Telemetry Equipment

Challenges & Use Cases | NetOps XIII

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PNSN
Pacific Northwest Seismic Network

Telemetry Challenges

Dense & Tall Tree Cover

- Impacts 900 MHz and 2.4 & 5.8 GHz

Bodies of Water

- Thanks for the multipath!

VHF is Crowded

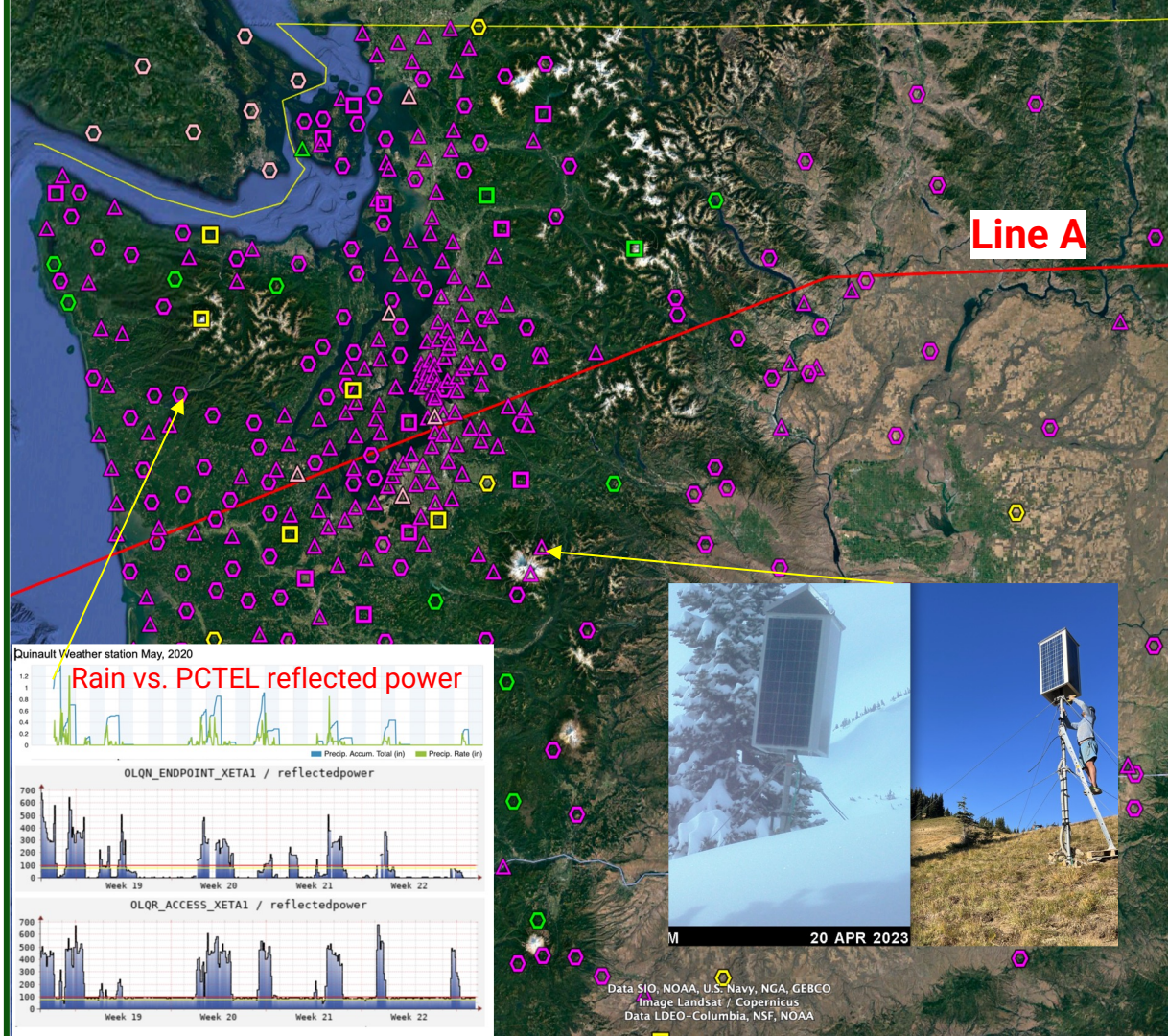
- Blame it on the tree cover
- Impacts shot performance
- Impacts licensure

Line A

- US & Canada coordinate on VHF and UHF licenses up to 470 MHz
- Further impacts to licensure
  - ‘Statewide’ licenses are void above line A
- Covers more than 30% of the state, matches much of the green area –>

Climate

- Water is wet
  - PCTel MYA Antennas (VHF) experience significant reverse power during rainfall
  - Multipath over bodies of water
- Ice is hard
  - Causes signal loss
  - Falls on antennas
- Snow is deep



Telemetry Devices

VHF Radios

Xeta1 Series

- Mediocre sensitivity
  - Don't trust a multipath-heavy shot
- Decent (for VHF) bandwidth @ 25 khz - ~60 kbps
  - Tx Rates lie! - estimate 88 kbps
  - Less viable @ 12.5 khz
- Good power draw - ~5 W average w/ duty cycle

4RF Aprisa SR+

- Great sensitivity
  - Still can't beat all multipath
  - Performs better over water
- Similar bandwidth to Xeta1
- Full Duplex compatible
  - Viable with 12.5 khz licenses
  - Good for Line A problems (licensing issues)
- More power draw - ~13 W
- Don't need to log into remote radio for settings changes

450 MHz UHF Radios

Xeta4 Series

- Bandwidth and power draw similar to Xeta1 series
- Tx Rates still lie!

Cellular

Sierra Wireless - RV55 Pro, RV55, RV50

- ~$800
- ALMS group management
- AT&T FirstNet (RV55 Pro) and Verizon Frontline

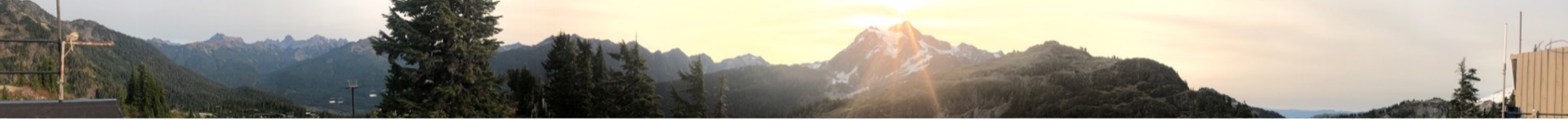
900 MHz UHF Radios

Xeta9 Series

- Mixed opinions on sensitivity
- Good bandwidth vs SNR
  - 2 Mbps @ 15 db separation
- Good power draw (similar to Xeta1 and Xeta4)

Aprisa SRi

- Great sensitivity
- Significantly less bandwidth available
- More power draw (similar to SR+)



Telemetry Devices

2.4 & 5.8 GHz SHF Radios

Ubiquiti Nanobeam & Powerbeam

- Cheap & high bandwidth ($60 - $150 per radio/ant)
- PtP or PtMP
- Low power - <4 W @ 4 Mbps duty cycle
- Surprisingly Hardy
    - but not recommended for snow/ice
- Powerbeam wind-load is hefty
- Relatively simple learning curve
    - You lose features as a result
    - 90 dB death!

Ubiquiti AirFiber

- Costlier - ~$600 for radio + antenna (model dependent)
- PtP only
- Hardier than Powerbeams
- 23 dBi slant < wind load than Powerbeam
- Beefier learning curve

Field Networking

Mikrotik Routers

- Cheap & powerful - $30 - $200 for field models
- Low power - hEX ~10 W
    - @20 Mbps duty cycle w/ POE to two Nanobeams
- VPN - WireGuard (skip IPSec)
- OSPF
- Steep learning curve to configure, but easy for simple tasks (Config cloning, OS & Firmware updates)

OnLogic CL210 Series Edge Servers

- $500+
- Full Linux OS
    - Great firewall
    - CentOS end of life will be a challenge
- Requires full sysadmin support

Alaska Earthquake Center

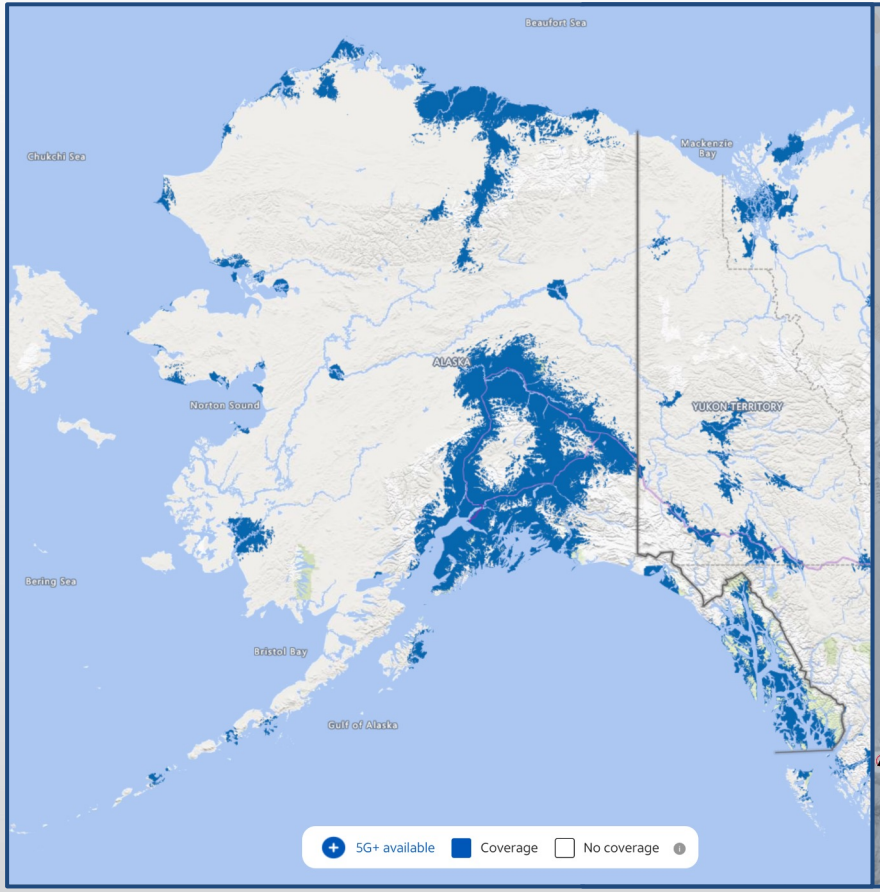
ALASKA EARTHQUAKE CENTER

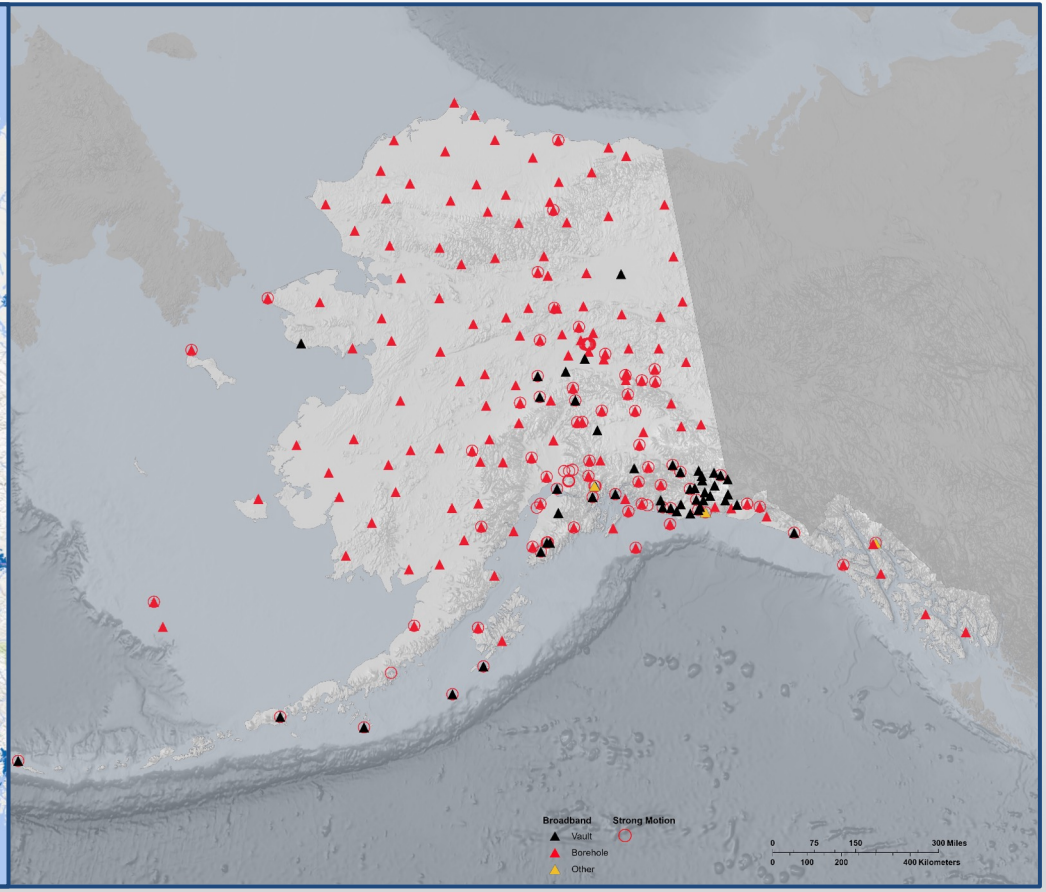
Challenges in Alaska

- **Remote locations**
  - Limited infrastructure and power options
  - Limited communications options
  - Limited transportation options
- **Variety of environments**
  - Large geographic region (~600k sq miles, 20 degree latitude range)
  - High variability: permafrost bogs, mountain ridges, coastal ranges, forests, tundra, etc.
  - Wildlife: infrastructure is popular with bears (and others) and they can spend lots of time at the stations
  - Winter: low sunlight, heavy snow, cold temperatures
- **Limited telemetry options**
  - Cell coverage limited to population areas
  - Few communities with reliable internet connections
  - Northern edge of satellite beams (satellites near southern horizon, some unreachable)
  - Multiple mountain ranges and topography limits lines of sight
  - Dual telemetry options at stations are rare, often only one practical path available (at best)

ALASKA EARTHQUAKE CENTER

Example: Limited cell coverage





ALASKA EARTHQUAKE CENTER

Example: remote power challenges

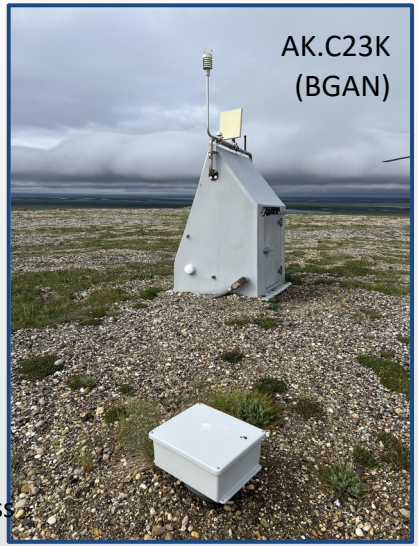
AK.BGLC

Solar power and AGM battery system for continuous Hughes Gen2 VSAT operation

- 80 SunSaver AGM (~100kWh storage)
- 2215 W solar charging

Telemetry devices

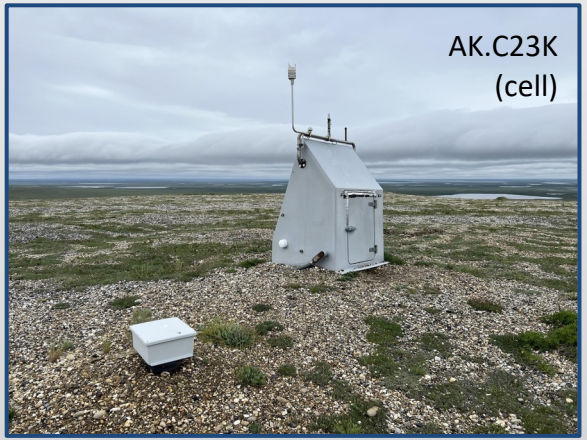
- 900 MHz Radios
  - Freewave FGR+, FGR2
    - traditional workhorse radio for AEC networks
    - sensitive to power input, ethernet ports can fail
  - Freewave Zumlink (new)
- Satellite Communications
  - Hughes Gen 2 (replacing)
  - BGAN
  - Starlink (new)
- Cell modems
  - Sierra Wireless RV50 and RV50X
  - 2G/EDGE networks still present in Alaska (requires RV50)
  - Private APNs (AT&T, Verizon, GCI) to block public access
- Field Router
  - Mikrotik RB750 HexLite
    - L2TP VPN tunnel (with or without IPSec)
    - Routing and firewall configurations prevent access beyond AEC.
  - OSPF routing for some networks, BGP routing with ISPs
  - ISP supplied DSL modems
    - ControlByWeb Relays for rebooting when connection drops
    - Coupled with Mikrotik RB750



AK.C23K, AK.C26K, AK.C27K converted from BGAN to cell, July, 2023

- BGAN subscriptions are expensive and the units are unable to run continuously in winter due to power limits.

- AEC is converting sites away from BGAN wherever possible



Current Telemetry Technology Challenges

- Hughes Gen2 VSAT systems are ending early summer 2024
  - Primary method for satellite communications for AEC (17 systems)
    - Gateways for radio networks
    - Single stations where no other communications is practical
  - Good coverage in Alaska
  - Static public IP, cheap, and other advantages
  - Testing Starlink and investigating Nanometrics Libra systems as replacements

- Freewave has discontinued FGR family of radios
  - AEC has used FGR+ and FGR2 radios almost exclusively for the past two decades
  - Zumlink, Freewave's next generation radio, is not radio link compatible with FGR series

- GCI (Alaska-based ISP) discontinuing some rural internet services due to lack of market

Starlink

- Installed High Performance Dishy at AK.TNA in September, 2023.
  - AC power (USAF radar station)
  - Difficult coastal environment (high winds, moisture)
  - Strong performance so far (near 100% station uptime)

- Cooperative Starlink installs with Earthscope in Akhiok (Kodiak) and Yakutat.
  - AC power
  - Good performance so far
  - Separate routers for Earthscope (Ubiquity) and AEC (Mikrotik) to provide separate VPN connections for both agencies

- Testing DC-power based Starlink power systems for installation in 2024
  - Off-the-shelf components available to run Starlink off a 12V DC power system (thanks to motorhome market)
  - Reliable performance so far, but more extensive testing this spring
  - Mikrotik RB750 HexLite router for VPN access and remote access to Dishy local control options
  - To be determined: Dishy heater toggling, ControlByWeb relays for power control and cycle scheduling, required uptime to fully upload a Q330 buffer (registration time, reliable bandwidth rates, etc.).

Freewave Zumlink radios

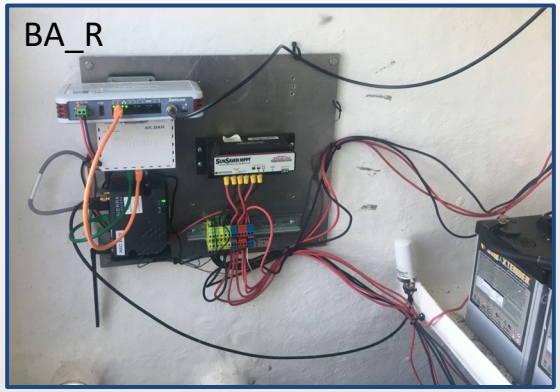
- Required high bandwidth for high res image transmission, FGR radios insufficient.

- Installed in our Barry Arm network in September 2023 with 1 Mbps data rate.

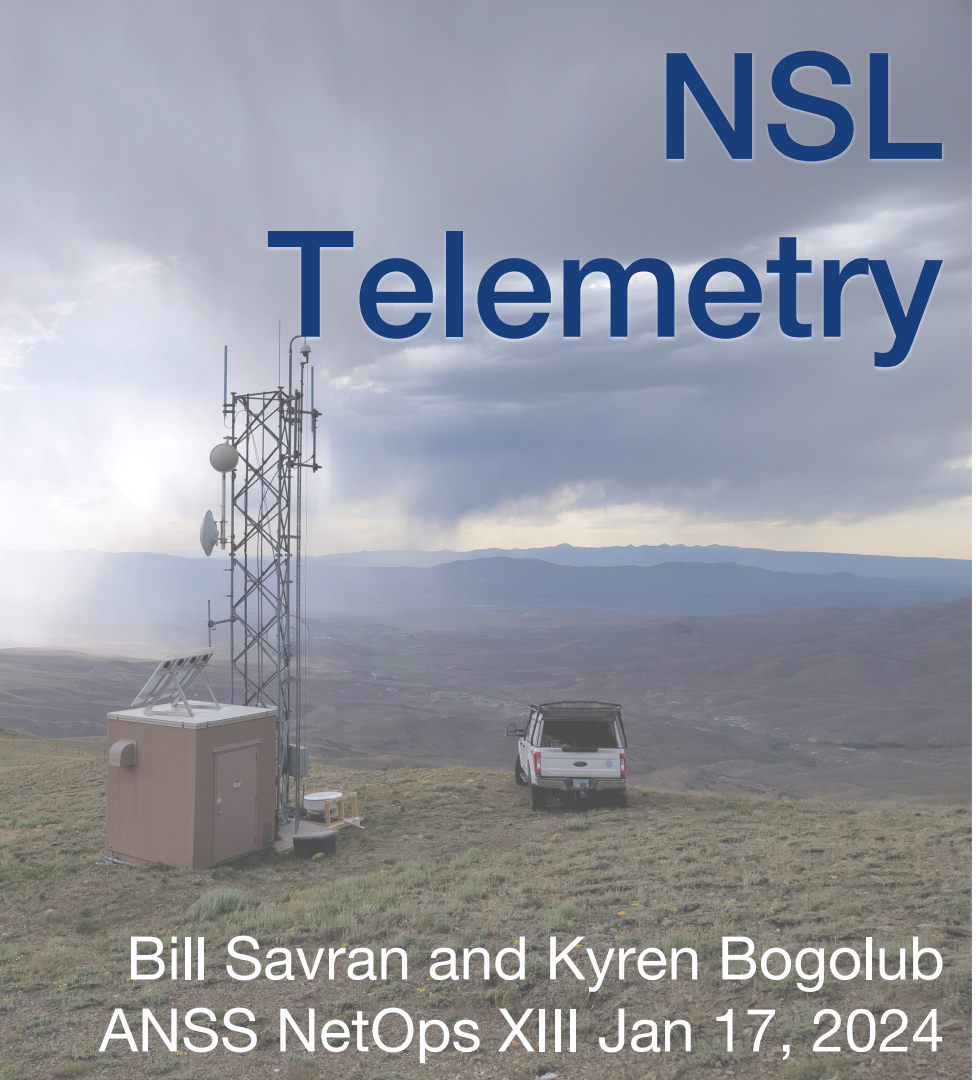
- Similar radio, ethernet, and SNMP settings to FGR radios with more general options.

- Strong performance so far.

- Menu GUI still seems to be in a beta state, but works fine



Nevada Seismological Laboratory



NSL Telemetry

Bill Savran and Kyren Bogolub

ANSS NetOps XIII Jan 17, 2024

Challenges

remote stations

poor cell coverage

Advantages

awesome team

multi-hazard monitoring leads to more stakeholders invested in keeping network alive

NEVADA SEISMOLOGICAL LABORATORY

University of Nevada, Reno

ANSS

USGS science for a changing world

Migration to 11GHz point-to-point radio in Henderson NV

Improving Network Comms

Improved point-to-point radio antennas to upgrade the backbone from Reno to Henderson NV

Starlink

Test on 2 previously untelemetered stations, awaiting to see how power survives winter

Redundancy

Microwave (primary), fiber, cell. Try to have 2-3 paths for data

Advancements

Implemented BFD to provide instant failover for OSPF routing
Wireguard VPN allows OSPF costing of dynamic WAN IP

NEVADA SEISMOLOGICAL LABORATORY

Northern California Seismic Network

NCSN Telemetry

Challenges

Dense Forests & Mountain Ranges

- Relocating some sites in order to improve their LOS
- Migrating other sites to cell

Federal Restrictions on Device Types & Manufacturers

- Impacts NCSN's ability to adopt new devices & manufacturers

Advantages

Partnership with CalOES Public Safety Communications

- Relays located across California
- Locations where NCSN doesn't have relay infrastructure
- Reduces reliance on cellular telemetry

MMS GPS Sync

- Allows for busy relays without interference

Last Mile Equipment

Cambium N500/550

- 900 MHz

Xeta7

- 700 MHz

Sierra Wireless Cell Modems

- Verizon
- AT&T FirstNet

HughesNet

- Converting to StarLink soon

USGS Microwave Network - Main Trunk

NTIA Licensed 4.5 GHz

- Converting from unlicensed 5.8 GHz
- PtP shots

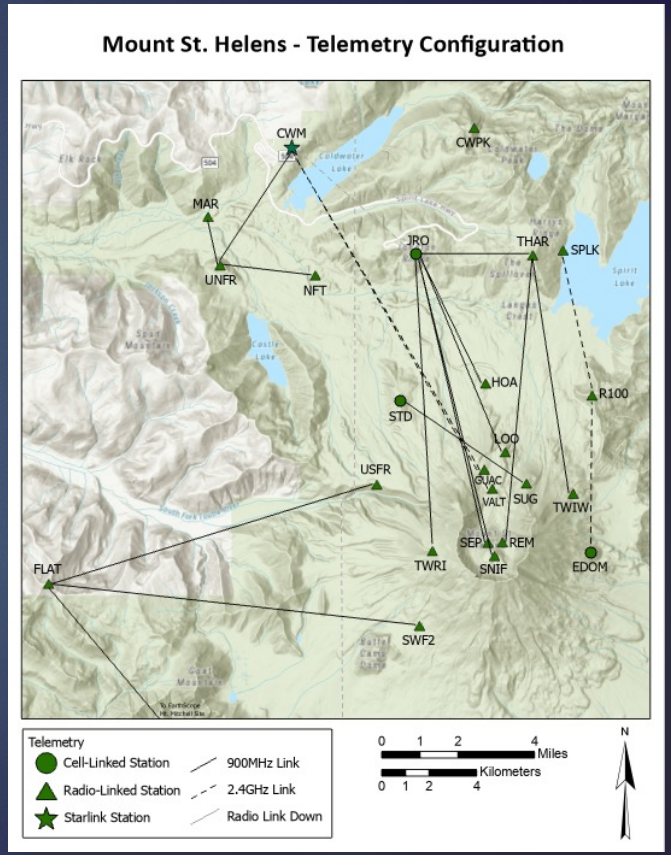
NTIA Licensed 7-8 GHz

- Converting to StarLink soon
- PtP shots

Cascades Volcano Observatory

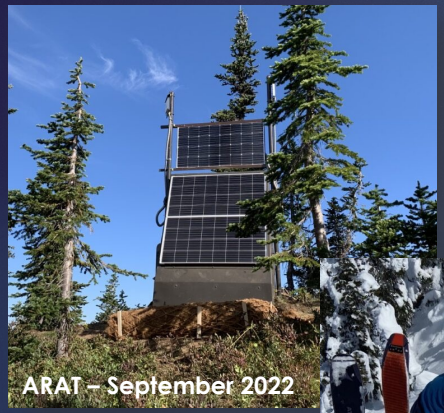
Telemetry Equipment

- Remote Sites
  - Xetawave 900MHz + 2.4GHz Radios
    - Xeta9, Xeta9x9, Xeta2.4
  - Freewave 900MHz Radios
    - FGR2, FGR2+, FGR+, HT+
  - Sierra Wireless Airlink Cell Modems
    - RV50, RV55
- Major Repeaters and/or AC Powered Sites
  - Ubiquity AirFiber 5.8GHz
  - Motorola PTP 5.8GHz
  - Starlink
  - Internet Connection
- New Equipment
  - Cell Modems
    - As coverage expands, more stations have been converted to cell
    - Currently 20 modems deployed
  - Starlink
    - Recent Mt. St. Helens install at AC powered receive site
    - Not feasible at most sites, too power hungry



USGS Cascades Volcano Observatory

Telemetry Challenges



- Challenges
  - Stations tend to be extremely remote
  - Challenging topography
  - Extreme mountain weather
  - Little to no existing infrastructure
  - Power limitations, especially in winter

- Advantages
  - Solar/battery power system, off the grid
  - Radio network low cost to operate once up and running
  - Simple field telemetry equipment, plug-and-play
  - Secure data streams

Texas Seismological Network & Seismology Research

TexNet Telemetry

Challenges

Remote Stations with Poor Cell Coverage

Cellular

Sierra Wireless RV55

- Lacks a free cloud manager
    - Each modem managed individually

Cradlepoint IBR900

- Strong reception

Antennas

Proxicast Omni Directional

- Easy Install
- Low gain - need robust coverage

Poynting Directional

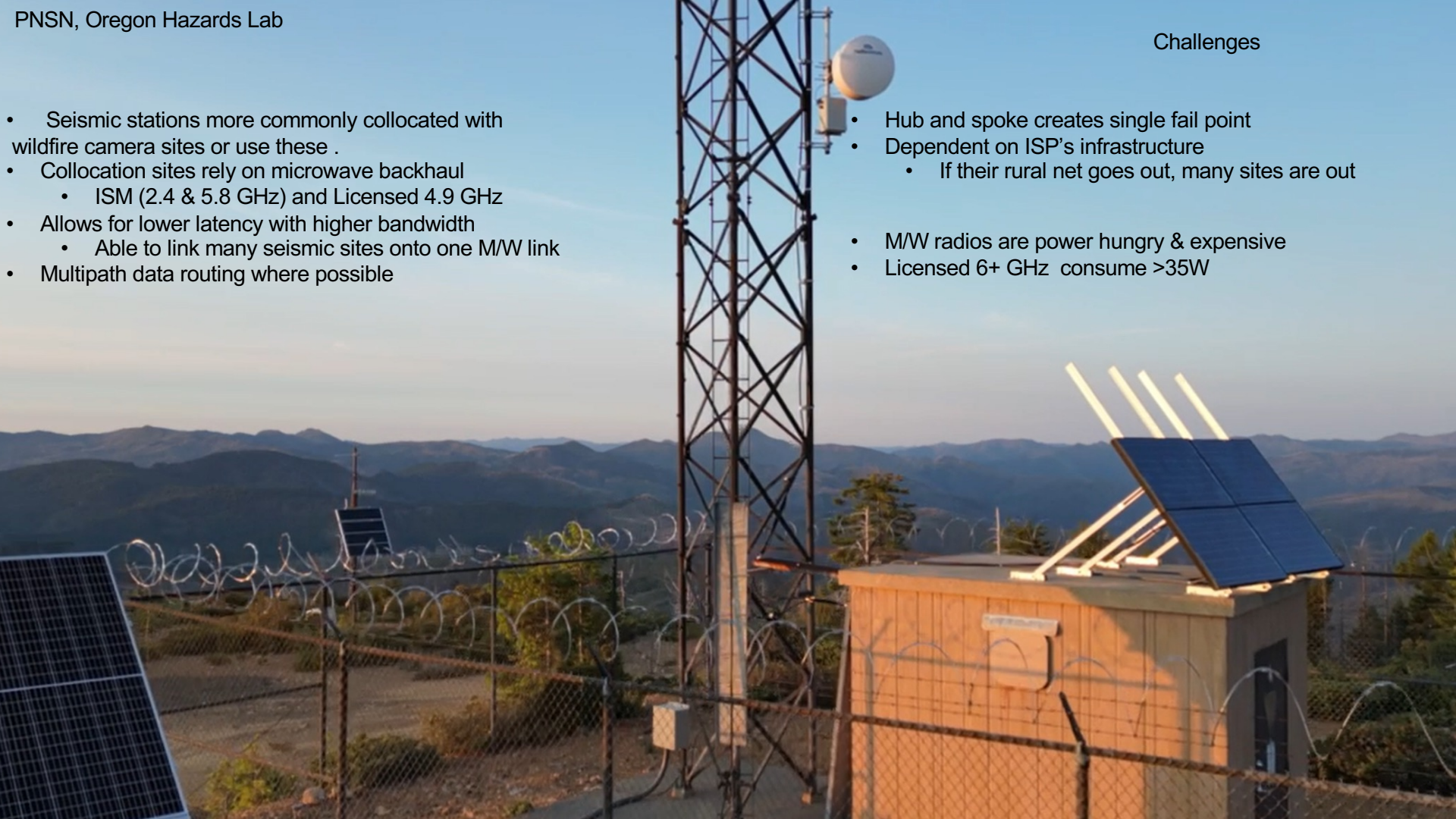
- Decent gain
- Requires robust mounting options

Waveform Directional

- Decent gain
- Requires robust mounting options

PNSN; Oregon Hazards Lab

PNSN, Oregon Hazards Lab



- Seismic stations more commonly collocated with wildfire camera sites or use these .
- Collocation sites rely on microwave backhaul
  - ISM (2.4 & 5.8 GHz) and Licensed 4.9 GHz
- Allows for lower latency with higher bandwidth
  - Able to link many seismic sites onto one M/W link
- Multipath data routing where possible

Challenges

- Hub and spoke creates single fail point
- Dependent on ISP's infrastructure
  - If their rural net goes out, many sites are out

- M/W radios are power hungry & expensive
- Licensed 6+ GHz consume >35W

PNSN, Oregon Hazards Lab

Seismic Telemetry Equipment

- 900 MHz XetaWave Xeta 9 & 9x9
- Antennas
  - PCTEL 7 Element Yagi
  - Scala Radome
  - Ventev small enclosed yagi

M/W Telemetry Equipment

- Radios
  - Ubiquity Nanobeam
  - Ubiquity AirFiber 5XD
  - Cambium PTP450i (new in 2023)
- Antennas
  - Range from 1-3 ft
  - RadioWaves brand