Cambium Networks™

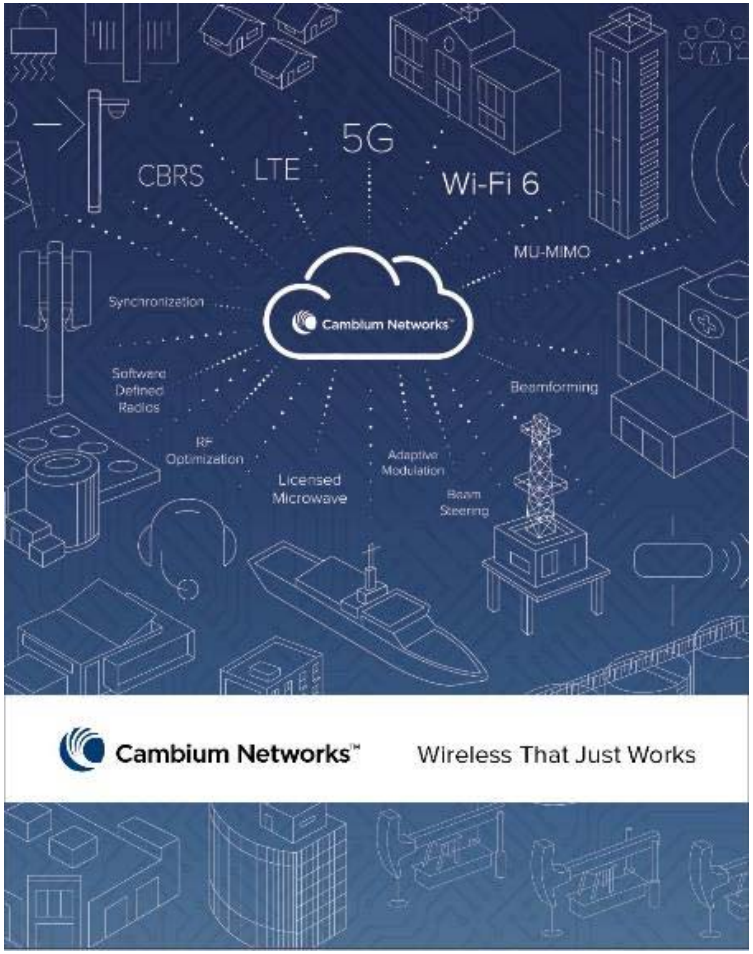
Animal Farm

WISPAmerica 2021

April 28, 2021

Cambium Networks at a Glance

- Industry leader in High-Density Wi-Fi
- Pioneer in Fixed Wireless Broadband
- Wi-Fi 6 and 60 GHz
- Facebook and Qualcomm technology partners
- Emerging leader in IIoT and 5G
- HQ outside of Chicago, IL with 700+ employees across 6 continents
- 6,000 channel partners in 150+ countries
- More than 7 million nodes shipped
- Spun out of Motorola Solutions in 2011
- IPO on NASDAQ in 2019



Addressing Wireless Challenges with Innovation

Leading spectral efficiency

Software, RF algorithms and GPS synchronization to allow reuse of frequencies and limit self-interference

Embedded network intelligence

Software and RF algorithms adapt and optimize network performance

Reliability

Bridging distances across outdoor terrains and in outdoor settings in spite of RF noise

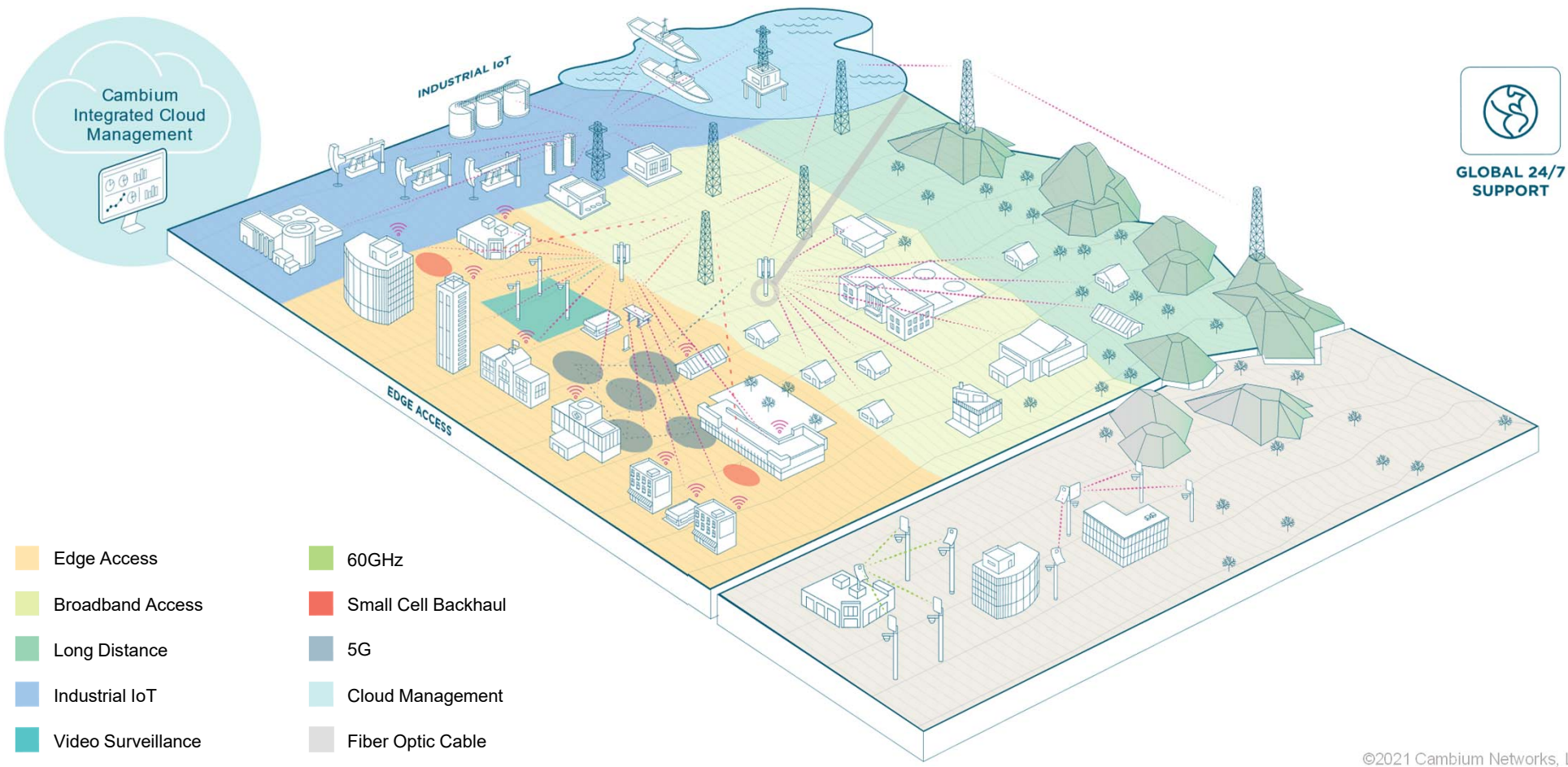
Attractive economics

Enable superior density of CPE to access point relationships

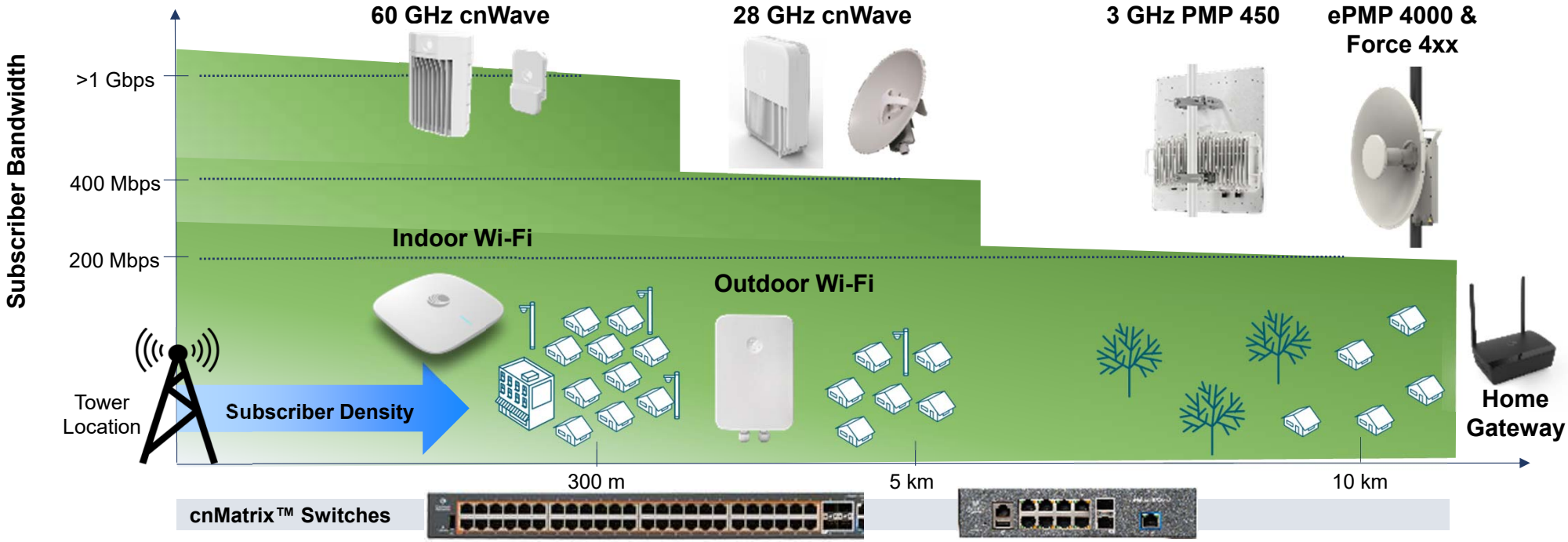
Scalability

Cloud-based software to design, install and manage networks from cloud-to-tower-to-edge

Wireless Fabric



Wireless Fabric Agility

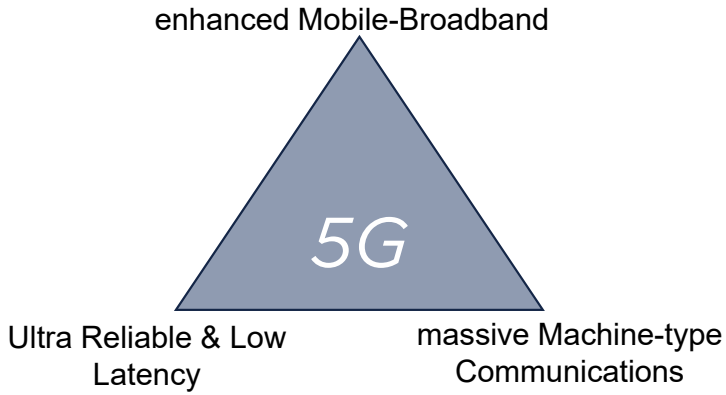


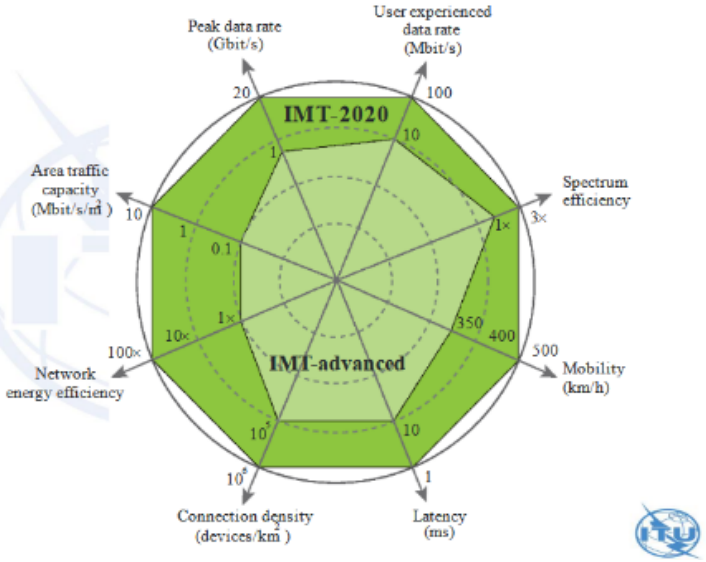
KPI			
Technology	**802.11ay Terragraph**	5G NR	cnMedusa MU-MIMO → 5G NR
Sector Capacity	**> 15 Gbps**	> 3 Gbps	> 1 Gbps
Subscribers per Sector	**30**	240	238
Management	← cnMaestro READY →		

5G NR mmWave PMP solution

Cambium Networks™

5G and 5G NR





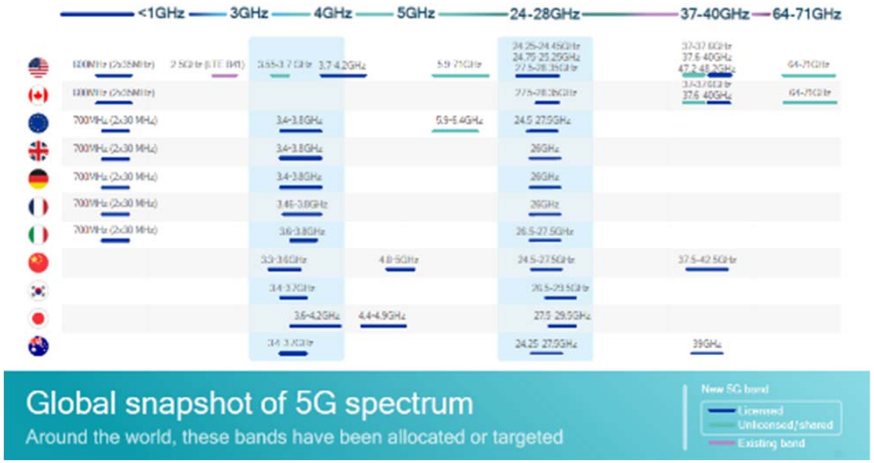
- **5G mobile communication standard requirements**
  - IMT-2020 published by the ITU-R in 2012
    - enhanced Mobile Broadband
    - Ultra Reliable Low Latency Communications
    - massive Machine-type Communications

- **3GPP's 5G NR standard**
  - Part of composite standard to meet IMT-2020 requirements
  - New air interface required
    - Higher frequency/bandwidth operation
    - Beam centric design/multi-antenna transmission
    - Ultra lean design/forward compatibility
    - Flexible duplex scheme/Dynamic TDD
    - Lower latency

Using 24 GHz to 30 GHz Band for Fixed Wireless Access

Cambium Networks™

- **Most common 5G NR band worldwide**
  - 24.25 - 29.50 GHz (TDD)
    - n257 (26.50 - 29.50 GHz), 28 GHz, TDD
    - n258 (24.25 - 27.50 GHz), 26 GHz, TDD
    - n261 (27.50 – 28.35 GHz), 28 GHz US, TDD



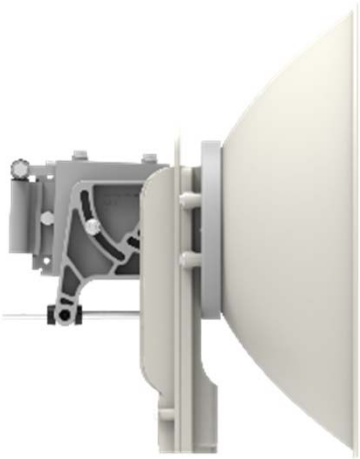
- **Commercially**
  - Wide spectrum enables high-capacity network
  - Security of **licensed** spectrum
  - **5G NR** has driven investment in cost optimized, integrated RF front-end modules (chipsets)
- **Technically**
  - Propagation allows **5+ km range** even in rain condition
  - Medium antenna aperture results in high antenna gain → better range/coverage

Using 5G NR as the Air Interface

- **Future proof investment**
  - Standard rather than vendor proprietary air interface
  - Cambium **SDR architecture** enables future enhancements
- **5G NR / 3GPP Release 15**
  - Designed for mmWave frequency (“FR2”)
  - More suited to FWA than 4G / LTE
- **Enables cost effective CPE based on 5G chipsets**
  - Cambium BTS will support Cambium & third-party 5G NR CPEs
  - Multiple types of CPEs can co-exist in same sector

Cambium Solution Key Differentiators

- **Optimized End-to-End for Fixed Wireless Access**
  - Benefits from cnMedusa™ world-class MU-MIMO expertise and field-proven performance
  - Lower cost & complexity solution by targeting FWA only (no mobility)
  - Optimized to exploit good signal quality & provide high throughput
- **Simple to deploy and operate**
  - Cambium 5G NR network infrastructure is a simple as 450 Series!
  - BTS can be stand-alone, no SIM card required on CPE
  - Mobile operator core network not required!



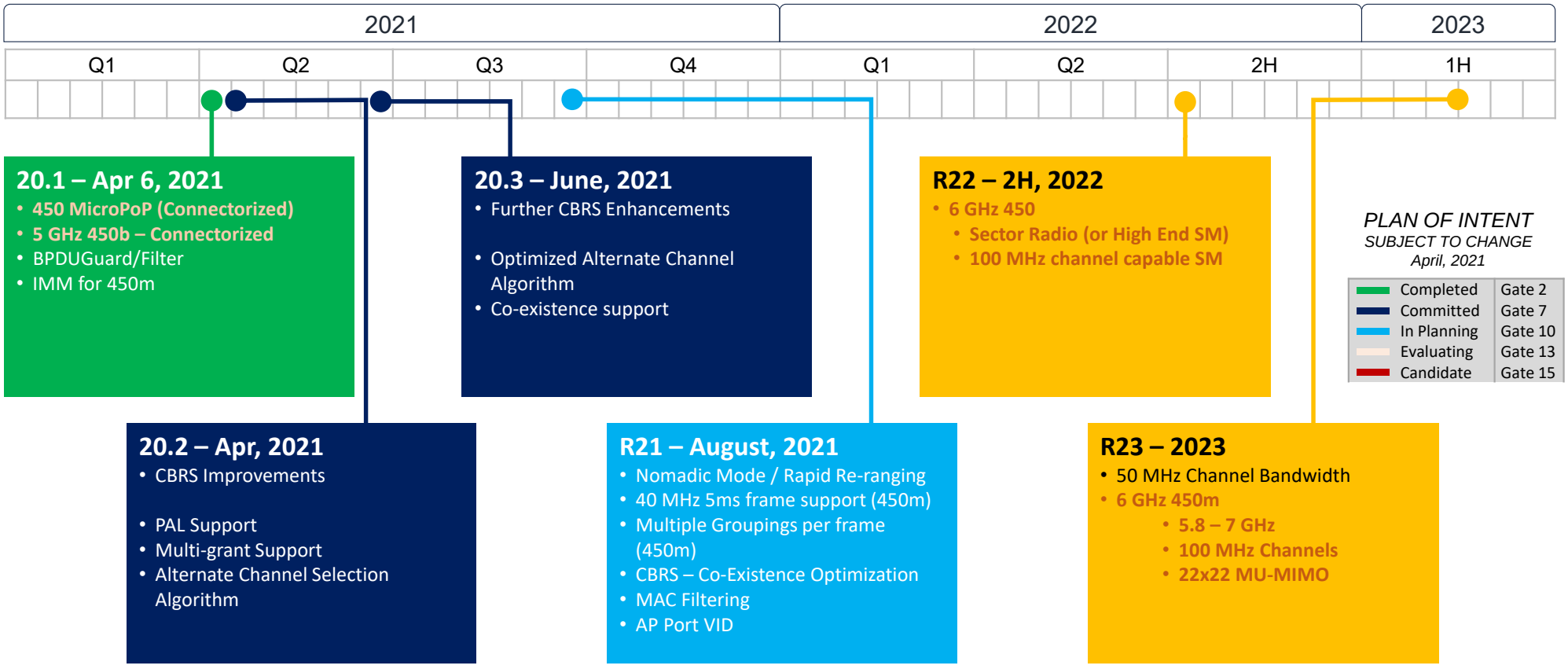
450 Platform

Cambium Networks™

450 Platform Strategy

- **Current Platform:**
  - ✓ Industry-leading purpose-built fixed wireless platform
  - ✓ Complete portfolio including 900 MHz, 2.4 GHz, 3 GHz and 5 GHz solutions
  - ✓ CBRS Solution provides ease-of-use and market leadership
  - ✓ Continuous Evolvement, Enhancement and Optimization keeps platform at the forefront
  - ✓ SDR (Software-defined Radio) allows ultimate flexibility and inclusion of innovative technology
- **Long Term Strategy:**
  - ✓ Adoption of standards makes sense for this platform
  - ✓ The goal is convergence of the 450 and cnRanger platforms to 5G NR architecture
    - ✓ Provides migration path for existing deployed equipment
    - ✓ Opens options for IOT, lower product cost and higher performance

Cambium 450 Plan of Intent 2021



PMP 450b

- **Two Form Factors:**
  - Integrated mid-gain antenna (17 dBi) similar to Force 180
  - High Gain integrated antenna (24dBi), similar to Force 200

Available since Sept, 2017

- **New FPGA / SoC architecture**
  - Next-gen processor, **Enhanced Packet Processing**
  - Better support for wider channels → more throughput
  - **Wideband support (4.9 – 5.925 GHz)**
- **I/O changes**
  - Single **Gigabit** Ethernet port
  - Audio jack for alignment tone
- **Re-use of 30 VDC Power scheme**
  - Same power supply as current 450 SM
  - Polarity Agnostic – Both “Canopy” or “UBNT” 30 VDC
- **Prices (MSRP):**
  - $309 for mid-gain version
  - $359 for Integrated dish version (sold in 4-packs)

Available since March, 2018

450b Connectorized

Target Release April, 2021

- **New FPGA / SoC architecture**
  - Next-gen processor, **Enhanced Packet Processing**
  - Better support for wider channels → more throughput
  - **Wideband support (4.9 – 5.925 GHz)**
- **I/O changes**
  - Single **Gigabit** Ethernet port
  - Audio jack for alignment tone
  - IP 67 ruggedized protection
  - 2x RP-SMA connections for external antenna
  - Will fit ePMP1000 twistport adaptor from RF Elements
- **Re-use of 30 VDC Power scheme**
  - Same power supply as current 450 SM
  - Polarity Agnostic – Both “Canopy” or “UBNT” 30 VDC
- **MSRP: $309**

3 GHz 450b

- **Form Factor:**
  - High Gain integrated antenna (19 dBi), similar to 5 GHz 450b High gain
  - Up to 29 dBm Tx Power, or 49 dBm EIRP
- **New FPGA / SoC architecture**
  - Next-gen processor, **Enhanced Packet Processing**
  - Better support for wider channels → more throughput
  - **Wideband support (3.3 – 3.9 GHz)**
- **I/O changes**
  - Single **Gigabit** Ethernet port
  - Audio jack for alignment tone
- **Re-use of 30 VDC Power scheme**
  - Same power supply as current 450 SM
  - Polarity Agnostic – Both “Canopy” or “UBNT” 30 VDC
- **Considerations:**
  - Packaging of devices will follow the 5 GHz version
  - LEDs moved to make more visible and installation-friendly

Released March, 2020

450 µPoP Hardware Plan

- **Power / Network**
  - Gigabit Ethernet PoE
  - Standard 802.3af/at PoE IN (± 48 VDC)
- **RF Options**
  - Integrated: Omni & 90/120˚ Sector
    - Omni – 9 dBi Gain
    - 90/120˚ Sector –13 dBi Gain, targeting 32 dB FB
- **Integrated GPS on all models**
  - External GPS antenna port
  - Supports sync over power method with cnPulse accessory
- **Physical default method**
  - Push button on rear, long press variations to reboot / reset to defaults
- **MSRP: $999**
- **Limitations**
  - 2 Miles Range / Up to 20 SMs connected
  - Limits can be removed with License Key (MSRP of key $1799)

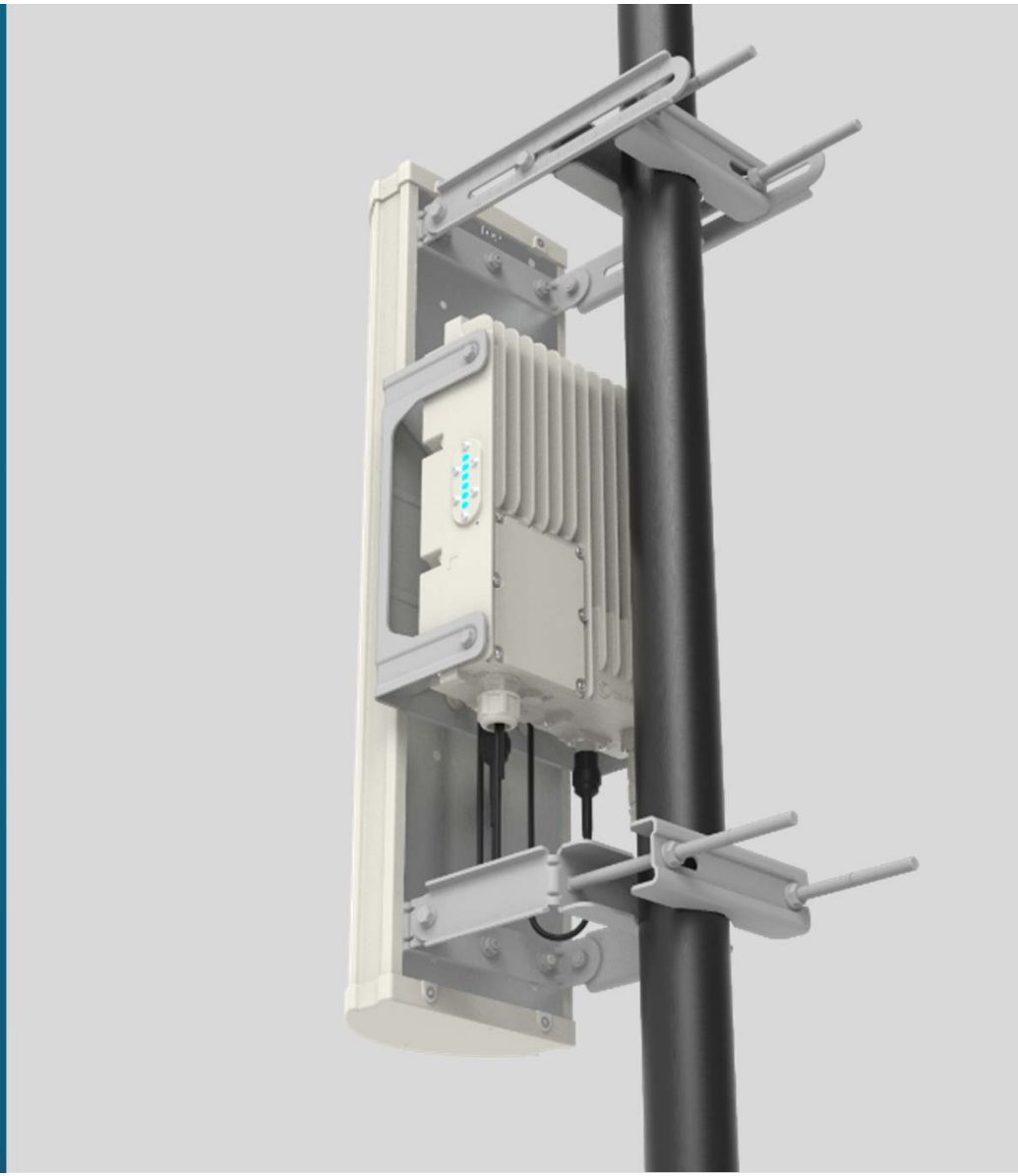
Connectorized
(April, 2021)

Omni

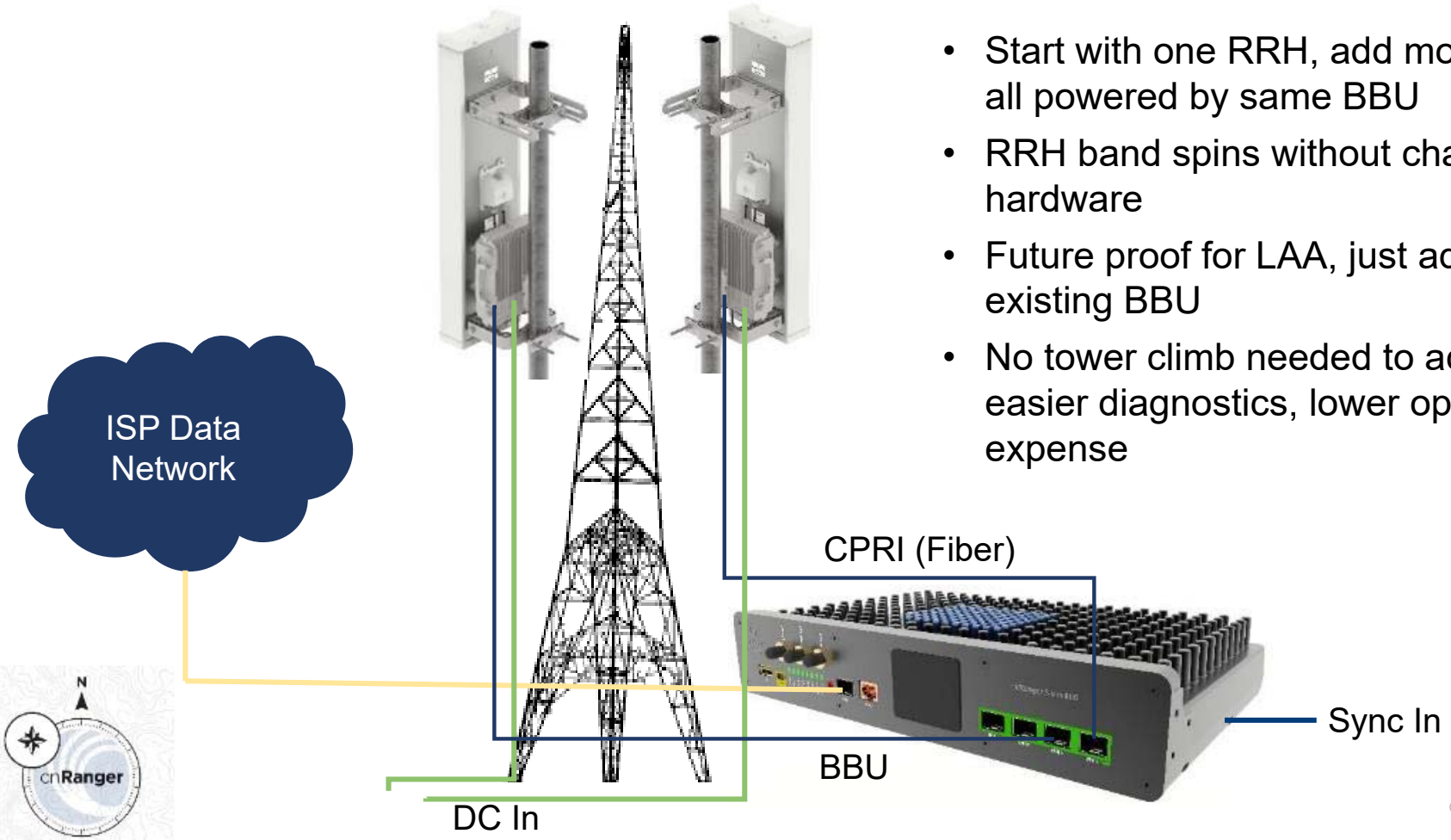
Sector

cnRanger

Cambium Networks™



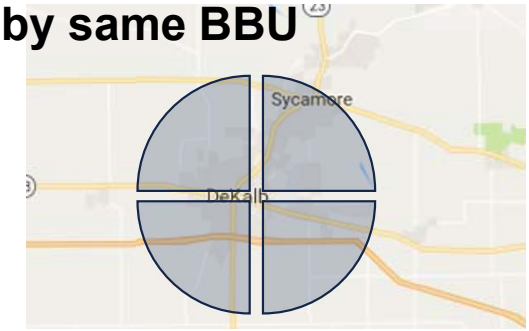
Deployment



- Start with one RRH, add more as you grow, all powered by same BBU
- RRH band spins without changing BBU hardware
- Future proof for LAA, just add 5GHz RRU to existing BBU
- No tower climb needed to access BBU – easier diagnostics, lower operational expense

Flexibility by Splitting Baseband and Radio

- **Start with one RRH, add more as you grow, all powered by same BBU**

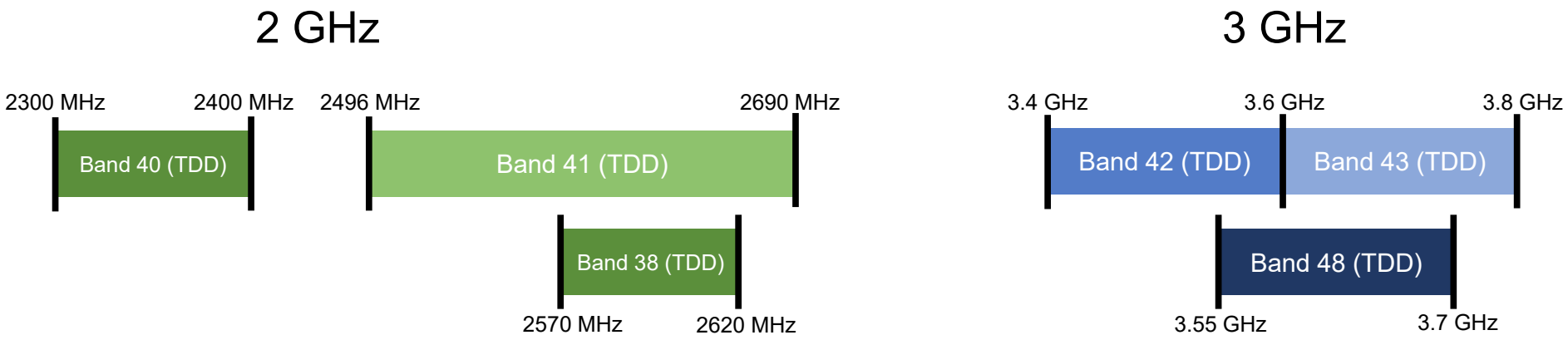


- **RRH bandspins without changing BBU hardware**

- **Future proof for LAA, just add 5GHz RRU to existing BBU**

- **No tower climb needed to access BBU – easier diagnostics, lower operational expense**

Spectrum Coverage



cnRanger 800 Baseband Unit, 8x8

- LTE-A Release 10
- 8TX, 8RX
- Up to 3 RRHs, 4 in future
- 192 Subscriber Units, 1024 in future
- Integrated EPC
- Built-in GPS
- 2 Carrier Aggregation*
- 1588v2*
- 19” Rack Mount

Part Number	Description	MSRP (USD)
LTE-BBU-800	cnRanger 800 Baseband Unit, 8x8	$7,995

2 GHz cnRanger RRH 220, SM 101, SM 201

- **LTE Bands 38, 40, 41 (2.3 – 2.7 GHz)**
- **2TX, 2RX**
- **2W per Port**
- **IP66/IP67**
- **2 Carrier Aggregation**
- **16 dBi Antenna**
- **Mount RRH on Antenna**

- **CAT4 SM**
- **CAT6 High Gain SM**

Part Numbers

Part Number	Description	MSRP (USD)
2LTE-RRH-220	2 GHz cnRanger 220 RRH, 2x2, 2W per port	$3,499
2LTE-ANT-90	2 GHz cnRanger Sector Antenna – 90/120 degree, 16 dBi	$895
2LTE-SM-101	2 GHz cnRanger 201 SM, CAT4, 14 dBi (PSU only)	$219
2LTE-SM-101-US	2 GHz cnRanger 201 SM, CAT4, 14 dBi (US PSU and AC Line Cord)	$219
2LTE-SM-201	2 GHz cnRanger 201 SM, CAT6, 20 dBi (PSU only)	$319
2LTE-SM-201-US	2 GHz cnRanger 201 SM, CAT6, 20 dBi (US PSU and AC Line Cord)	$319

- 2LTE-SM-201 is capable of +26 dBm Tx Power
- Combined with high gain dish, this is a competitive advantage over other LTE CPE equipment

cnRanger 3 GHz RRH

- LTE Bands 42, 42, 48 (3.4 – 3.8 GHz)
- 2TX, 2RX
- 1W per Port
- IP66/IP67
- 2 Carrier Aggregation
- 17 dBi Antenna
- Mount RRH on Antenna

- CAT6 High Gain SM

Part Numbers

Part Number	Description	MSRP (USD)
3LTE-RRH-210	3 GHz cnRanger 210 RRH, 2x2, 1W per port	$3,499
3LTE-ANT-90	cnRanger Sector Antenna – 90/120 degree, 17 dBi	$895
3LTE-SM-201	3 GHz cnRanger 201 SM, CAT6, 21 dBi (PSU only)	$319
3LTE-SM-201-US	3 GHz cnRanger 201 SM, CAT6, 21 dBi (US PSU and AC Line Cord)	$319

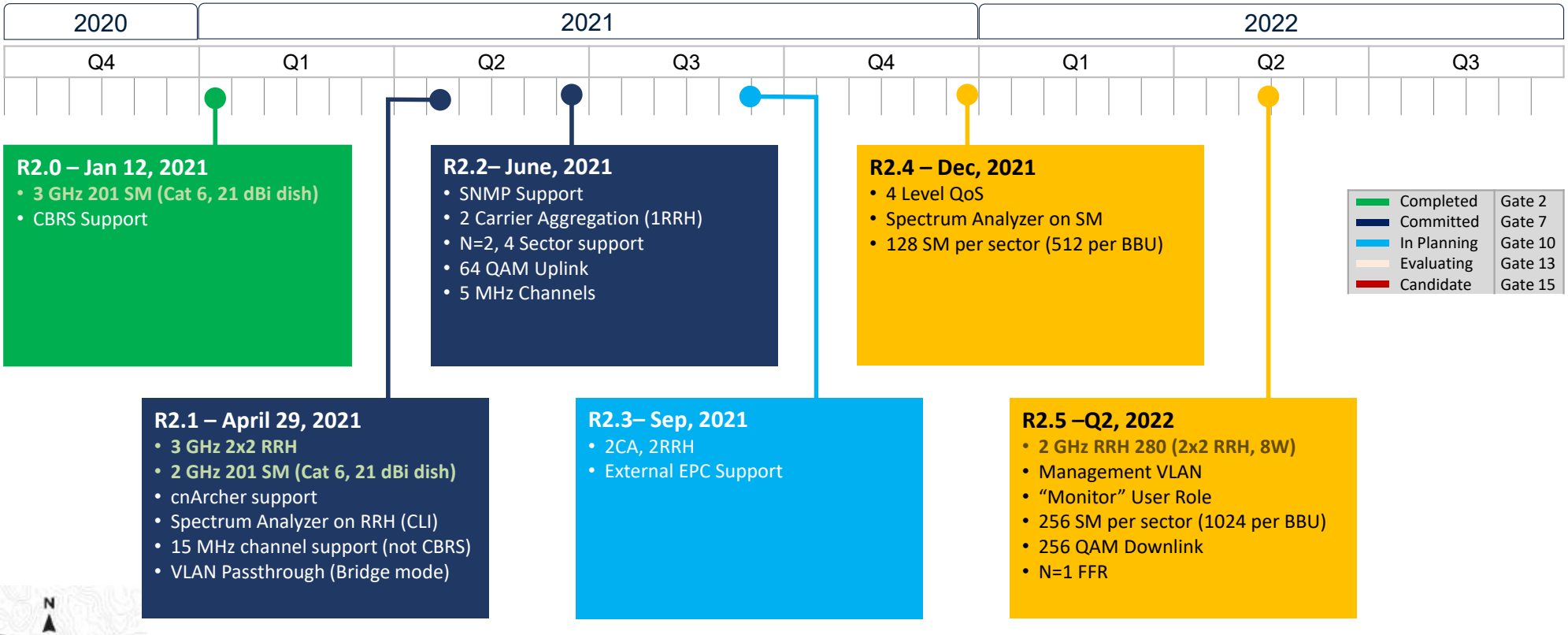
- As with 450, cnRanger is CBRS Compliant
- Customers can choose SAS Administrator

- Communication is done via Domain Proxy using cnMaestro
- Difference with cnRanger is that each device communicates independently

Cambium cnRanger Plan of Intent

PLAN OF INTENT
SUBJECT TO CHANGE
April, 2021

Cambium Networks™



BIG Things are Changing with CBRS!

Critically important to Cambium's CBRS Services operators is the need to keep tightly coupled with the ongoing maturation of CBRS features and improvements *AS THEY HAPPEN*!

1. **PALs** – Landscape changes as these roll out… each SAS taking a slightly different approach
2. **CoExistence Parameters** – Will help as band gets more utilized
3. **Multigrant Flexibility** – Breaking larger grants into 10 MHz chunks allow for flexible use of available spectrum
4. **Alternate Channel Adaptability** – If a grant becomes unusable, finding alternate spectrum will be automatic

Rolled out initially in R20.2, optimization in R20.3

ePMP

Cambium Networks™

Why ePMP?

1. **ePMP air interface based on 802.11ac Wave 2**
   - 4x4 MU-MIMO
   - Wider Channels
   - Higher Modulation
2. **Leader in scalability and interference tolerance**
   - Uplink beam-steering and Dynamic Filtering
   - Synchronization
3. **Protects your investment**
   - Compatibility with 11n devices
   - Improved performance (LDPC and MRC)
4. **Lowers TCO (Total Cost of Ownership)**
   - 3-year hardware warranty
   - Support direct from the channel and the supplier

Access Point Topologies to Fit the Application

ePMP MicroPOP

ePMP 3000L

Sector

Omni

Twist-Port adaptor
RF Elements

ePMP 3000

MU-MIMO
Sector

MU-MIMO Omni
KP Performance

MU-MIMO Omni
ITElite

MU-MIMO
Dual Horn

Dual-Horn Case Study – Mountain West

"The dual-horn antenna allows us to take advantage of a narrower beamwidth while leveraging the benefits of superior noise rejection of a horn. This helps us get a better signal to a tighter grouping of users in high-noise areas."

- TIM MEADS, NETWORK/INFRASTRUCTURE MANAGER, MOUNTAIN WEST TECHNOLOGIES


MOUNTAIN WEST TECHNOLOGIES CORPORATION

Wireless That Just Works

ePMP 3000 Dual-Horn MU-MIMO Antenna Allows Mountain West Technologies to Leverage the Benefits of Superior Noise Rejection and Improve Uplink SNR

"The dual-horn antenna allows us to take advantage of a narrower beamwidth while leveraging the benefits of superior noise rejection of a horn. This helps us get a better signal to a tighter grouping of users in high-noise areas."

TIM MEADS, NETWORK/INFRASTRUCTURE MANAGER, MOUNTAIN WEST TECHNOLOGIES

Overview

BASED IN WYOMING, UNITED STATES, Mountain West Technologies is an internet provider known for the high speeds they deliver to their residential and business customers.

They have provided dependable wireless internet services for over a decade in the Casper, WY area, reaching speeds of up to 500 Mbps on wireless. Their customers experience incredibly smooth streaming and gaming on their broadband network thanks to these speeds.

Mountain West Technologies uses wireless technologies from industry-leading partners like Cambium Networks to reduce infrastructure costs and offer a cutting-edge service to their customers. Cambium Networks' ePMP 3000 MU-MIMO solution is one of the latest technologies that Mountain West Technologies decided to deploy in their network.

The Challenge

MOUNTAIN WEST TECHNOLOGIES USES a 90-degree sector antenna but dealt with poor signal-to-noise ratio (SNR) on the uplink direction. They searched for a better solution that would improve the uplink throughput. Eventually, they started looking for an antenna solution which would attract less noise from all sides except the intended direction.

The Solution

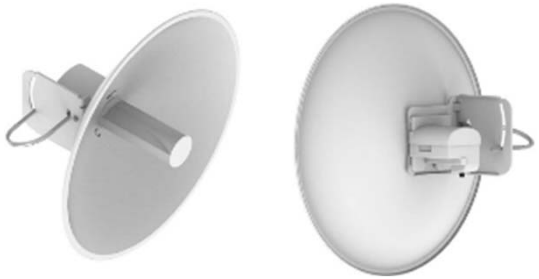
CAMBIUM NETWORKS' NEW SOLUTION, ePMP 3000 Dual-Horn MU-MIMO sector antenna, proved to be a good choice for such conditions. Horn antennas have the key advantages of focusing higher gain in the main boresight while minimizing side lobes in the propagation pattern. These side lobes further reduce the generation and susceptibility to noise. A small form factor dual-horn sector antenna also simplifies installations at the base station site.

Their approximate total subscriber base of 10 is expected to grow in the near future. Most of these subscribers are within two miles of the base station. Mountain West Technologies was less concerned about high antenna gain, but high radio throughput in noisy environments was critical.

A view of the base station and customers

CS Mountain West 07082020

ePMP Force 300 Subscriber Module Portfolio



F300-25
- 25dBi gain
- Gigabit Ethernet
- Real time spectrum analyzer

F300-16
- 16dBi gain
- Gigabit Ethernet
- Real time spectrum analyzer
- Small form factor
- 15 degree Azimuth/Vertical orientation

F300 CSM (IP67)
- 2X2 Wave 2 Connectorized SM
- Support for external horns and dishes

F300-19 (IP55)
- 2X2 Wave 2 SM
- 19 dBi gain flat panel antenna

F300-19R (IP67)
- 2X2 Wave 2 SM
- 19 dBi gain flat panel antenna
- Adds 5/10 MHz channels
- Enterprise SW Plan of Intent

F300-13 (IP55)
- 2X2 Wave 2 SM
- 13dBi gain

ePMP Force 425 and Force 400C

Cambium Networks

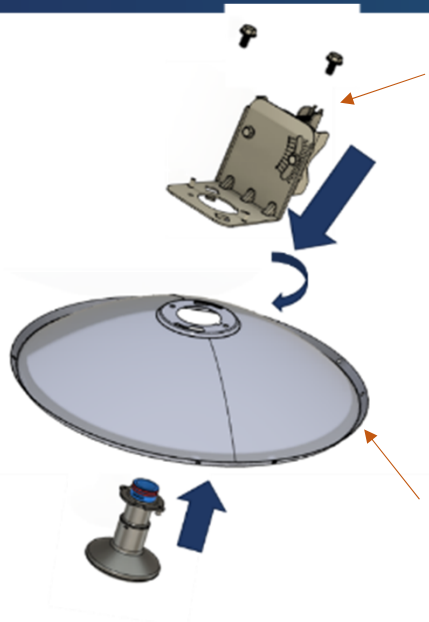
Gigabit Performance
Last-mile Fiber alternative

- **Target Markets / Applications**
  - High-capacity Enterprise point to point
  - Low-cost WISP back-haul
  - GPON last mile
  - Especially for applications requiring:
    - High spectral efficiency (12.5 bps/Hz)
    - Low cost
    - Long range
- **Key Specifications**
  - Gbps usable throughput
  - Sub 5 ms latency
  - 4.9 to 5.925 GHz
  - IP67 Ruggedization
  - 25 dBi integrated dish (optional 28 dBi range extender)
  - GigE and SFP port (optional GPON module)

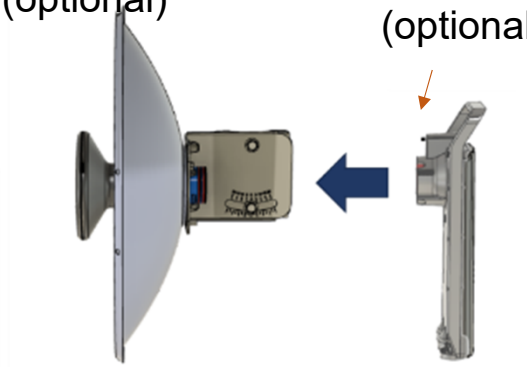
Force 425

Force 400C

Force 425 – Designed for Installers



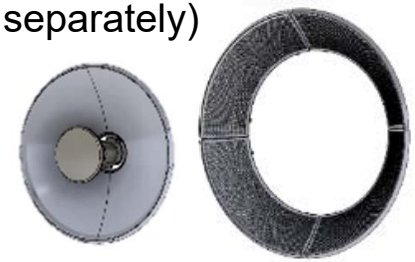
Spare Mounting Kit
(optional)



Spare Radio
(optional)

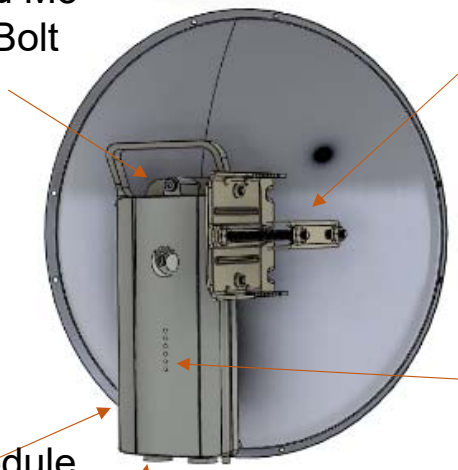
Spare Dish
(optional)

Optional Range Extender
(sold separately)



Mast mounting scheme
Reversible for left/right side installs

Captivated M5
Securing Bolt



Bright LEDs

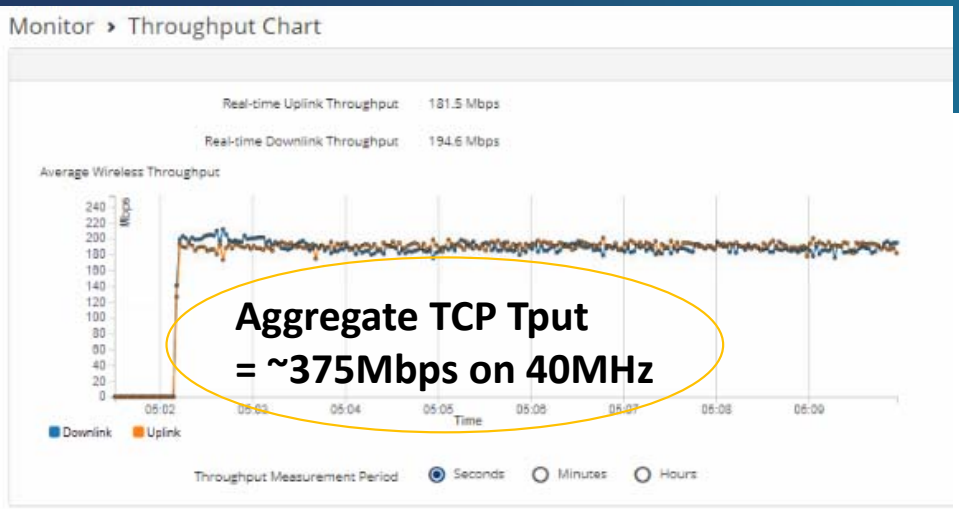
Replace radio module
without removing/re-
aligning the dish

SFP -> supports
GPON Module
M28 Gland

100/1000BaseT
802.3at or 48VDC
Passive PoE
M25 Gland

Force 425 Field Trial – Canada

Cambium Networks



Aggregate TCP Tput = ~375Mbps on 40MHz

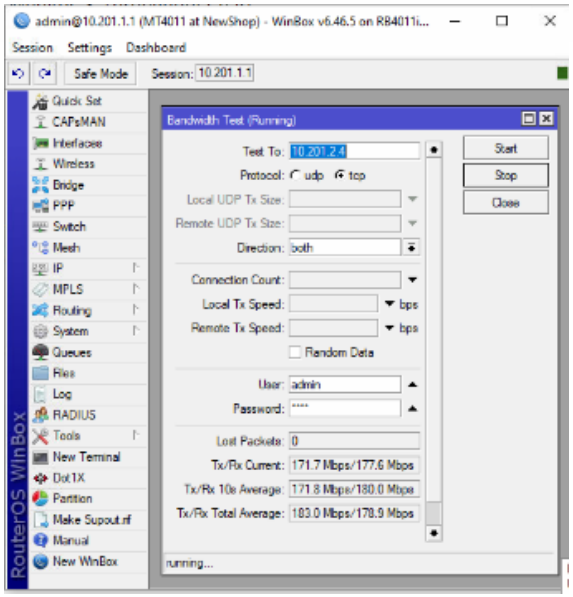
99.8% of packets in 1024QAM

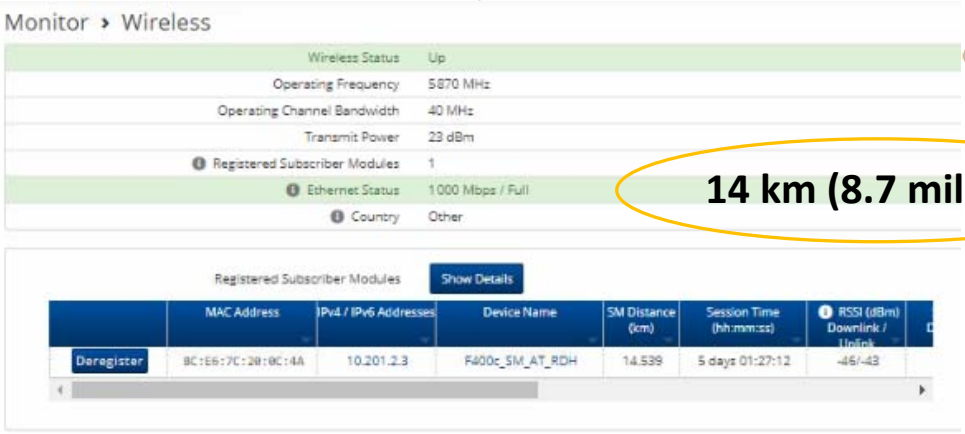
Downlink Packets Per MCS

DS MCS 11 - 1024-QAM 5/6	1348036 (85.8%)	SS MCS 11 - 1024-QAM 5/6	31388 (2%)
DS MCS 10 - 1024-QAM 3/4	184477 (11.7%)	SS MCS 10 - 1024-QAM 3/4	4633 (0.3%)
DS MCS 9 - 256-QAM 5/6	2400 (0.2%)	SS MCS 9 - 256-QAM 5/6	0 (0%)
DS MCS 8 - 256-QAM 3/4	0 (0%)	SS MCS 8 - 256-QAM 3/4	0 (0%)
DS MCS 7 - 64-QAM 5/6	0 (0%)	SS MCS 7 - 64-QAM 5/6	0 (0%)
DS MCS 6 -	0 (0%)	SS MCS 6 -	0 (0%)

Uplink Packets Per MCS

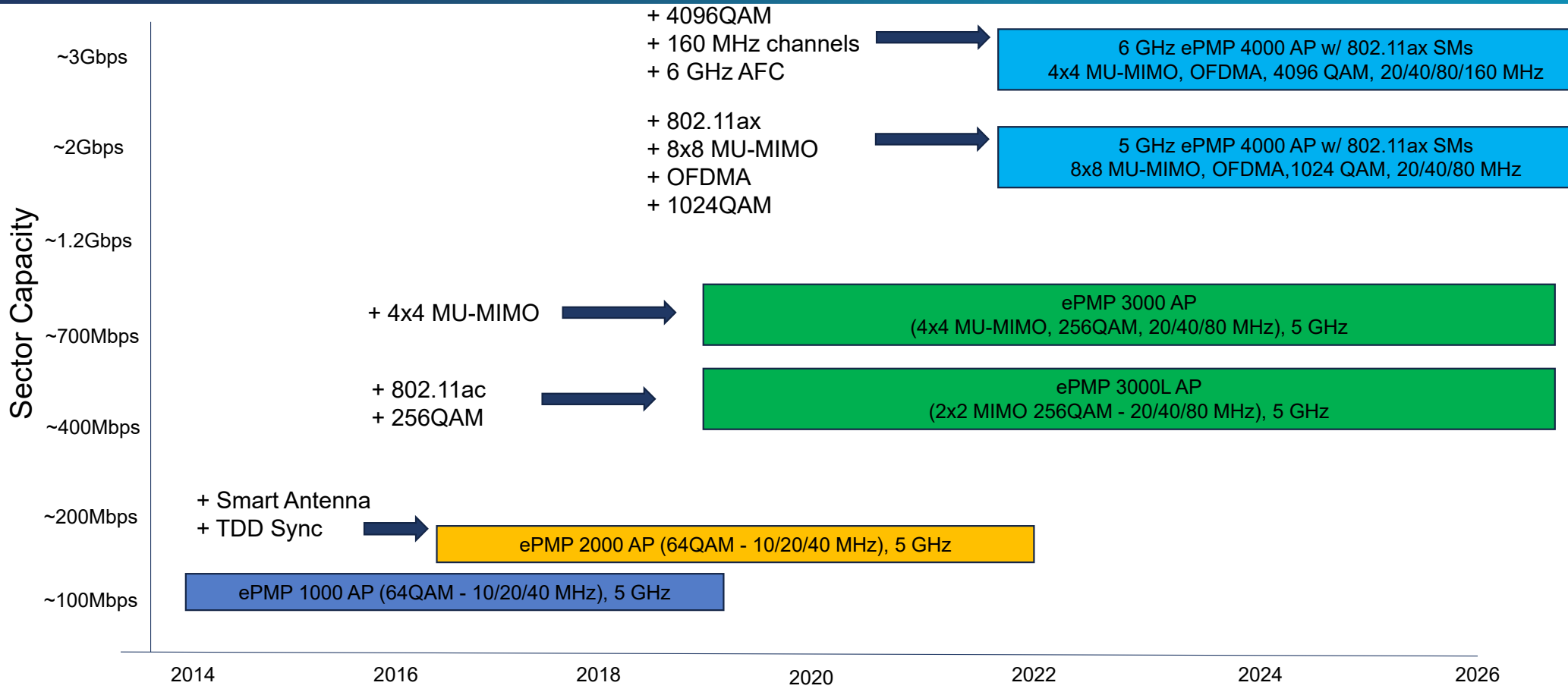
DS MCS 11 - 1024-QAM 5/6	2393 (0.2%)
DS MCS 10 - 1024-QAM 3/4	1523278 (96.5%)
DS MCS 9 - 256-QAM 5/6	48888 (3.1%)
DS MCS 8 - 256-QAM 3/4	3520 (0.2%)
DS MCS 7 - 64-QAM 5/6	0 (0%)
DS MCS 6 - 64-QAM 3/4	0 (0%)
DS MCS 5 - 64-QAM 2/3	0 (0%)



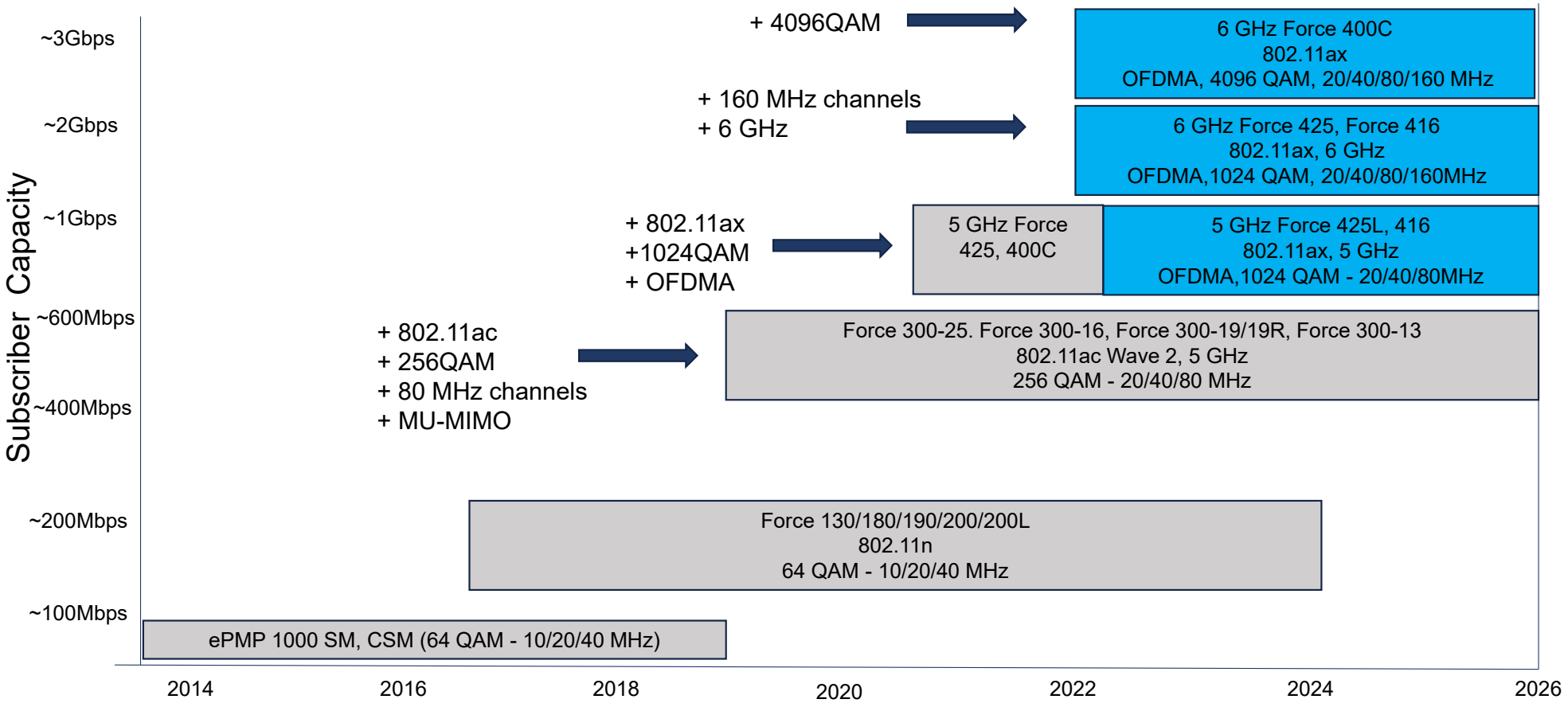


14 km (8.7 miles)

ePMP Platform Evolution – Access Point Evolution



ePMP Platform Evolution – Subscriber Module



6 GHz ePMP 4000 Draft Specifications

6 GHz ePMP 4000 Aggregate Capacity

1024 QAM	20 MHz Channel	40 MHz Channel	80 MHz Channel	160 MHz Channel
4x4 AP (TCP / TDD Capacity (Mbps))	341	682	1429	2858
Per-SM (Mbps)	170	341	715	1429

4096 QAM	20 MHz Channel	40 MHz Channel	80 MHz Channel	160 MHz Channel
4x4 AP (TCP / TDD Capacity (Mbps))	453	908	1901	3802
Per-SM (Mbps)	227	454	950	1901

Hardware Specs

- Proven ePMP Air Interface
- 802.11ax family of chipsets
- 4x4 MU-MIMO AP w/ 90 degree beamforming sector
- 6 GHz band: 5.925 – 7.125 GHz
- 20 / 40 / 80 / 160 MHz channel bandwidth
- 1024QAM / 4096QAM
  - 4096QAM proprietary mode w/ high-tier SM
- Ethernet ports:
  - 1G RJ-45
  - 10G SFP+ for AP and High-performance SM
- PoE IEEE 802.3at – 56V
  - 30W - AP; 15W - SM
- GPS on AP: built in and external
- Optional external GPS Rx on SM to comply with AFC

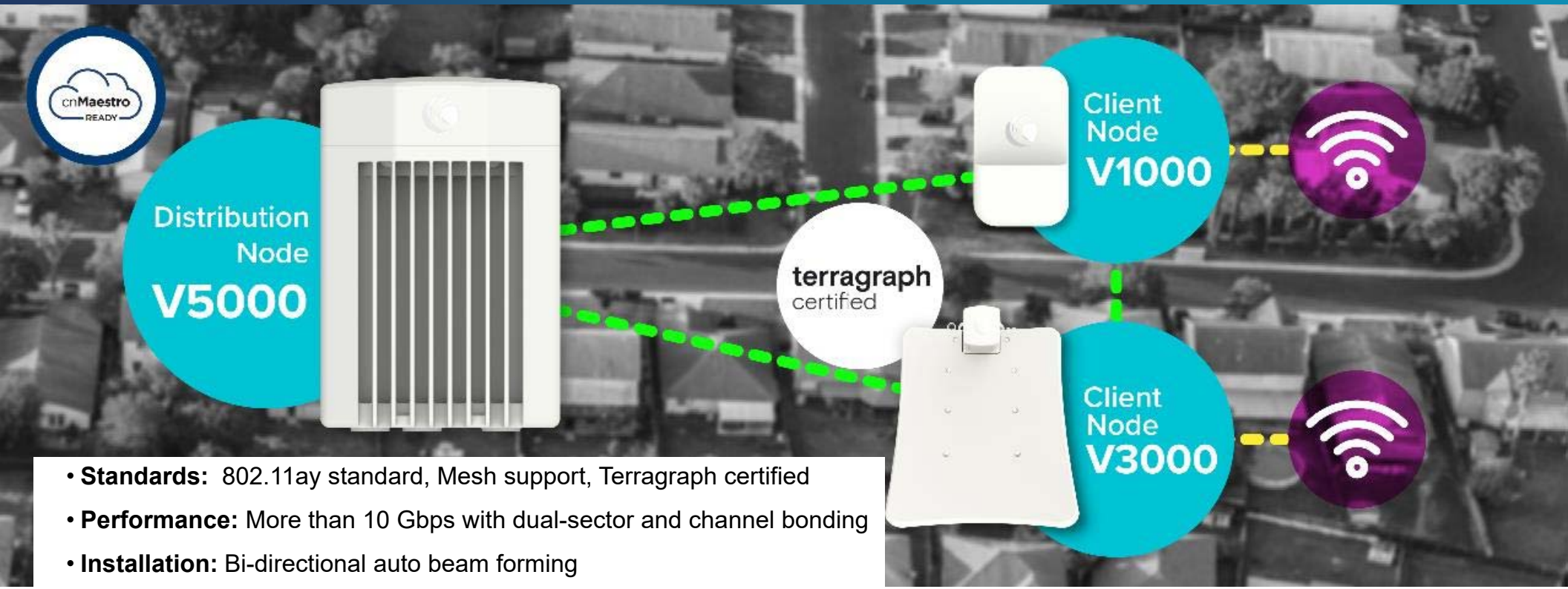
Performance Specs

- Concurrent 4x4 MU-MIMO & DL/UL OFDMA
  - Double spectrum efficiency with MU-MIMO
  - OFDMA efficiently uses bandwidth for short transmissions
- Higher efficiency of 802.11ax -- less overhead (short guard intervals)
- 3 QoS Levels: VoIP, High & Low
- Priority-based air-fairness scheduling with starvation avoidance.
- TDD scheduling with GPS Sync
  - 5 & 2.5 ms frame duration
  - Flexible duty cycle (DL/UL) from 75/25 – 30/70 with 5% step.
- TDD Scheduling w/o GPS sync:
  - Flexible frame duration
- AFC support based on GPS/GNSS geolocation.
- ACS (Automatic Channel Selection)

60 GHz cnWave

Cambium Networks™

Cambium 60 GHz cnWave

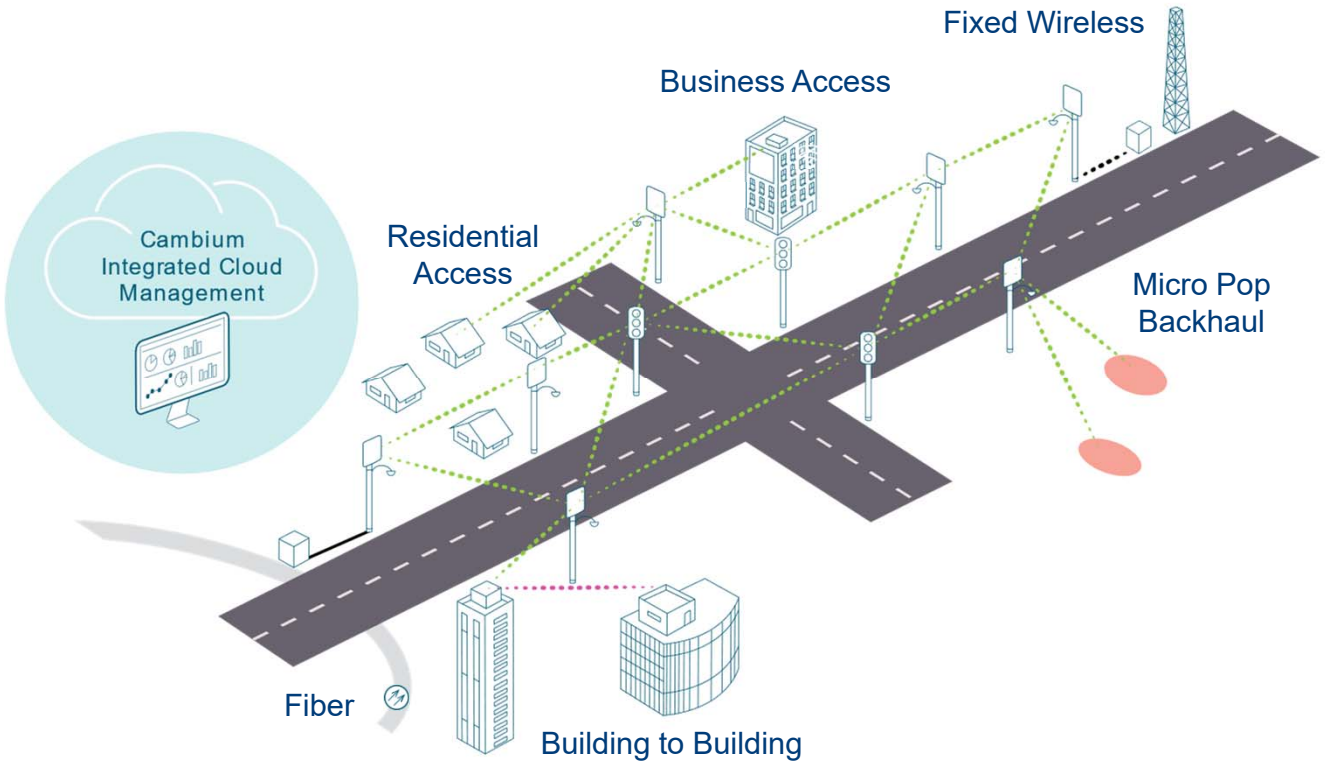


- **Standards:** 802.11ay standard, Mesh support, Terragraph certified
- **Performance:** More than 10 Gbps with dual-sector and channel bonding
- **Installation:** Bi-directional auto beam forming
- **Operation:** Auto expansion, auto healing with Mesh support
- **Configuration:** Point-to-Point, Point-to-MultiPoint, Mesh
- **Management:** cnMaestro™

Technical Advantage of 802.11ay Solution

Advantage	Description	Benefit
TDMA/TDD	• Removed access conflict of CSMA defined in 802.11ad, removed overhead of RTS/CTS etc. • Each CN is assigned specific time slots based on request, which it can transmit and receive	• Maintain high spectrum efficiency even with congestion • Single channel for complete network
Network Synchronization	• All radios are time synchronized • Time Synchronization via GPS	• Ensure Tx/Rx TDD frame alignment across whole network • Minimize interference
Channel Bonding	• Support 4.32 GHz channel by channel bonding	• Double the throughput
Mesh Routing	• Distributed network application platform • Determine appropriate routes between the mesh nodes	• Minimize latency • Auto heal and auto expansion • Efficient usage of DN notes within the mesh

60 GHz Deployment Architecture



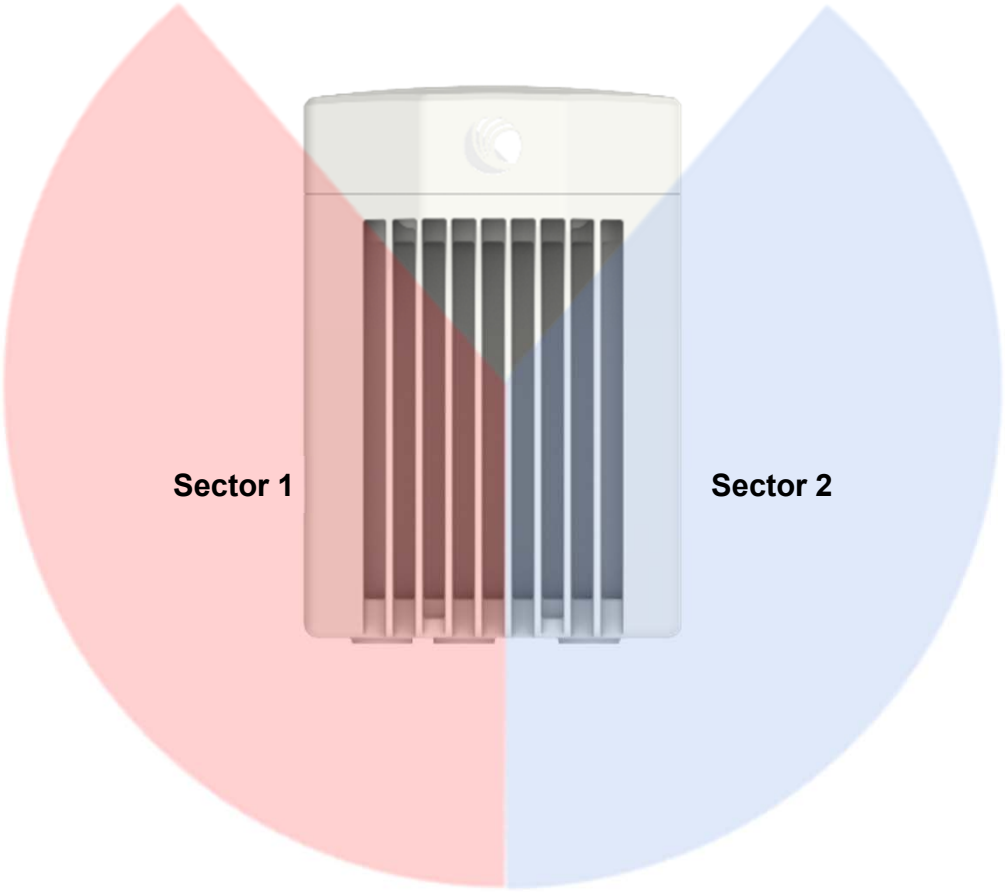
- **WTTH** – **W**ireless **T**o **T**he **H**ome
  - Providing Wireless Broadband access directly to the home.
- **WTTB** – **W**ireless **T**o **T**he **B**uilding
  - Wireless Broadband access provided to rooftops or side of buildings, which then get distributed to individual offices and homes via wire.
- **RTTRT** – **R**oof-**T**op **T**o **R**oof-**T**op
  - Long range Point to Point with high gain dish
  - Multi Dwelling Distribution
- **Fiber Extension**
- **Backhaul** for 5G Small Cell, outdoor Wi-Fi, MicroPoP and CCTV

Suburban / Rural FWA

- *"In our field test in Weatherford, Texas, we achieved close to 1.8 Gigabit uplink and downlink speeds using Cambium's 60 GHz cnWave solution in a single channel configuration," said Cameron Kilton, Chief Technology Officer of NextLink.*

- Key Application:
  - +100Mbps high speed internet broadband service to residential customers.
- Solution:
  - PMP with Mesh using cnWave V5000, V3000 and V1000

cnWave V5000 – 280º Coverage with a Single Node



Frequency: 57 to 66 GHz

Modulation: BPSK to 16 QAM (MCS 0 to MCS 12) with ACM

Throughput:

- 1.9 Gbps Uplink + 1.9 Gbps Downlink per sector
- Channel bonding* typically doubles capacity up to a maximum of 2.7 Gbps Uplink + 2.7 Gbps Downlink per sector

Coverage: Dual Sector 280 Degree Coverage with Beam Forming

Configurations: Up to 30 CNs or 4 DNs + 26 CNs

Latency: < 1 ms

Interfaces: 1 x 10GbE PoE Input
1 x 1 GbE PoE Output (802.3at)
1 x SFP+

* Roadmap feature

cnWave V5000 Interfaces

- **PSU Port**
  - 10/100/1000/10G BaseT with passive PoE in (57V)
- **AUX Port**
  - 10/100/1000 BaseT with 802.3at PoE out
- **SFP+ Slot**
  - 10G SFP Slot
    - Single Mode
    - Multiple Mode
    - GPON

V3000 – High Gain Client Node

Frequency

- 57 to 66 GHz

Modulation

- BPSK to 16 QAM (MCS 0 to MCS 12) with ACM

Throughput

- 1.9 Gbps Uplink + 1.9 bps Downlink
- 2.7 Gbps Uplink + 2.7 Gbps Downlink with channel bonding*

Ultra High Antenna Gain with Beam Forming

- 44.5 dBi or 40.5 dBi antenna
- +/- 2.0 (Azimuth), +/- 1.0 (Elevation)

Synchronization: IEEE-1588 TC*

Low Latency: < 1 ms

Data Interface

- 1 x 10 GE + PoE in (Passive)
- 1 x 1 GE + PoE out (802.3at)
- 1 x SFP+

Physical

- 346 x 414 x 344 mm (13.6 x 16.3 x 13.5 Inches), 2.5 kg (5.5 lbs.) without clamp
- -40°C to +60°C (-40 to +140ºF)

V3000 with 44.5 dBi Antenna

V3000 with 40.5 dBi Antenna

* - Available in future

V1000 – Mid Gain Client Node

Frequency

- 57 to 66 GHz

Modulation

- BPSK to 16 QAM (MCS 0 to MCS 12) with ACM

Throughput

- 1 Gbps Uplink + 1 Gbps Downlink

Ultra High Antenna Gain with Beam Forming

- +/- 40.0 (Azimuth), +/- 20.0 (Elevation)
- EIRP 38 dBm

Low Latency: < 1 ms

Data Interface

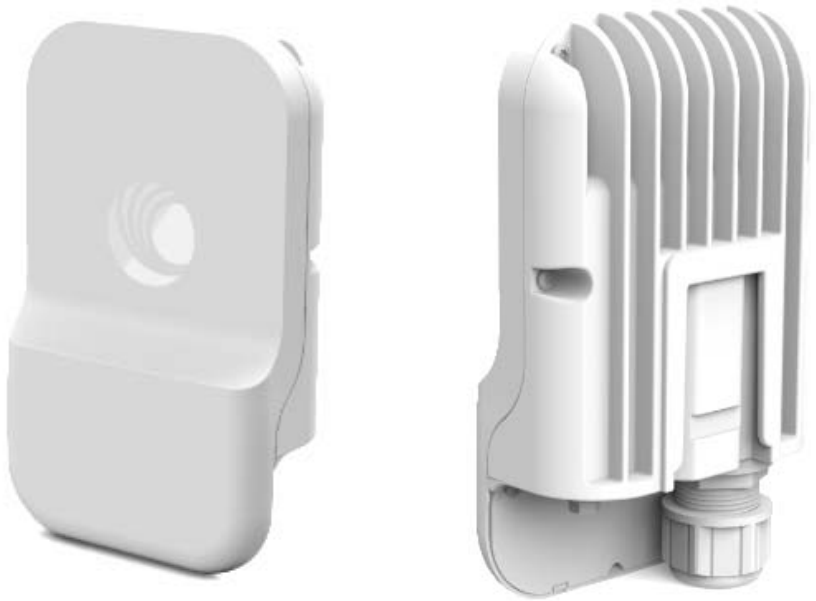
- 1 x 1 GE + PoE in (802.3af)

Power Consumption:

- 10 W

Physical

- IP66/67
- 140 x 85 x 40 mm (5.5 x 3.3 x 1.6 Inches), 0.25 kg (0.55 lbs.)
- -40 to +60ºC (-40 to +140ºF)



Small Form-Factor V3000 Antenna

V3000 with 40.5 dBi Antenna

Sales Model	Description
C600500D002A	60GHz cnWave V3000 Client Node Antenna Assembly, 40.5 dBi, 4 Pack
C600500D003A	60GHz cnWave V3000 Client Node Antenna Assembly, 44.5 dBi, 4 Pack

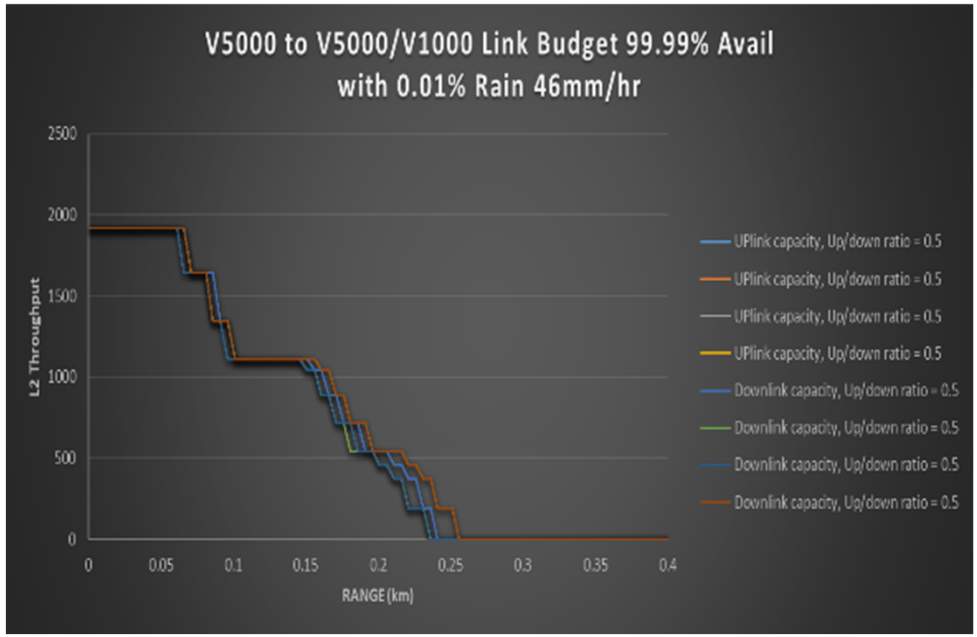
Throughput Test Results

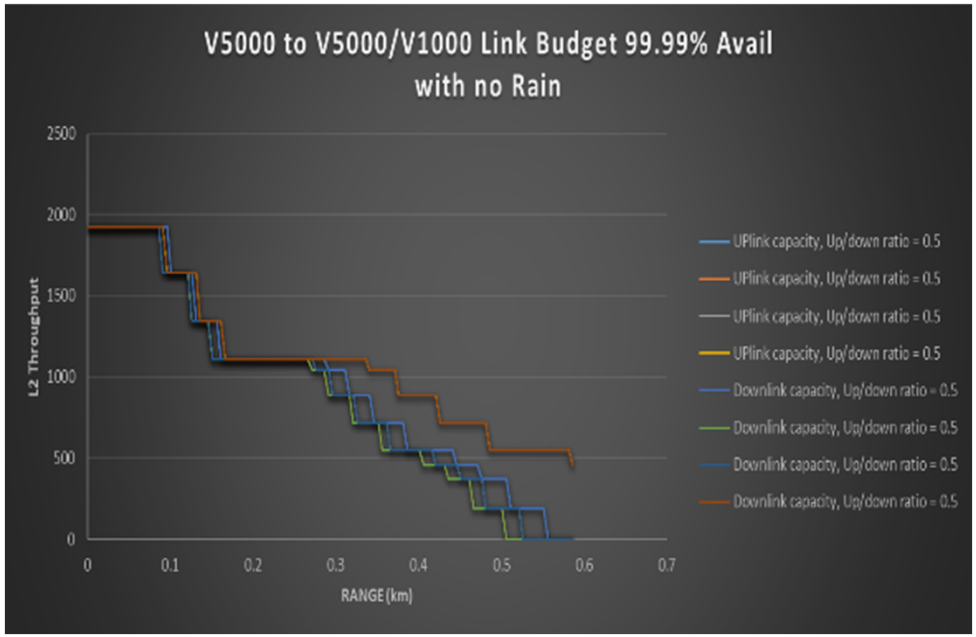
V5000 to V3000			
		TCP (Gbps)	UDP(Gbps)
Uplink		1.75	1.86
Downlink		1.75	1.82
Bidirectional	Uplink	1.47	1.76
	Downlink	1.65	1.74

V5000 to V1000			
		TCP (Mbps)	UDP(Mbps)
Uplink		932	947
Downlink		939	955
Bidirectional	Uplink	889	945
	Downlink	569	558

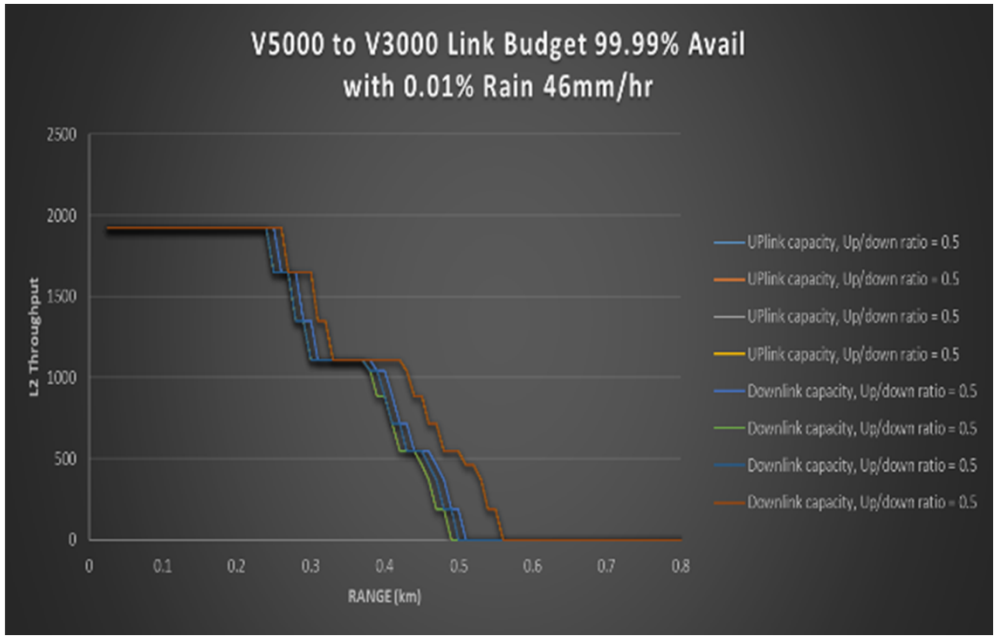
V1000 to V1000			
		TCP (Mbps)	UDP(Mbps)
Uplink		929	947
Downlink		887	931
Bidirectional	Uplink	703	668
	Downlink	569	672

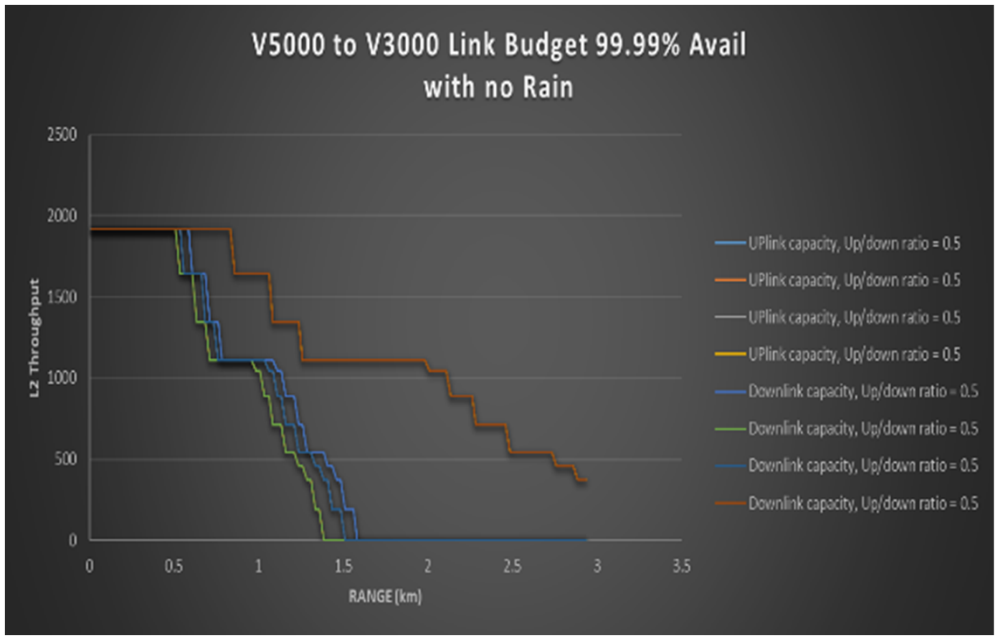
Link Budget, V5000 to V5000/V1000, 99.99%



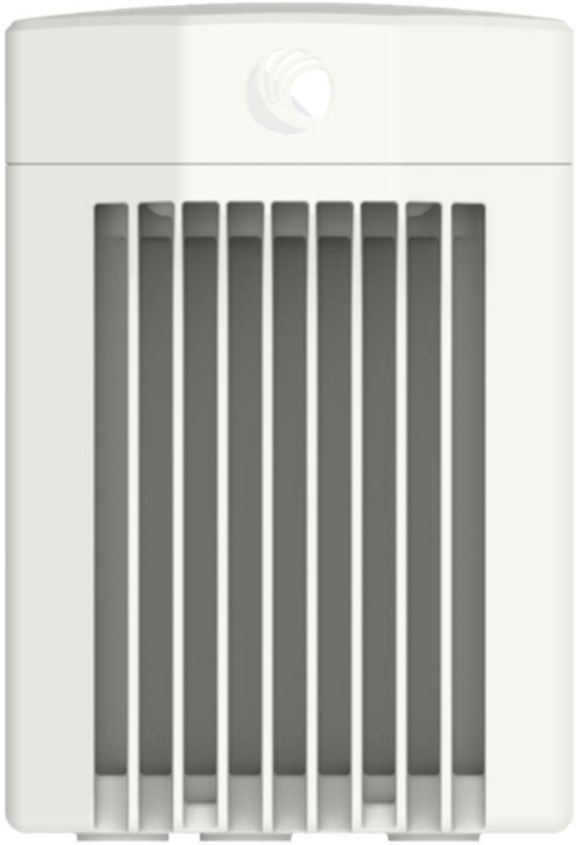


Link Budget, V5000 to V3000, 99.99%





What Makes cnWave Unique?

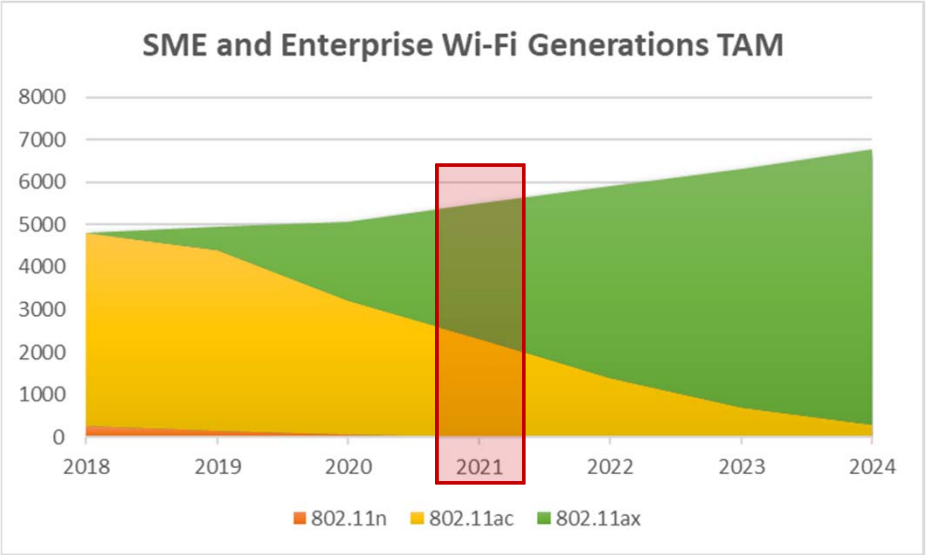


- **Low Total Cost Ownership (TCO)**
  - **V5000** 280-degree coverage with dual sector - No need for site router, simple installation
  - **V1000 + V3000** to meet various ranges
  - Auto Beamforming for easy installation
- **Super-long range V3000** with beamforming
- **Channel Bonding H/W ready**, double the capacity with F/W upgrade
- **IP 66/67 rated enclosure**
- **High density deployment**, each DN can support up to 30 CNs or 26 CNs + 4 DNs
- **cnMaestro cloud management** – one panel for NMS
- **Easy planning** (Advanced Network Planning + LINKPlanner)

Enterprise and Residential Wi-Fi

Cambium Networks™

Crossed the tipping point on Wi-Fi 6

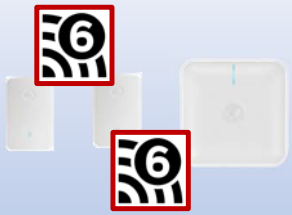


Source: Gartner, 4Q20

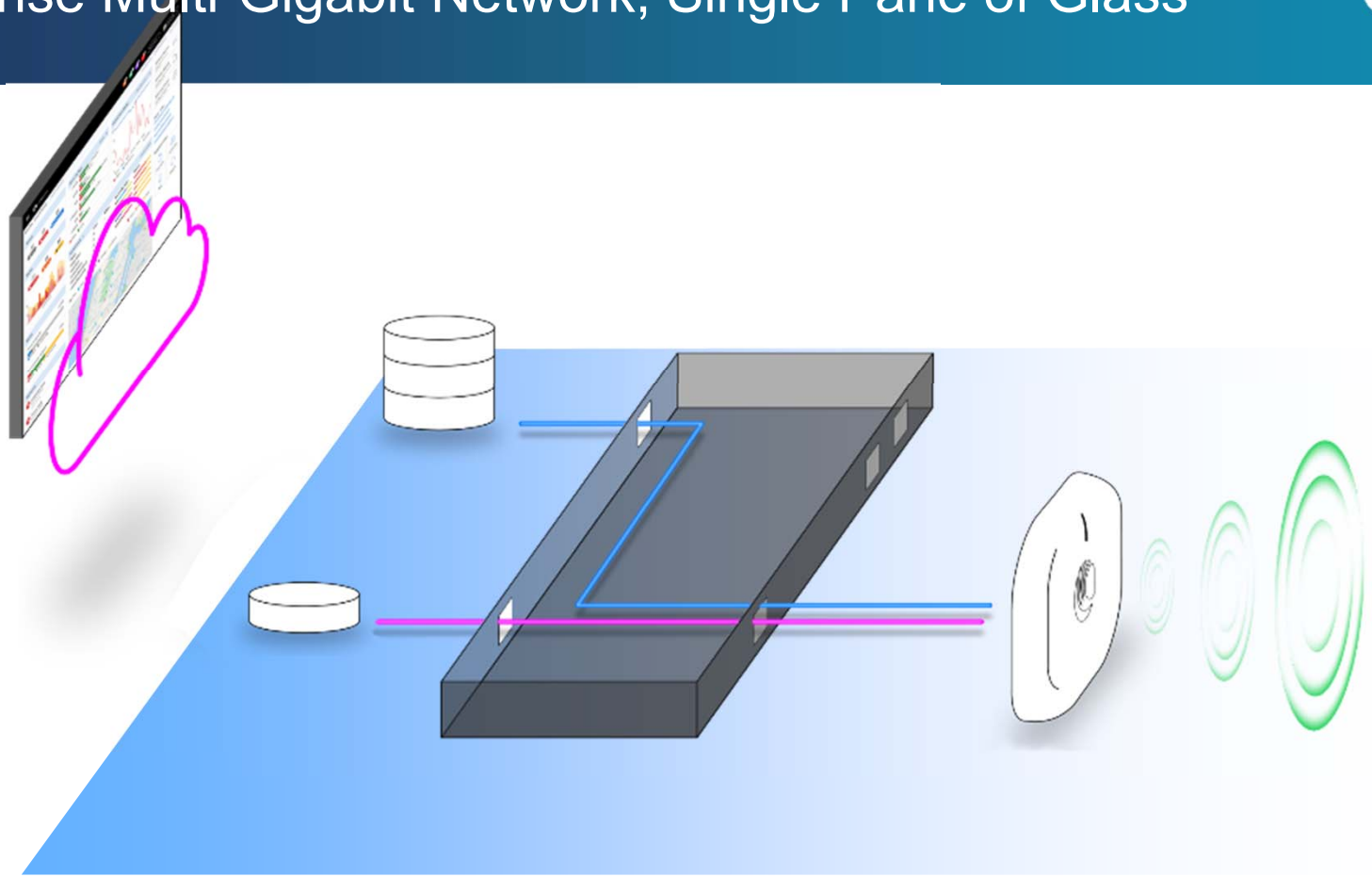
"If I could add some qualitative comments. As you pointed out, there is this enterprise transformation of the home. It's driving a lot of connectivity."

Cristiano Amon - QUALCOMM Incorporated – President
https://www.fool.com/earnings/call-transcripts/2020/11/05/qualcomm-qcom-q4-2020-earnings-call-transcript/

Wi-Fi Access Point Portfolio

Low density ~(1 – 10) Internet access, streaming video, voice Residential, Hospitality, SME, EDU	**Medium density ~(10 – 50)** Public Wi-Fi, voice, video, access Hospitality, Enterprise, Edu, Healthcare	**High density ~(50 – 1000)** Mission critical, voice, video Education, Enterprise, Healthcare
Outdoor  2x2, dual radios	 2x2, dual radios	 4x4, dual and quad radios
Indoor 	 2x2/4x4, dual radios	 4x4/8x8, dual, tri, quad+ radios
Residential 		

Enterprise Multi-Gigabit Network, Single Pane of Glass



cnMatrix
TX2K Tower Switches

Cambium’s Ethernet Switching

Cambium Networks™

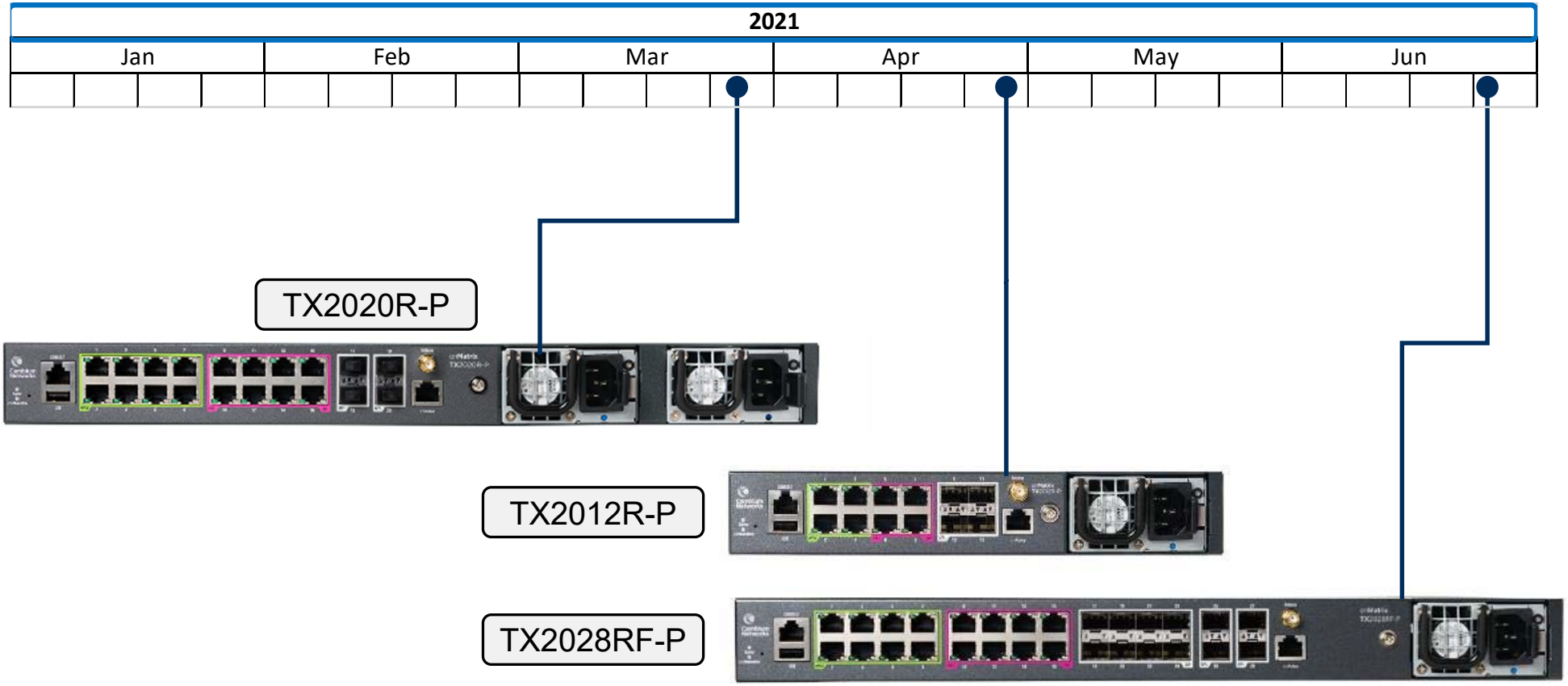
cnMatrix TX 2K – Product Concept

- **New family of Switches purpose built for WISP tower deployments**
- **Fully integrated solution – PoE, Cambium Sync, & L2/L3 Switching**
  - **Switching** - Enterprise grade, non-blocking, with Layer 2 & Layer 3 features
  - **PoE** - Intelligent & flexible - 802.3af/at/bt, 24V Passive PoE, & High Power 4PPoE (90W)
  - **Cambium Sync** - Dual redundant GPS synchronization sources
- **Fully Manageable - cnMaestro cloud-based Network Management System**
- **Dual redundant AC and DC removable power supplies - Purchased as accessory**
- **Extended Temperature Range: -10C° to +65C°**
- **3 Year Warranty**
- **One SW image for both EX and TX switch family**

cnMatrix Plan of Intent

PLAN OF INTENT
SUBJECT TO CHANGE
April 2021

Cambium Networks™



cnMatrix – TX2020R-P – Front Panel Interfaces

- Everything located on the front panel

- Console Port
- USB Port

- 4 10G Fiber Uplinks
- SFP+

- Dual power supplies
- Removable
- Redundant
- Only 1 required

- Ground Terminal

- R
- C
- PoE (4PPoE)
  - 802.3af/at/bt(90W)
  - Passive 54V(90W)

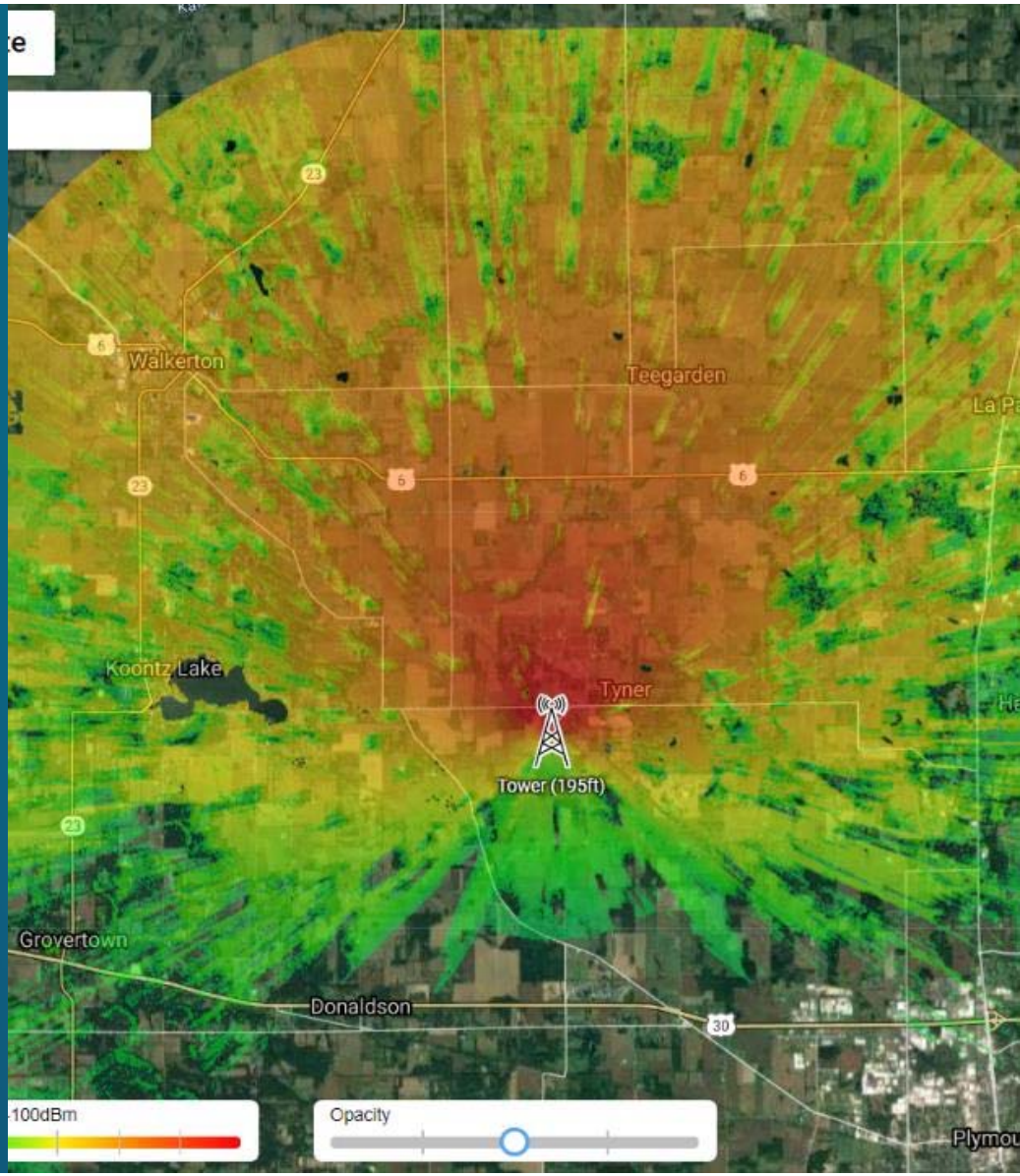
- PoE (2PPoE)
  - 802.3af/at/bt (30W)
  - Passive 54V (30W)
  - Passive 24V (15W)

- External antenna
- cnPulse

Everything Located on the front panel

cnHeat

Cambium Networks™



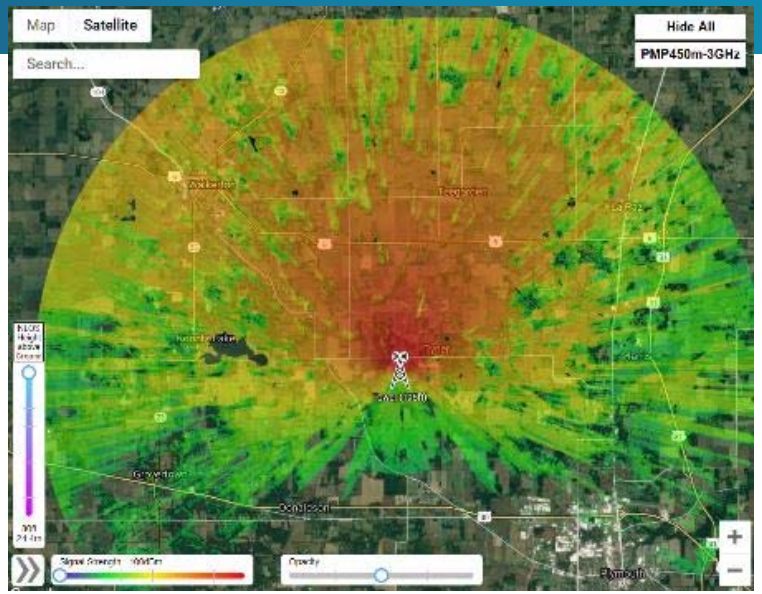
cnHeat Innovations

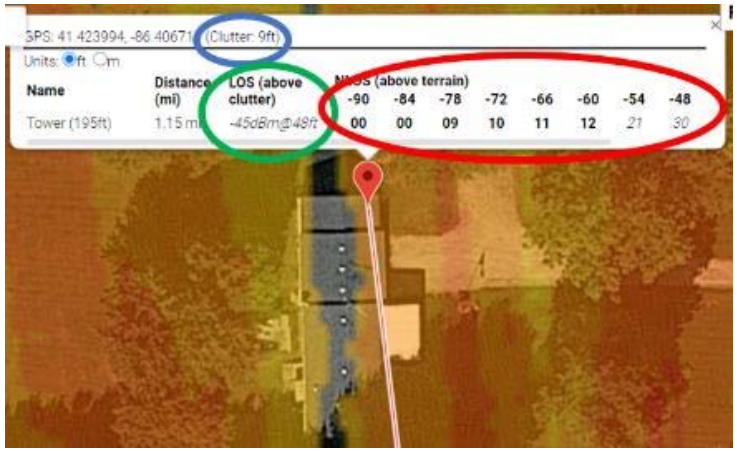
cnHeat 3D heat maps in NLOS

- **Instantly look at coverage at every square meter**
- **Dynamically adjust height of install**
- **Dynamically adjust desired RSSI**
- **Information bubble shows**
  - **Heights of RSSI values**
  - **Clutter height**
- **Best in class NLOS propagation model in prediction and variability**

Access cnHeat demonstration site here:

https://cnheat.cambiumnetworks.com/
Account Name: cnheat
Password: demo





cnHeat Innovations

cnHeat IDENTIFY identifies covered buildings and associated addresses

- **Specify by height above roof or height above ground**
- **Specify by minimum RSSI**
- **Receive quantity of buildings covered**
- **Receive building latitudes and longitudes**
- **Receive building addresses**

cnHeat Upcoming Deliverables

cnHeat LOCATE for 60 GHz and 28 GHz

- **Releasing 60 GHz now and 28 GHz in J**

cnHeat LOCATE 60 GHz Specifics

- **Supports**
  - **V1000/v5000 or V3000 CNs**
  - **Four different channels**
  - **Rain**

DN named “Tower” coverage at right

- **HixDN and Bagley reached at -61 dBm**

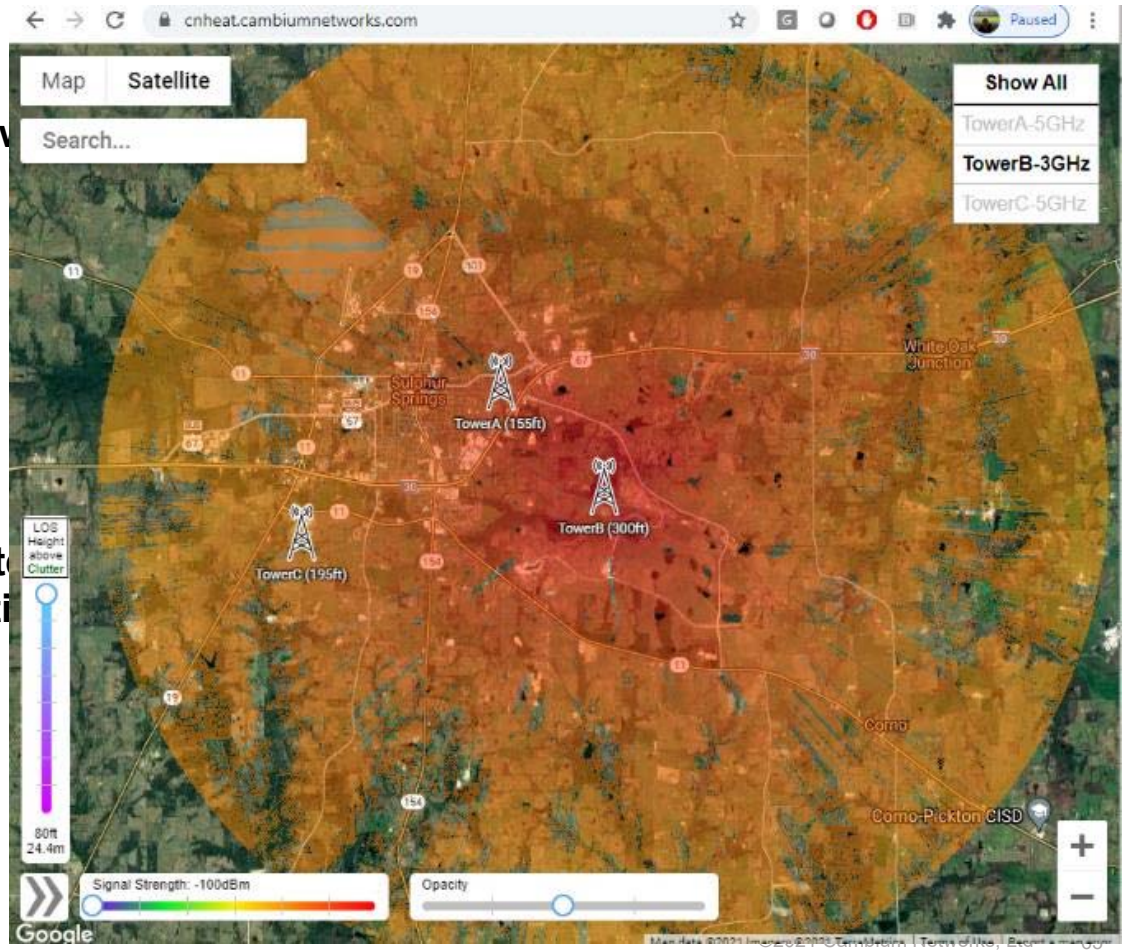
cnHeat Upcoming Releases

cnHeat 2.0 – Dynamically Change a Site

- **Place the site yourself**
- **Set / change site parameters as much as you v**
  - **APs**
  - **Height**
  - **Azimuth**
  - **Mechanical Tilt**
  - **Antenna**
  - **EIRP**
  - **Frequency**
  - **Subscriber Module**
- **Run as many predictions as you want for a sit**
- **Grandfathered in as part of existing subscripti**
- **Delivery in late summer-time**

Other features for 2022

- **2 GHz and 5 GHz NLOS**
- **Embedded cnHeat in WISP GUI**
- **API interface to billing system**
- **Form 477 support**

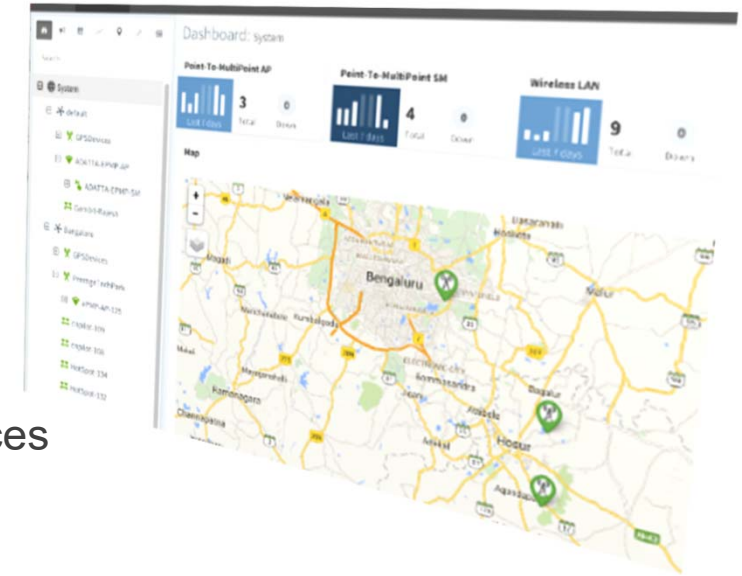


cnMaestro Overview

Cambium Networks™

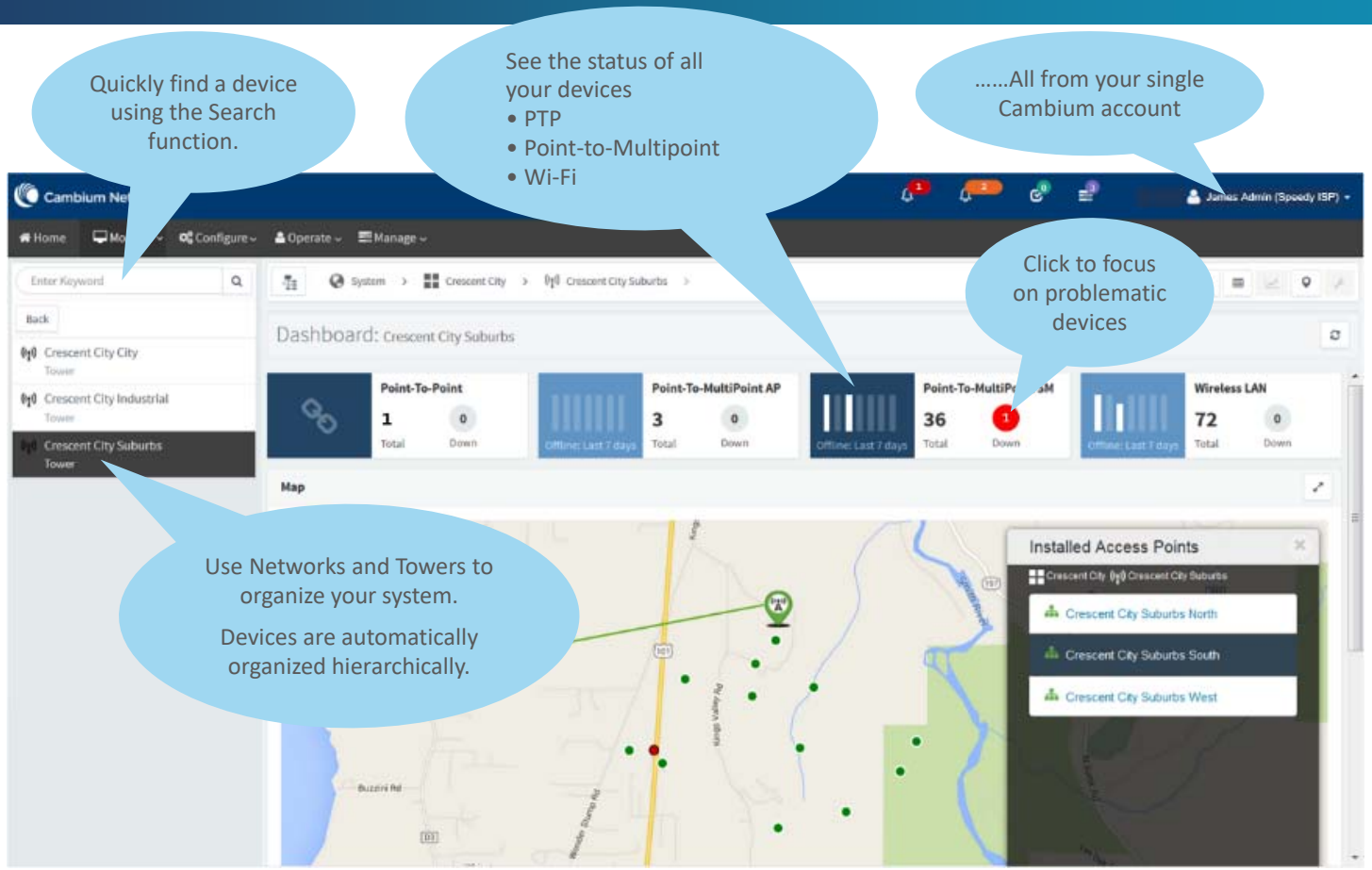
cnMaestro – End-to-End Management

Cambium Networks' cnMaestro provides an integrated, intelligent, easy way to manage your network in the cloud or On Premise

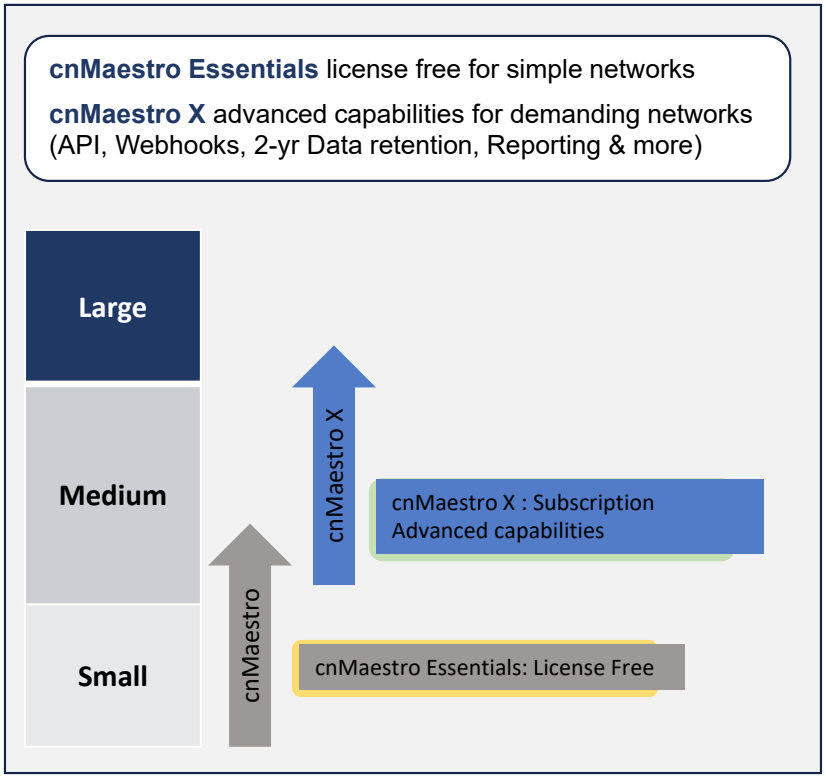


- Easy onboarding – Claim your ePMP or Wi-Fi devices in the cloud or on-site
- Monitor your entire network – Leverage hierarchical dashboards, statistics, and maps to view status and drill into problem areas.
- Configure devices – Automatically provision devices upon registration, or group devices and apply configuration parameters across your network
- Intuitive end-to-end troubleshooting – Visualize tower-to-edge device health and evaluate real-time client network connectivity

Easy Operation: One Dashboard for End-to-End Network



Introducing cnMaestro X



- ❑ RESTFul APIs: Allowing workflow automation
- ❑ Webhooks: Enabling integration to backend systems

Technology Partner Ecosystem

Billing & CRM	QoE vendors	Support services
Powercode IPPay Sonar Visp.net Other?	Preseem Sandvine Other?	Pager duty Slack Twillo Datadog Zapier Other?

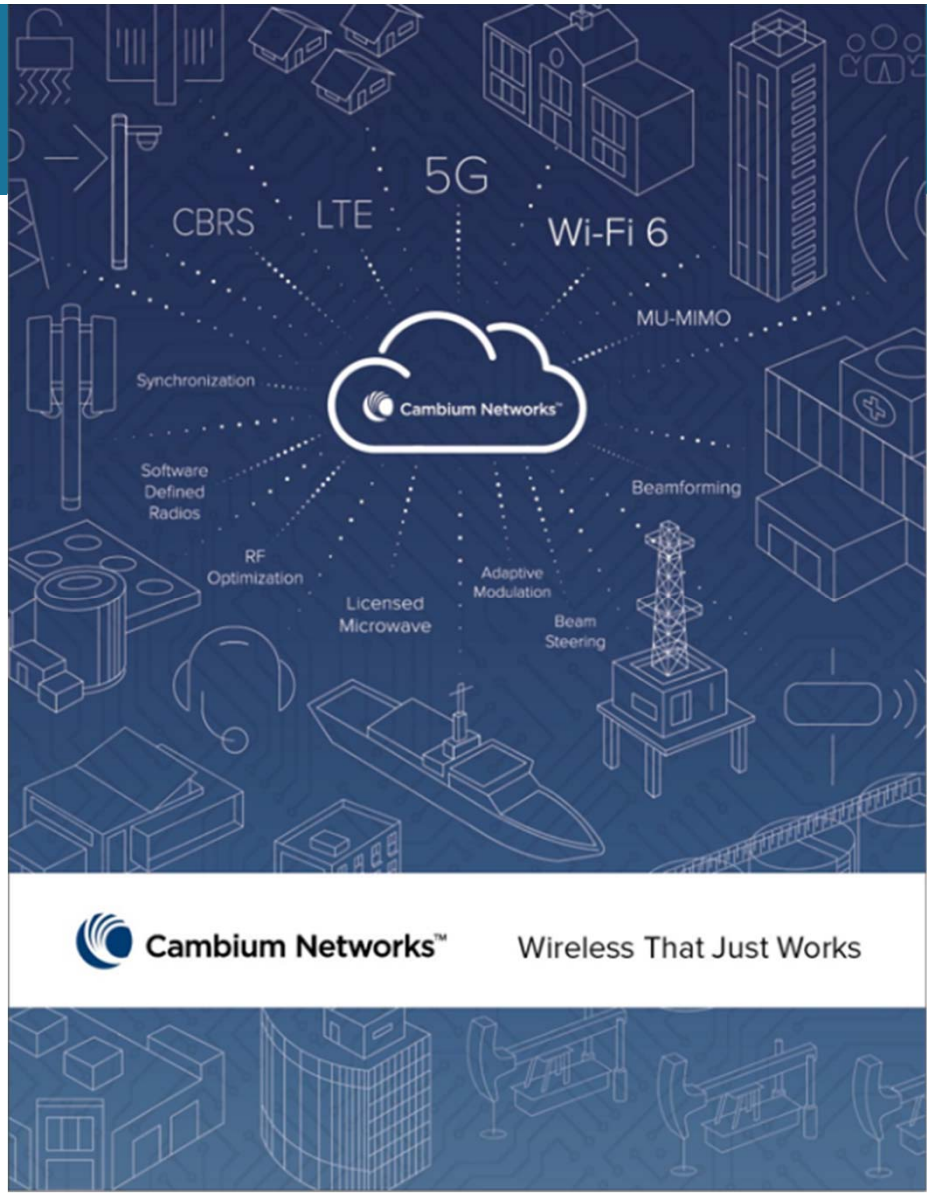
Ask: Please reach out to your Cambium RSM if you would like to see other Tech Partners added to this list

Cambium Gigabit Wireless and Beyond

Finding ways to move data faster

mmWave platforms combined with advances to the latest standards (like Wi-Fi 6) make true Gigabit to the home possible

Cambium Networks is ready to help network operators achieve their goals and grow together long into the future



Questions

- +1-888-863-5250
- cambiumnetworks.com