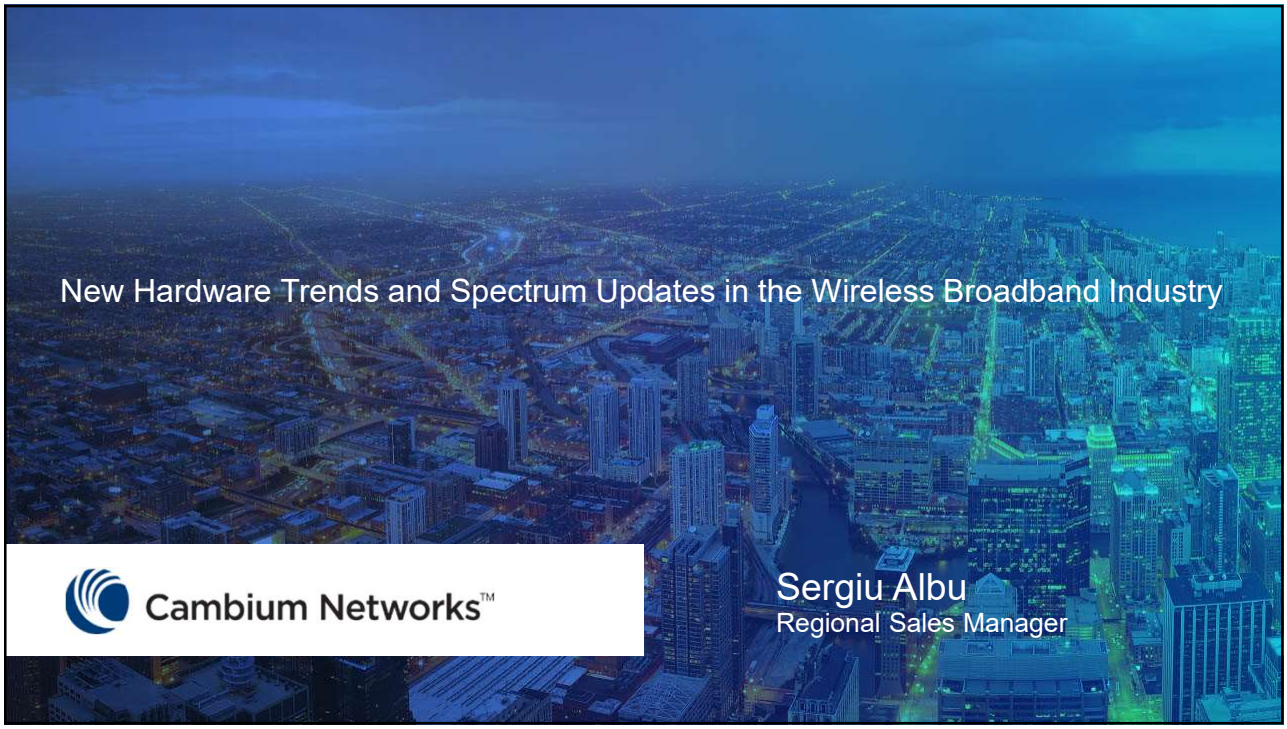
New Hardware Trends and Spectrum Updates in the Wireless Broadband Industry
Cambium Networks™
Sergiu Albu
Regional Sales Manager

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Cambium Networks™
PMP 6 GHz
Regulatory Update

2

FCC Report and Order and Further Notice of Proposed Rule Making – April 2020

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Device Class	Operating Bands	Maximum EIRP	Maximum EIRP Power Spectral Density
Standard-Power Access Point (AFC Controlled)	**U-NII-5** (5.925-6.425 GHz) **U-NII-7** (6.525-6.875 GHz)	36 dBm	23 dBm/MHz
Client Connected to Standard-Power Access Point		36 dBm	17 dBm/MHz
Low-Power Access Point (indoor only)	**U-NII-5** (5.925-6.425 GHz) **U-NII-6** (6.425-6.525 GHz) **U-NII-7** (6.525-6.875 GHz) **U-NII-8** (6.875-7.125 GHz)	30 dBm	5 dBm/MHz
Client Connected to Low-Power Access		24 dBm	-1 dBm/MHz

- **850 MHz Outdoor with Automatic Frequency Coordination (AFC)**
- **1200 MHz Low Power Indoor**
- **Further Notice of Proposed Rule Making**
  - A. Very Low Power Operation
  - B. Power Spectral Density Increase for Low Power Indoor Operation
  - C. Mobile Standard-Power Access Point Operation
  - D. Higher Power Limits and Antenna Directivity for Standard-Power Access Points
- **Legal Petition to Set Aside FCC R & O**

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New Spectrum – 6 GHz

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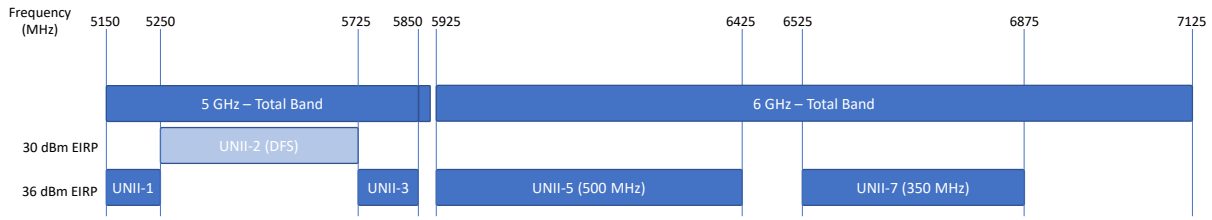

- In the US, FCC has allowed usage of 5850-5895 MHz (likely they will soon allow up to 5925 MHz)
- 6 GHz will open soon but will require the use of Automated Frequency Coordination (AFC).
- UNII-5 and UNII-7 will be allowed for outdoor use at “standard power” (36 dBm EIRP)
- UNII-6 and UNII-8 will be restricted to LPI (Low Power Indoor) use

850 MHz Outdoor with Automatic Frequency Coordination (AFC)
1200 MHz Low Power Indoor

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Automatic Frequency Coordination

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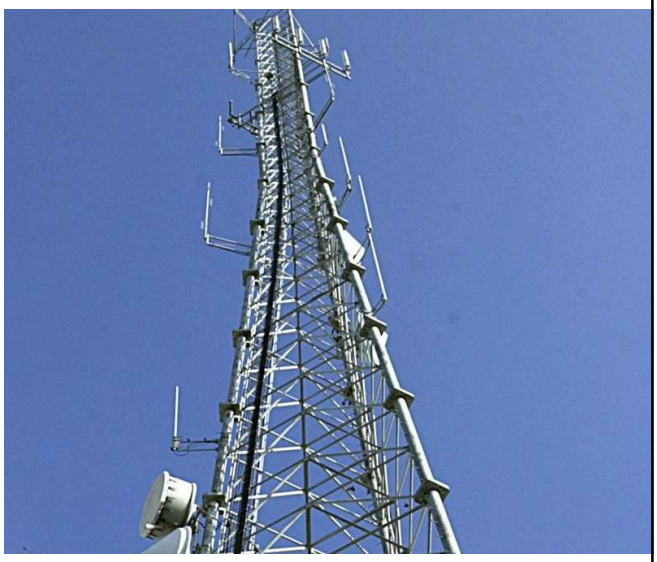
Required to exercise outdoor standard power in 5.925-6.425 GHz and 6.525-6.875 GHz (850 MHz total)

The AFC is intended to protect licensed operators in 6 GHz from harmful interference

- Does not coordinate multiple interferers as does CBRS SAS
- Expect multiple AFCs to be approved and in operation

AFC is now Live!



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Next Gen Platform Capabilities

Feature	Operator Benefit
5 GHz to 7 GHz support in same hardware	Single SKU to stock and maintain
Backward *and* Forward compatibility	Leverage existing platform investment, migrate gracefully to next generation
Ultra Wide-band support (2x100 MHz channels)	Total Capacity Increase, more bandwidth
Dual Sector Mode	Can operate 2 carriers independently (i.e. one 5 GHz and one 6 GHz), very flexible
Carrier Aggregation – - The two carriers can have different bandwidths	Flexibility in spectrum usage - 5 GHz may be congested and require smaller channel while 6 GHz can utilize larger channel
Transmit and Receive Diversity	Link Budget increase, better nLOS performance and enhanced robustness to interference
Downlink and Uplink can have different channel bandwidths	If AP is subject to additional interference, the Uplink could run in smaller channel size to achieve better signal and higher modulation

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Platform Capabilities (cont'd.)

Feature	Operator Benefit
Higher Modulation Coding levels	Plans to support 512- and 1024-QAM will increase capacity and throughput
Higher Order MU-MIMO	Simultaneous communication with up to 12 SMs, maximizing spectral efficiency
Frequency Re-use of 1 (i.e. N=1)	Increased Spectral Efficiency
Null Steering and Interference Cancellation	Increase n- and NLOS capabilities, reduce effect of noise

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Proven Air Interface now adds 802.11ax advantages

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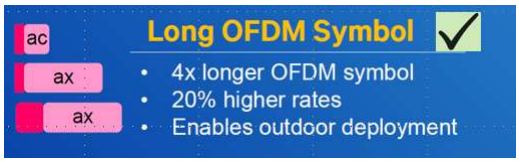

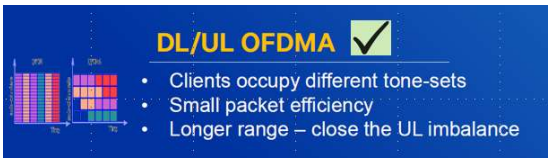

802.11be features like 4096QAM and 160 MHz Channels also supported

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5 & 6 GHz

Cambium Networks

1. **High-Performance PMP and PTP Access Networks**
   - Up to 4 Gbps capacity
   - 8x8 MU-MIMO with single user beam forming
   - Wide Channels (up to 160 MHz)
   - High Modulations (up to 4096QAM)
2. **Scalable and Interference Tolerant**
   - Beam-steering and Dynamic Filtering
   - TDD with GPS Synchronization
   - Up to 120 Clients per Sector
3. **Investment Protection with Low TCO (Total Cost of Ownership)**
   - Proven Multi-Generation Compatibility (802.11n/11ac/11ax)
   - Broad portfolio of SMs to meet any ARPU
   - End-to-end management

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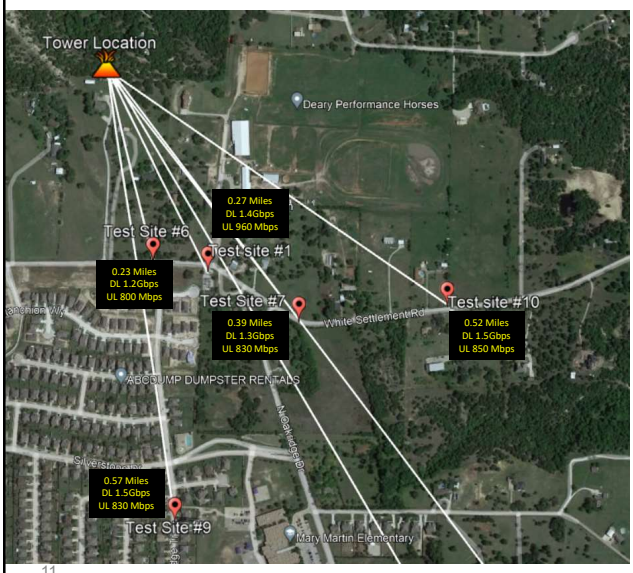
6 GHz Field Trial



- **Wireless Internet Service Provider in Texas**

	Range	Downlink	Uplink
Site 10	0.52 miles	1.5Gbps	850 Mbps
Site 7	0.39 miles	1.3 Gbps	830 Mbps
Site 9	0.57 miles	1.5 Gbps	830 Mbps

- **Utilizing 6 GHz with FCC-approved experimental licenses**
- **4x4 Access Point**
- **2x2 Subscriber module**
- **Aggregate capacity from ≈ 2.0 to 2.36 Gbps**

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6 GHz Field Trial - at Range

	Range	Downlink	Uplink
Site 5	1.48 miles	1.2 Gbps	640 Mbps
Site 2	2.07 miles	930 Mbps	435 Mbps

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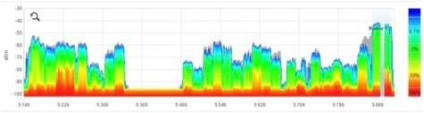
5 GHz Field Results

Top contributor 21h ·

The more I play around with ePMP 4500, the more impressed I am with what I can get away with.

I'm sure that you've all had those sites where you've run a spectrum analysis and when you got the results your heart sinks because it's completely trashed and you don't see any way that you can operate reliably. I've attached an SA from a site that we've tried everything on, including Tarana 5GHz, and we were never able to get stable results, so we pulled all the equipment from the site. As a favor to **Sakid**, we took a gamble and put up a beta 4500 8x8 AP in the same physical location we had a Tarana AP, and started slowly testing. As the firmware matured and we played around with settings and different client configs, we're now able to reliably deliver at minimum 50mbps service, and up to 200mbps service using a 40MHz channel. At this site we had difficulty running 20MHz reliably with previous equipment, and now with 4500 we can run 40MHz no problem. This site is highly contentious and the 5GHz landscape is always changing. With previous 5GHz equipment, I was having to change channels every other month. I haven't had to do that once with e4k since I started testing Fall of 2022. It's fun just plopping my e4k in a small gap in the SA using a 40MHz carrier and still getting a couple hundred mbps. **With tools like this, there's never been a better time to be a WISP**😊



You, Fedor Trutsko and 31 others 23 comments

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AP with 47 SM's

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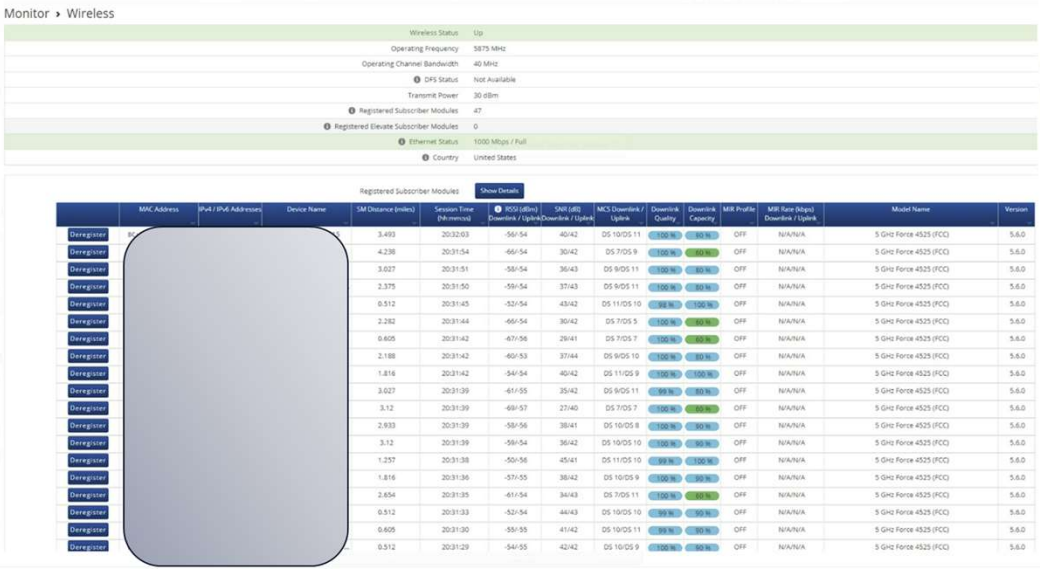

Monitor › Wireless

Wireless Status	Up
Operating Frequency	5875 MHz
Operating Channel Bandwidth	40 MHz
DFS Status	Not Available
Transmit Power	30 dBm
Registered Subscriber Modules	47
Registered Elevate Subscriber Modules	0
Ethernet Status	1000 Mbps / Full
Country	United States

Registered Subscriber Modules — Show Details

	MAC Address	IPv4 / IPv6 Addresses	Device Name	SM Distance (miles)	Session Time (hh:mm:ss)	RSSI (dBm) Downlink / Uplink	SNR (dB) Downlink / Uplink	MCS Downlink / Uplink	Downlink Quality	Downlink Capacity	MIR Profile	MIR Rate (kbps) Downlink / Uplink	Model Name	Version
Deregister	[redacted]			3.493	20:32:03	-56/-54	40/42	DS 10/DS 11	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				4.238	20:31:54	-66/-54	30/42	DS 7/DS 9	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				3.027	20:31:51	-58/-54	36/43	DS 9/DS 11	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				2.375	20:31:50	-59/-54	37/43	DS 9/DS 11	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				0.512	20:31:45	-52/-54	43/42	DS 11/DS 10	98 %	100 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				2.282	20:31:44	-66/-54	30/42	DS 7/DS 5	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				0.605	20:31:42	-67/-56	29/41	DS 7/DS 7	100 %	60 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				2.188	20:31:42	-60/-53	37/44	DS 9/DS 10	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				1.816	20:31:42	-54/-54	40/42	DS 11/DS 9	100 %	100 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				3.027	20:31:39	-61/-55	35/42	DS 9/DS 11	99 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				3.12	20:31:39	-69/-57	27/40	DS 7/DS 7	100 %	60 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				2.933	20:31:39	-58/-56	38/41	DS 10/DS 8	100 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				3.12	20:31:39	-58/-54	36/42	DS 10/DS 10	100 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				1.257	20:31:38	-50/-56	45/41	DS 11/DS 10	99 %	100 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				1.816	20:31:36	-57/-55	38/42	DS 10/DS 9	100 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				2.654	20:31:35	-61/-54	34/43	DS 7/DS 11	100 %	80 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				0.512	20:31:33	-52/-54	44/43	DS 10/DS 10	99 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				0.605	20:31:30	-55/-55	41/42	DS 10/DS 11	99 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0
Deregister				0.512	20:31:29	-54/-55	42/42	DS 10/DS 9	100 %	90 %	OFF	N/A/N/A	5 GHz Force 4525 (FCC)	5.6.0

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CBRS and 3 GHz Spectrum

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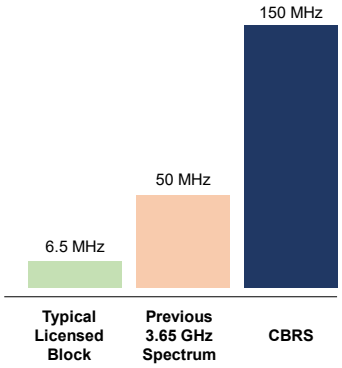
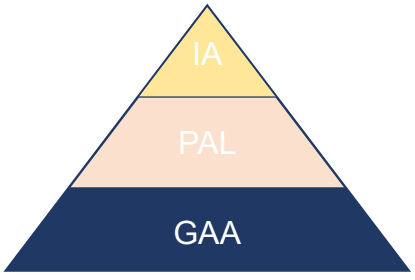
100 MHz of new spectrum



Priority Tiers

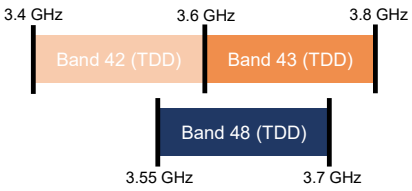


Incumbents
- DoD Radars (coastal areas)
- Satellite Earth Stations

Priority Access Licenses (PAL)
- Up to 70 MHz of spectrum licensed by auction

General Authorized Access (GAA)
- At least 80 MHz nationwide

Establishes a New Common Band



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CBRS and 3 GHz Spectrum

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- **LTE and proprietary platforms are FCC Part 96 Certified & CBRS ready!**
- **Multiple SAS Options with simplified administration**

federated wireless

Google

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60 GHz

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What is the 60 GHz Frequency Band?

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- 12 GHz of spectrum from 57.24 to 70.2 GHz
- Divided into six channels
- Each channel has Bandwidth of 2.16 GHz

Channel	Center (GHz)	Min. (GHz)	Max. (GHz)
1	58.32	57.24	59.40
2	60.48	59.40	61.56
3	62.64	61.56	63.72
4	64.80	63.72	65.88
5	66.96	65.88	68.04
6	69.12	68.04	70.20

Channel Assignments Vary by Country	
Region	Frequency channels
USA	1,2,3,4,5,6
EU	1,2,3,4
Japan	1,2,3,4
South Korea	1,2,3

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What is 60 GHz?

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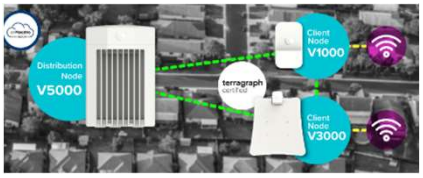
An **innovative** wireless Band which provides **fast, reliable, cost-effective, and quick-to-deploy** wireless gigabit connectivity for communities

- A true alternative to fiber.
- Specially designed radios create a mesh network, connecting multiple nodes in a self-organizing network.
- Supports speeds of conventional fiber and faster
- Highly reliable: Distributed network with sophisticated routing protocols, can self-heal because nodes have multiple paths to the internet
- Uses compact “distribution nodes" (installed on poles and buildings) to form the wireless mesh, and smaller client nodes installed on homes
- cnWave is MUCH lower in cost compared to traditional fiber and VERY fast to deploy. It can be brought to market in a matter of weeks!



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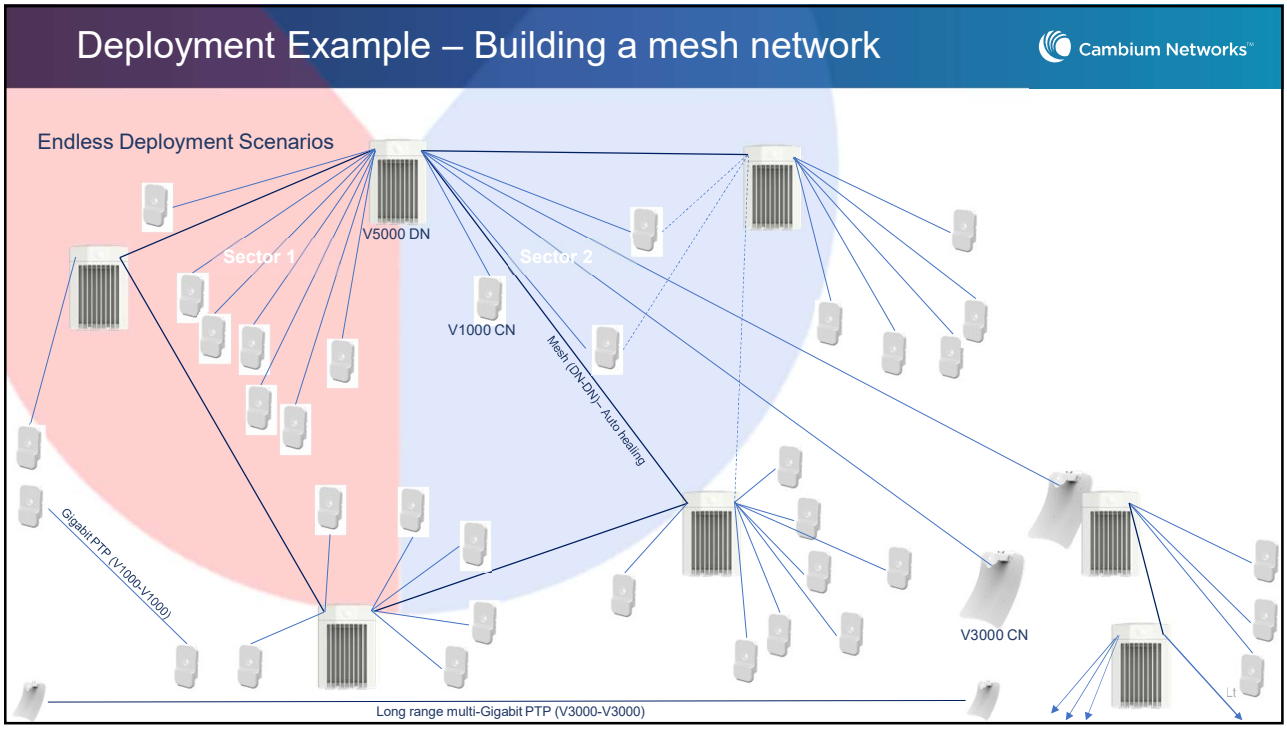
Deployment Example – Building a mesh network



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Connect Mobility – Village of Standard

"Fast deployment of 60 GHz cnWave has extended the village's fiber core to connect every business and resident. Adding the ePMP 3000 Wide Area Network was an excellent choice to support local families living on acreages and farms. Its proven architecture made it a great choice for Standard, Alberta."

Merle Isaacson
Owner/Operator
Connect Mobility Inc

Connect

The Results

CONNECT MOBILITY COMPLETED THE INSTALLATION and turn-up of 38 sites in just 21 days, including the 60 GHz cnWave and ePMP 3000 devices.

Connect can provide residents up to 1 Gbps of download speed, a dramatic improvement compared to the village's previous service speeds, and comparable to the capabilities of fiber. Cambium

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Gigabit services

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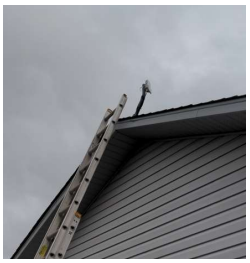
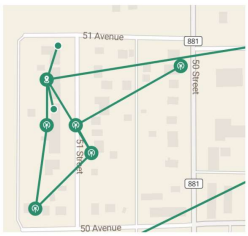
- Leverage existing towers and customer homes to create Hub/spoke →mesh networks.
- Work with target municipalities / town councils to achieve buy-in and access to city-owned structures
- High ratio of DNs vs. CNs to enable mesh
- Deliver major upgrade to gigabit/fiber-like speed.
- Capitalize on the buzz coming from delighted customers enjoying their new ultra-fast internet
- Marketing blitz for each new township





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Example: Fiber vs. cnWave in small network

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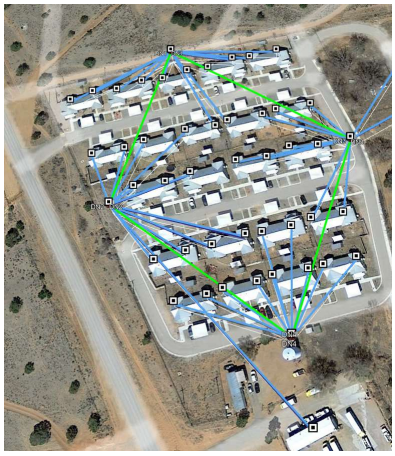
The Challenge:
Deploy broadband to all homes

- Blue= Existing Fiber, Orange= Existing Copper
- **Estimated $150K+** project to deploy Fiber to all homes
- Fiber too expensive and will take too long!

The Solution:
cnWave Wireless Mesh



- Est. $15K for cnWave including poles and solar power
- Deployed in days, not months

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