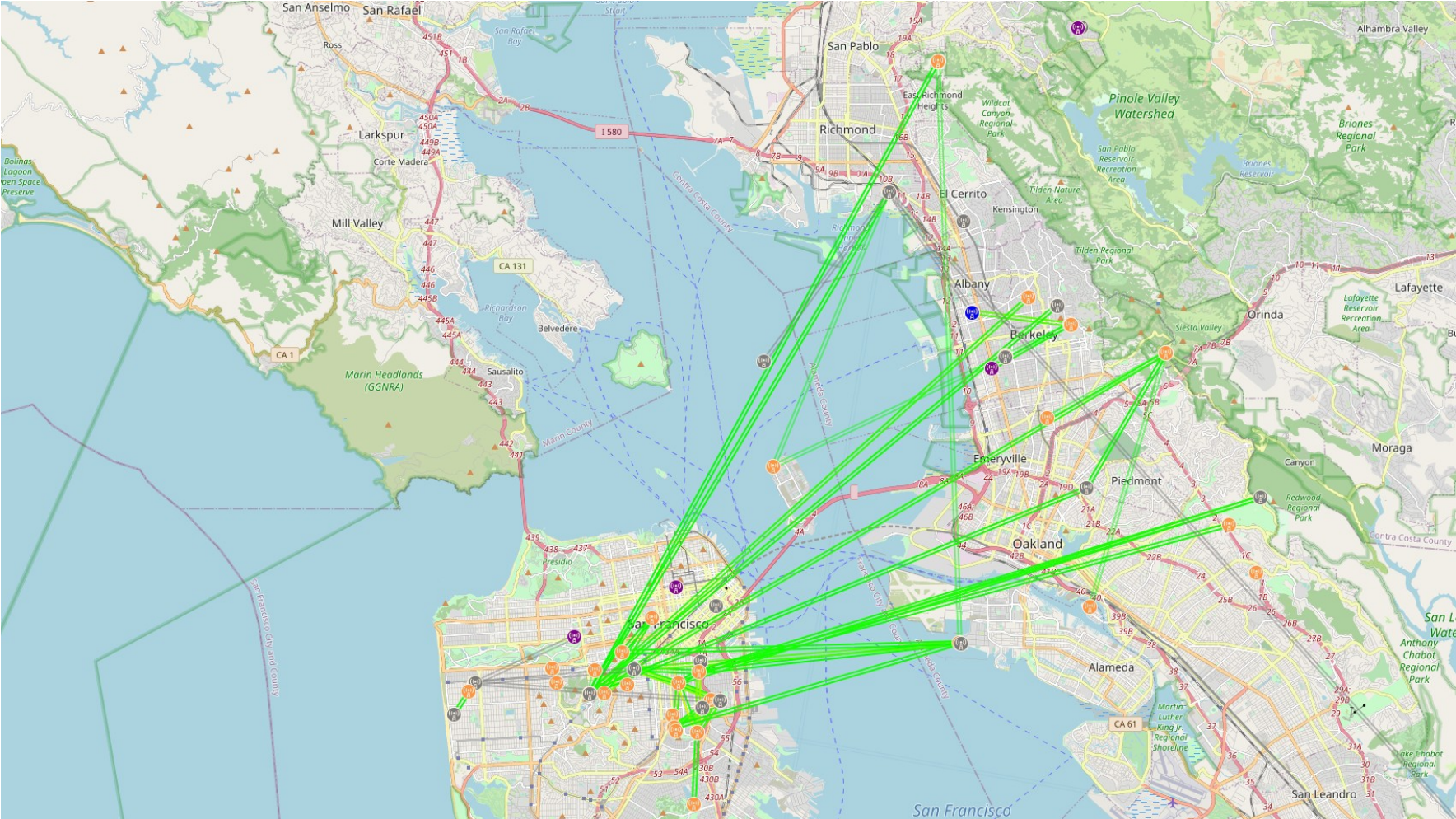
Network map – Hawaiian Islands
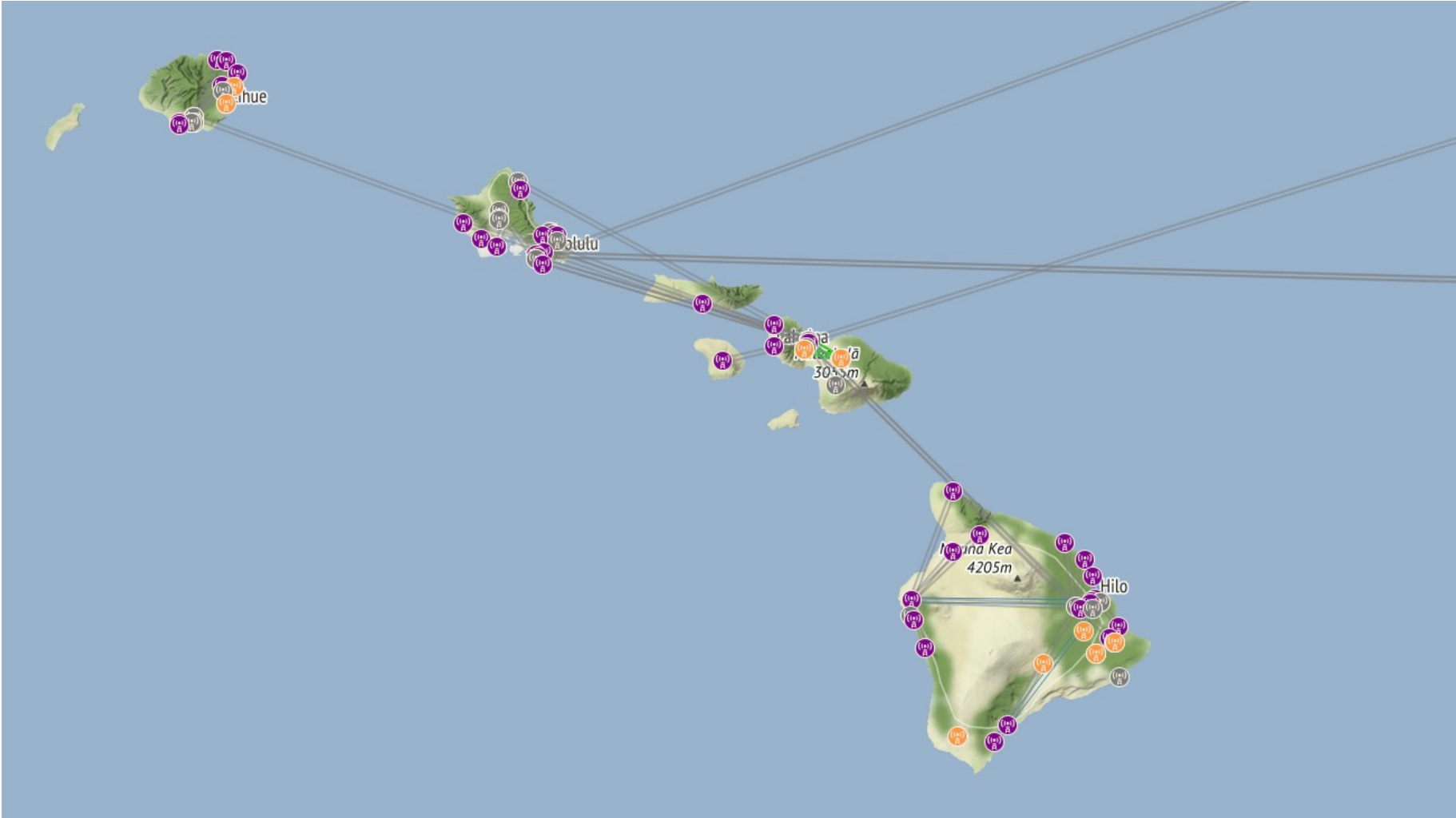
Network map – SoCal (~410 reachable nodes visible)
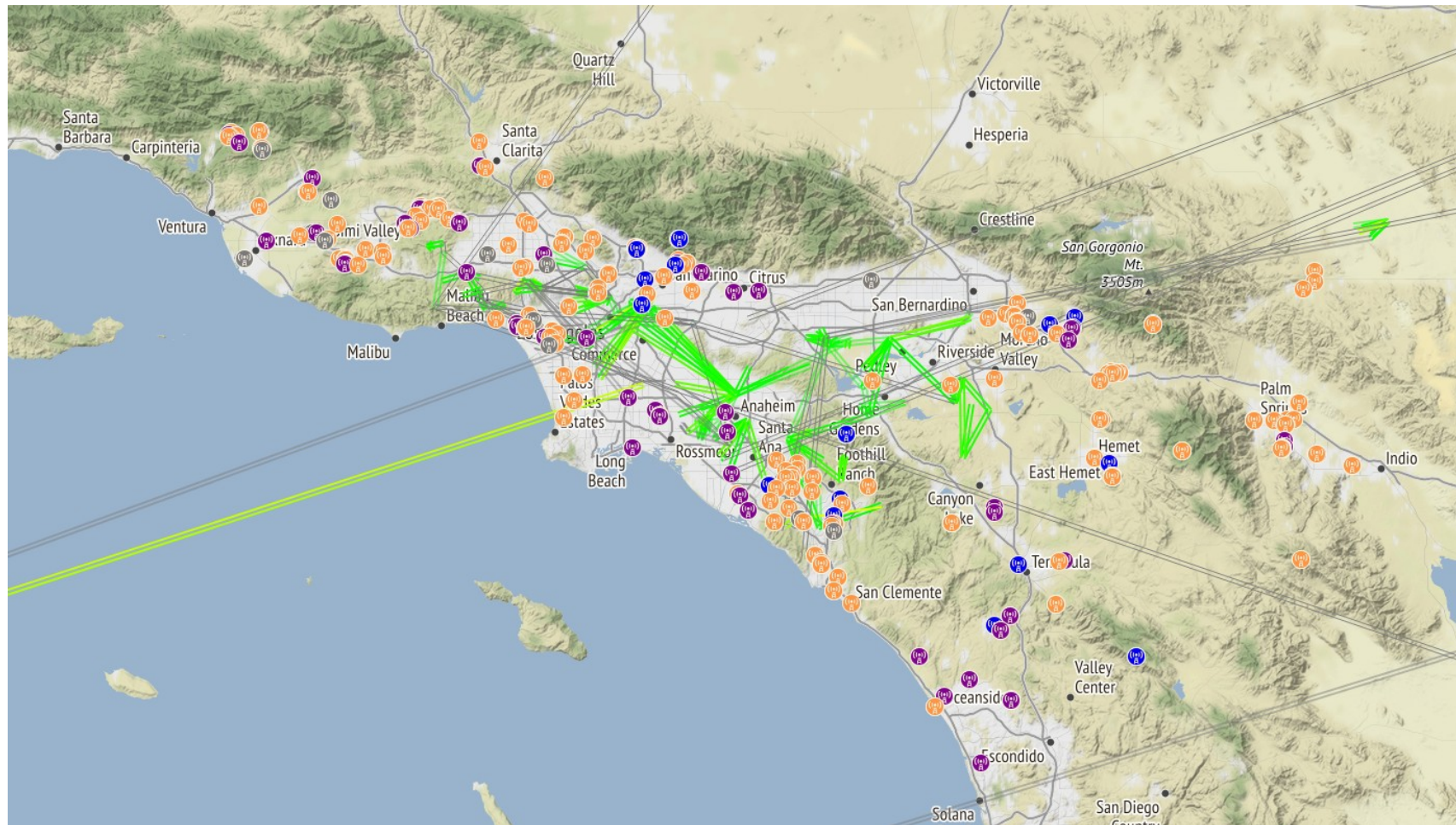
Typical end-user Configuration

AREDN nodes for both 2 and 5 GHz;
provides redundancy.
Done when possible at EOCs, hospitals
and other critical sites.

Typical end-user Configuration

High-gain dish for access to distant network backbone node; Lower-gain node for local user access (neighborhood)

Mikrotik LDF 5 (5 GHz) installed at surplus satellite dish feedpoint using universal mount ($8 from Amazon)

Ideal for hams under an HOA, as satellite dishes are allowed

LDF 2 (2 GHz) now also supported by AREDN software

Small site Example - North Orange County, California
120 degree sector antennas + nodes for 2.4, 3 & 5 GHZ

Medium Site Example – Chatsworth Peak, California
User access points on 2.4 & 5 GHz; dish for backbone link; PTZ camera

Another medium-sized site (post wind-storm)
(80% FM repeaters, 20% networking) Verdugo Peak, California

Large site (co-located at commercial site)
Yellow-highlighted gear is for mesh network. Multiple sector antennas provide for 360 degree user access. Backbone links (not visible, lower on tower) + PTZ camera
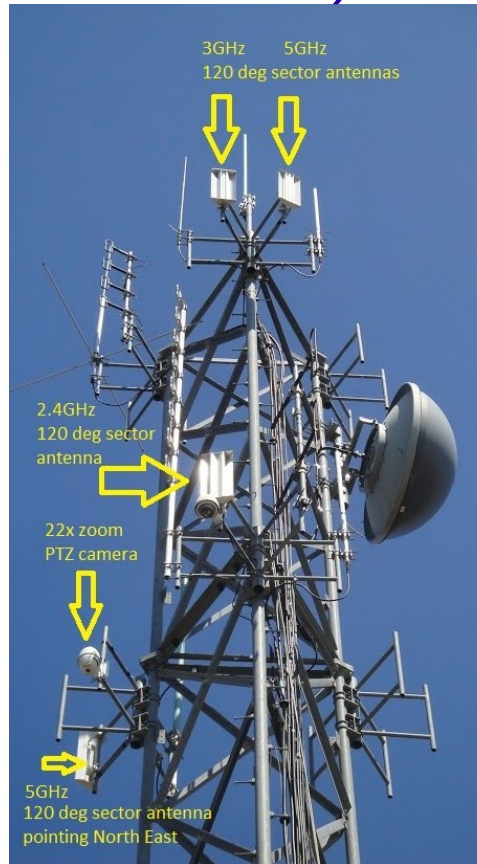
Ham Radio Allocations – 2.4 & 3 GHz

AREDN Offers 2 Non-Shared Channels on 2.4 GHz

2.4 GHz	Channel	-2	-1	0*	1	2	3	4	5	6
	Status	Ham Band			Shared Ham and ISM/WiFi Band					
	Freq	2.397	2.402	2.407	2.412	2.417	2.422	2.427	2.432	2.437

*Not available for use

Only one usable 10 MHz channel. Splatter from Part 15 limits usefulness

24 Non-Shared Channels on 3.4 GHz

3.4 GHz	Channel	76	77	78	79	80	81	82	83	84	85	86	87
	Status	Ham Band											
	Freq	3.380	3.385	3.390	3.395	3.400	3.405	3.410	3.415	3.420	3.425	3.430	3.435
		88	89	90	91	92	93	94	95	96	97	98	99
		3.440	3.445	3.450	3.455	3.460	3.465	3.470	3.475	3.480	3.485	3.490	3.495

Refer to your local band plan for coordination

11/2020 – FCC removed amateur allocation; will be given to 5G carriers.
We'll have 1-2 years to vacate.

Ham Radio Allocations – 5 GHz

52 Channels, 14 Non-Shared, on 5.8 GHz

5.8 GHz	Channel	133	134	135	136	137	138	139	140	141	142	143	144	145
	Status	Ham Band shared with U-NII-2C/wifi/unlicensed												
	Freq	5.665	5.670	5.675	5.680	5.685	5.690	5.695	5.700	5.705	5.710	5.715	5.720	5.725

146	147	148	149	150	151	152	153	154	155	156	157	158
Ham Band shared with U-NII-3/wifi/unlicensed												
5.730	5.735	5.740	5.745	5.750	5.755	5.760	5.765	5.770	5.775	5.780	5.785	5.790

159	160	161	162	163	164	165	166	167	168	169	170	171
Ham Band shared with U-NII-3/wifi/unlicensed											Ham Band	
5.795	5.800	5.805	5.810	5.815	5.820	5.825	5.830	5.835	5.840	5.845	5.850	5.855

172	173	174	175	176	177	178	179	180	181	182	183	184
Ham Band												
5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920

Refer to your local band plan for coordination; ★5825 to 5850 Shared under Part 15.247 with a limited number of WISP operators and may be encountered at tower sites

11/2020 – FCC removed DOT's primary allocation (they hadn't started using it). We kept our secondary allocation but the FCC will let Part 15 users expand into the entire band.
Over time, expect channel noise levels to rise. Will need to deploy higher gain devices to compensate.

Questions, comments?

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