



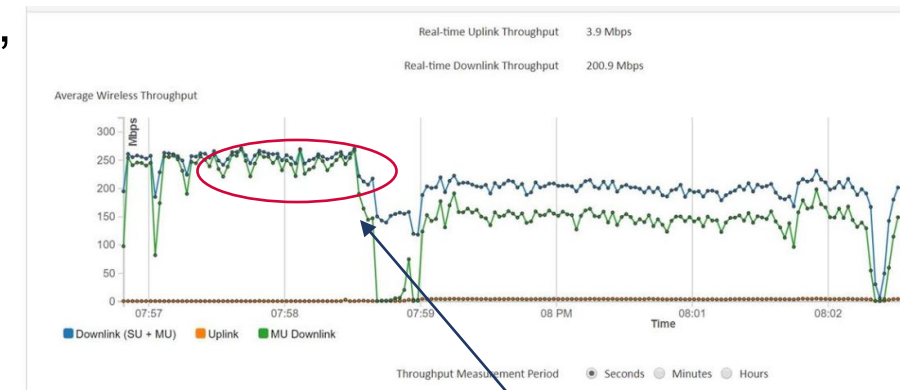
Cambium Networks™

ePMP 6GHz/5GHz AX update
September 28th, 2021

- 1. 802.11ac Wave 2 for up to 5X performance**
 - 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 and Elevated 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



- **Longer term Cambium benefits**
- Investment protection and strategic benefits
- ✓ Every AC SM you deploy today will be compatible with an 8X8 MU-MIMO AP. This ensures a path to higher order MU-MIMO systems. End result? More capacity in your network simply by swapping APs.
- ✓ Cambium focus on MU-MIMO is following the trends set by IEEE, 3GPP and 5G. Multiple input/output systems and the ability to send/receive data is the only way to higher tput. Systems only supporting higher modulation will always be limited by noise/interference.
- ✓ Cambium support at many levels. An engagement from a senior engineer is a forum post away or a quick escalation away.
- ✓ A partnership at every level with 3 year warranties and a company willing to be by your side.



MU gain

ePMP Portfolio – Access Points



ePMP 3000

- 5 GHz
- 4x4 MU-MIMO
- 802.11ac Wave 2
- 120 SM's
- Dynamic Filtering
- Opt. UL Beam-Steering



ePMP 3000L

- 5 GHz
- 2x2 MIMO
- 802.11ac Wave 2
- 64 SM's



ePMP 2000

- 5 GHz
- 2x2 MIMO
- 802.11n
- Full (120 SM) or Lite (10 SM)
- Dynamic Filtering
- Opt. UL Beam-Steering



ePMP 1000

- 2.4, 2.5, 6.4 GHz
- 2x2 MIMO
- 802.11n
- Full or Lite



Omni Micro-POP

- 5 GHz
- 2x2 MIMO
- 802.11ac Wave 2



CSML (ROW only)

- 5.15 to 6.13
- 2x2 MIMO
- 802.11AC
- Non GPS AP
- Licensable to 12 SMs

Access Point topologies to fit the Application

ePMP MicroPOP



ePMP 3000L



ePMP 3000



Sector



Omni



Twist-Port adaptor
RF Elements



MU-MIMO
Sector



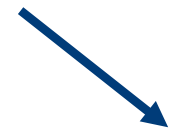
MU-MIMO Omni
KP Performance



MU-MIMO Omni
ITELite



MU-MIMO
Dual Horn



ePMP Force 300 (802.11ac Wave 2) 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



F300-13L (IP55)

- Low-Cost
- 2X2 Wave 2 SM
- 13dBi gain
- Not available in N. America



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)





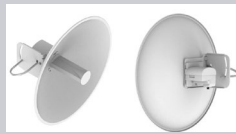


- 2X2 Wave 2 SM
- 13dBi gain



F200L & 325L (ROW)

- Low-Cost 11n & 11AC SM
- 4.9 to 6200
- No dedicated SA
- Peak tput @80 ~400Mbps

Force 300 Subscriber Module Portfolio Summary

	300-13L	300-13	300-16	300-19	300-25	300-19R	300 CSM
							
Form Factor	13 dBi Panel	13 dBi Panel	16 dBi Panel	19 dBi Panel	25 dBi Dish	19 dBi Panel	Connectorized
Applications / Key Features	<ul style="list-style-type: none"> Short-range SM or PTP Not available in N.America sales region 	Short-range SM or PTP	Mid-Range SM or PTP	Mid-Range SM or PTP	Long-Range SM or PTP	Mid-Range SM or PTP + 5/10 MHz PTP + Enterprise features (256AES, SNMPv3) + 4.9 GHz FCC	Long-range SM or PTP Twistport compatible
IP Rating	IP55	IP55	IP55	IP55	IP55	IP67	IP67

All support:

- 802.11ac Wave 2
- 20/40/80 MHz channels up to 256QAM
- 600 Mbps max capacity (300-13L = 400 Mbps)
- Synchronization with appropriate AP
- Compatible with ePMP 3000, 3000L, 2000 and 1000 Access Points
- LINKPlanner
- cnMaestro
- cnHeat

Introducing the ePMP Force 425 and Force 400C

Industry first proprietary point to point product based on 802.11ax

Target Markets / Applications

- High-capacity Enterprise point to point
- Low-cost WISP back-haul
- GPON last mile

Key Specifications

- Up to 1Gbps usable throughput
- Sub 5 ms latency
- 4.9 to 6.135 GHz – **an additional~230MHz for ROW!**
- 25 dBi integrated dish (**optional 28 dBi range extender - a first for Cambium**)
- IP67 Ruggedization
- GigE and SFP port (**optional GPON module – a first for Cambium**)

Gigabit Performance
Last-mile Fiber alternative

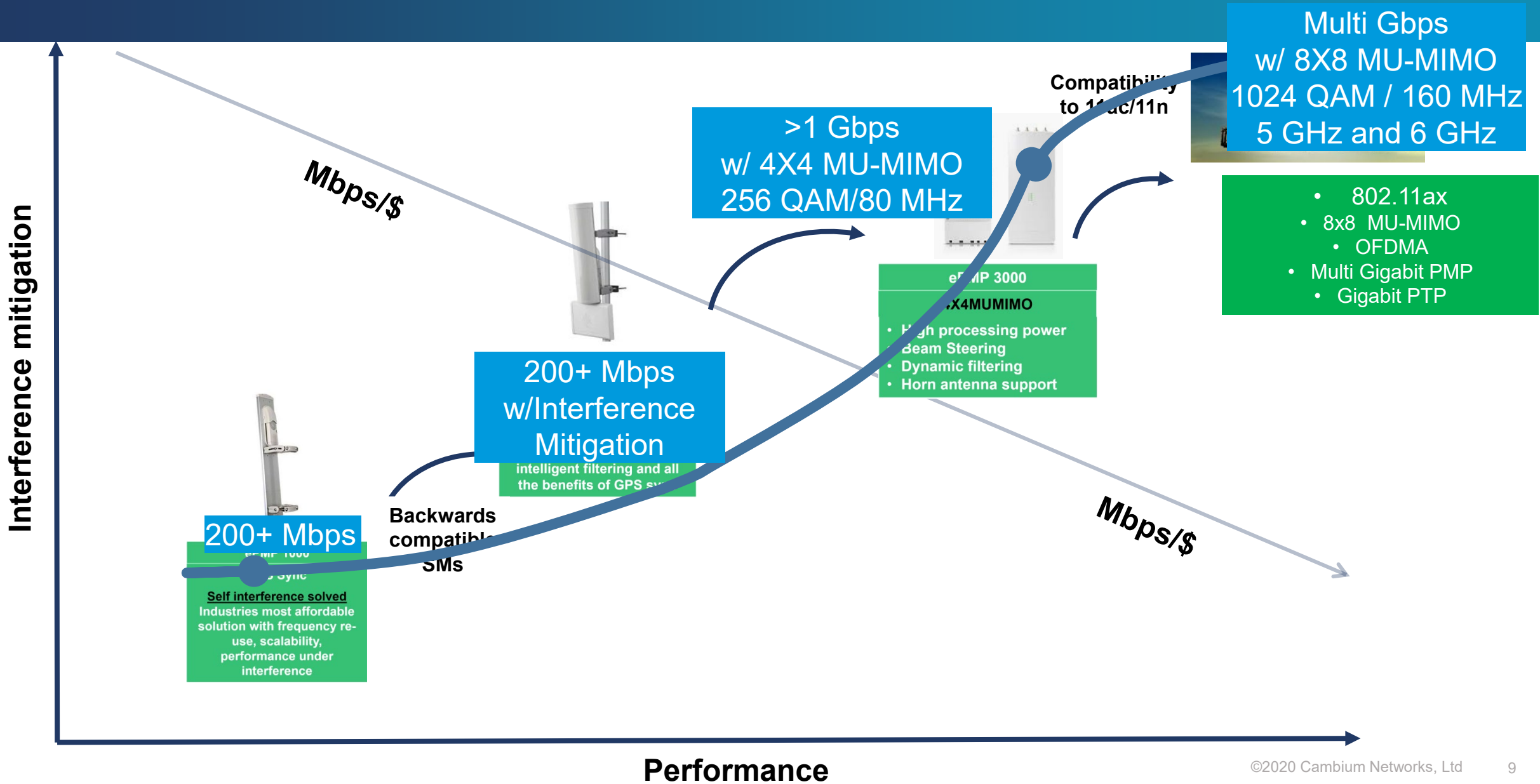


Force 425

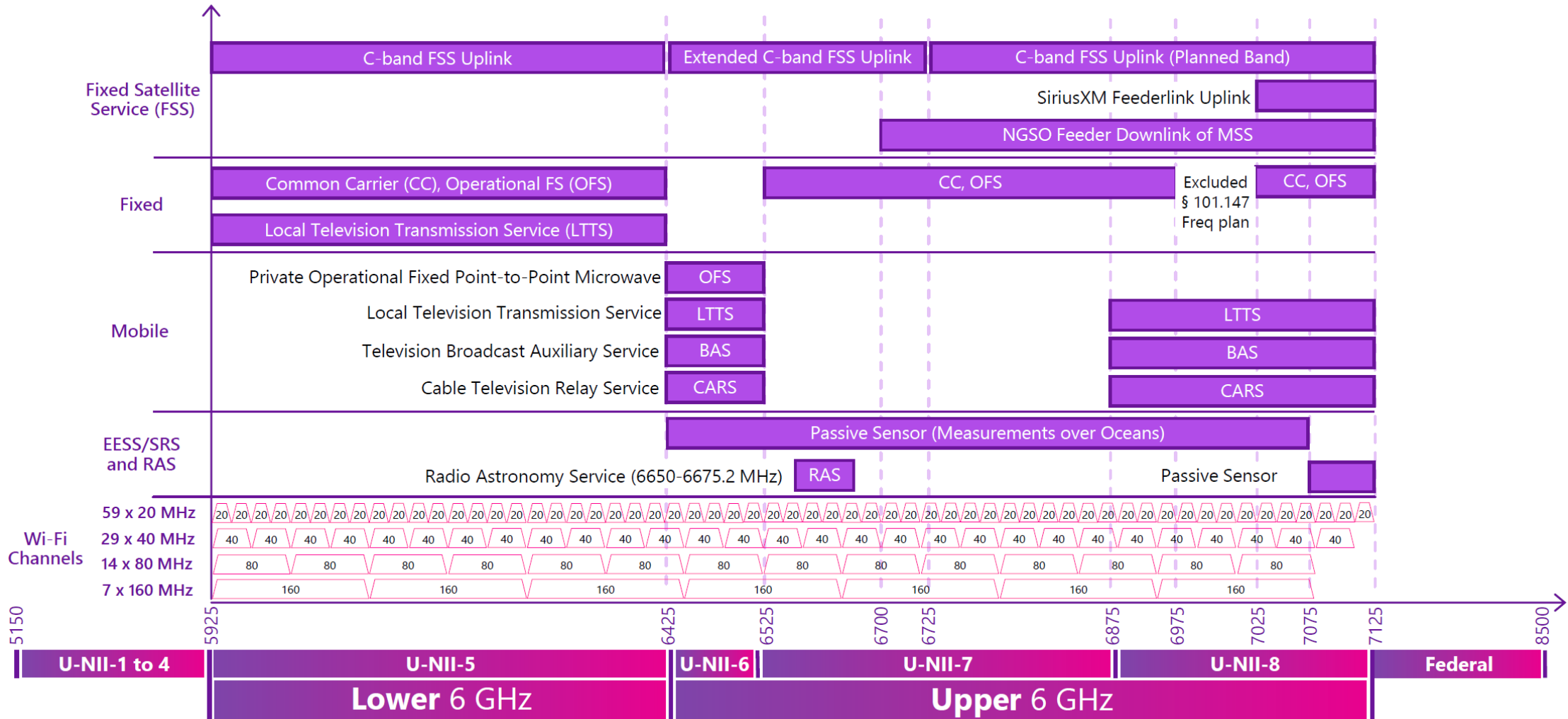


Force 400C

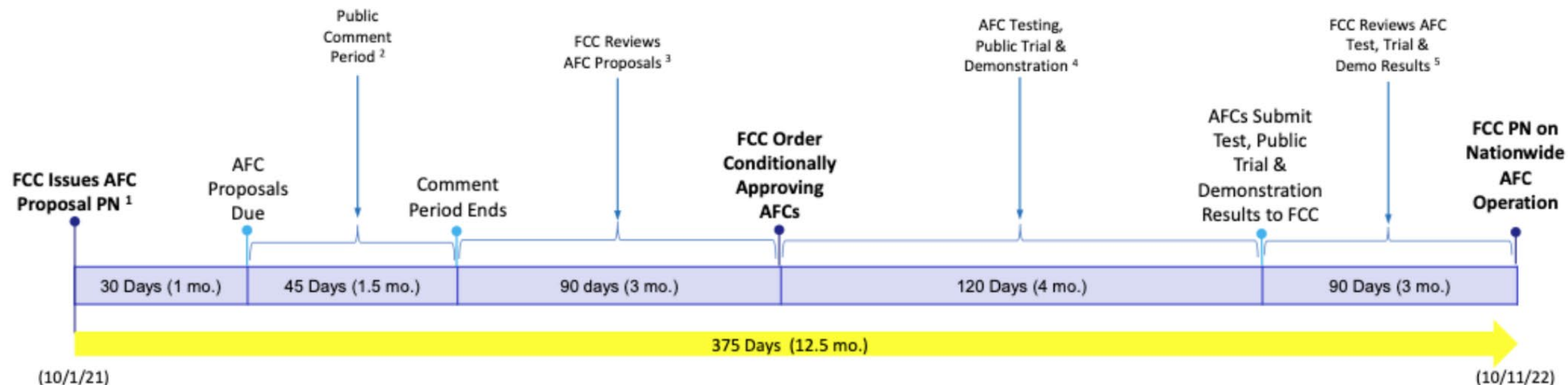
ePMP Evolution



6 GHz | Bands



Possible AFC Testing & Certification Timeline (More Likely)

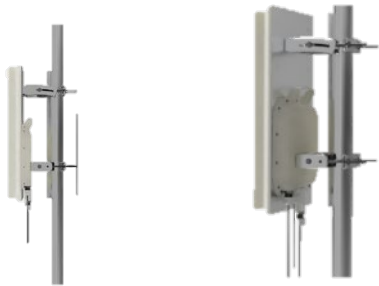


Notes:

General – this approach assumes maximum number of processes and reviews running in parallel with more time spent on each.

1. FCC AFC proposal PN could also seek proposals for public trial and demonstration projects.
2. Comment period includes 30 days for comments and 15 days for replies.
3. 90 days to review AFC proposals is still aggressive.
4. This step combines AFC testing, public trial and demonstration project, somewhat similar to TVWS. AFCs could move into public trials/demonstrations as soon as they've passed testing. Public trial/demonstration period will likely be no less than 30 days each, which leaves 60-90 days for testing. Main question is whether FCC will move AFCs ahead or hold everyone until all have completed testing.
5. 90 days to review and approve test and public trial results is consistent with CBRS, but will depend on the number of AFCs involved.

8x8 5GHz AP



Features

- Integrated 8x8 Sector Antenna
- Freq Support **4.9 - 6.135** GHz
- 48V PoE/ and **4 wire DC in**
- SFP+ interface
- IP67
- 636 mm x 485 mm
- 80 MHz Ch, 1024 QAM
- TX Power 25 dBm/Chain

4x4 6 GHz AP



Features

- 4x4 6 GHz sector antenna
- Freq Support **5.9 - 7.250** GHz
- 48V PoE in
- SFP+ interface
- IP67
- Radio – 235 mm x 125 mm, Antenna 594 mm x 157 mm
- 160 MHz Ch, 4096QAM support
- TX Power 24 dBm/chain

ePMP Force 400 Subscriber Modules

6 GHz PTP/SM



Features

- Supports RFE Twistport
- Freq Support **5.9-7.250 GHz**
- 48V Active PoE in
- SFP+ interface
- IP67
- 256 mm x 125 mm
- **160 MHz Ch, 4096 QAM**
- TX Power 24 dBm/Chain
- Internal GPS

6 GHz SM



Features

- 25 dBi Antenna
- Freq Support 5.9-7.250 GHz
- 48V Passive PoE in
- IP55
- 450 mm Diameter
- 160 MHz Ch, 1024 QAM
- TX Power 24 dBm/Chain
- USB GPS Accessory

5 GHz SM



Features

- 25 dBi Antenna
- Freq Support 4.9 -5.9 GHz
- 48V Passive PoE in
- IP55
- 450 mm Diameter
- 80 MHz Ch, 1024 QAM
- TX Power 25 dBm/Chain

5 GHz SM (ROW)



Features

- 25 dBi Antenna
- Freq Support 4.9 -5.9 GHz
- 30V Passive PoE in
- IP55
- 450 mm Diameter
- 80 MHz Ch, 1024 QAM
- Peak tput of 400Mbps
- TX Power 25 dBm/Chain

6GHz ePMP 4000 headline data rates for UDP				
MCS11, 1024 QAM	HE160	HE80	HE40	HE20
AP capacity (4X4)	4083	2042	975	487
SM capacity (2X2)	2042	1021	487	244
MCS13, 4096 QAM	HE160	HE80	HE40	HE20
AP capacity (4X4)	5431	2715	1296	647
SM capacity (2X2)	2715	1357	648	323

Hardware Specs

- Proven ePMP Air Interface
- Qualcomm 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
 - 4096 QAM proprietary mode w/ high-tier SM
- Ethernet ports:
 - 1G RJ-45
 - 10G SFP+ for AP and F600C
- PoE IEEE 802.3at – 56V
 - 30W - AP and F600C; 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 AX with less overhead (shorter 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)










20 MHz channels, device configs: AP

Status










-  Quick Start 
-  Configuration 
-  Monitor 
-  Tools 

Status













Device Name	F600_99ee10
SSID	Cambium-AX
 Operating Frequency	6125 MHz
 Operating Channel Bandwidth	20 MHz
 Transmitter Output Power	5 dBm
 Antenna Gain	0 dBi
 Country	United States
 Access Point Mode	ePTP Master
Wireless Security	WPA2
 cnMaestro Remote Management	Disabled













 Wireless MAC Address	00:00:FF:99:EE:11
 Ethernet MAC Address	00:00:FF:99:EE:10
Auxiliary Port MAC Address	00:00:FF:99:EE:12
 IP Address	192.168.0.1
 Date and Time	14 Sep 2021 07:54:53 GMT
 System Uptime	12 minutes, 51 seconds
System Description	--
 Device Coordinates	--
 Ethernet Status	Down
 Wireless Status	Up
Auxiliary Port	Up
Auxiliary Port Connector	SFP
Auxiliary Port Type	10G BASE-SR
 Registered Subscriber Modules	1

20 MHz channels, device configs: SM

-  Status
-  Quick Start 
-  Configuration 
-  Monitor 
-  Tools 

Status

Device Name	F600_f00168
 Operating Frequency	6 125 MHz
 Operating Channel Bandwidth	20 MHz
 Transmitter Output Power	5 dBm
 Antenna Gain	0 dBi
 Country	United States
 Subscriber Module Mode	ePTP Slave
 Network Mode	Bridge
 Downlink RSSI	-43 dBm
 Downlink SNR	41 dB
 Uplink MCS	DS 13 - 4096-QAM 5/6
 Downlink MCS	DS 13 - 4096-QAM 5/6
 cnMaestro Remote Management	Disabled

 Wireless MAC Address	BC:E6:7C:F0:01:69
 Ethernet MAC Address	BC:E6:7C:F0:01:68
Auxiliary Port MAC Address	BC:E6:7C:F0:01:6A
 IP Address	192.168.0.2
 Date and Time	14 Sep 2021 07:56:31 GMT
 System Uptime	13 minutes, 42 seconds
System Description	--
 Registered AP SSID	Cambium-AX
 Registered AP MAC Address	00:00:FF:99:EE:11
 Device Coordinates	--
 Link Quality (Uplink)	100 %
 Link Capacity (Uplink)	0 %
 Ethernet Status	Down
 Wireless Status	Up
Auxiliary Port	Up
Auxiliary Port Connector	SFP
Auxiliary Port Type	10G BASE-SR

20 MHz channels, device stats: AP

Monitor

Performance

System

Wireless

Throughput Chart

Network

System Log

Tools

Downlink Packets Per MCS			
DS MCS 13 - 4096-QAM 5/6	1508591 (99.8%)	SS MCS 13 - 4096-QAM 5/6	0 (0%)
DS MCS 12 - 4096-QAM 3/4	2827 (0.2%)	SS MCS 12 - 4096-QAM 3/4	0 (0%)
DS MCS 11 - 1024-QAM 5/6	5 (0%)	SS MCS 11 - 1024-QAM 5/6	0 (0%)
DS MCS 10 - 1024-QAM 3/4	6 (0%)	SS MCS 10 - 1024-QAM 3/4	0 (0%)
DS MCS 9 - 256-QAM 5/6	5 (0%)	SS MCS 9 - 256-QAM 5/6	0 (0%)
DS MCS 8 - 256-QAM 3/4	5 (0%)	SS MCS 8 - 256-QAM 3/4	0 (0%)
DS MCS 7 - 64-QAM 5/6	6 (0%)	SS MCS 7 - 64-QAM 5/6	0 (0%)
DS MCS 6 - 64-QAM 3/4	5 (0%)	SS MCS 6 - 64-QAM 3/4	0 (0%)
DS MCS 5 - 64-QAM 2/3	0 (0%)	SS MCS 5 - 64-QAM 2/3	0 (0%)
DS MCS 4 - 16-QAM 3/4	0 (0%)	SS MCS 4 - 16-QAM 3/4	0 (0%)
DS MCS 3 - 16-QAM 1/2	0 (0%)	SS MCS 3 - 16-QAM 1/2	2 (0%)
DS MCS 2 - QPSK 3/4	0 (0%)	SS MCS 2 - QPSK 3/4	0 (0%)
DS MCS 1 - QPSK 1/2	0 (0%)	SS MCS 1 - QPSK 1/2	0 (0%)
DS MCS 0 - BPSK 1/2	0 (0%)	SS MCS 0 - BPSK 1/2	0 (0%)

Uplink Packets Per MCS			
DS MCS 13 - 4096-QAM 5/6	987423 (99.7%)	SS MCS 13 - 4096-QAM 5/6	0 (0%)
DS MCS 12 - 4096-QAM 3/4	1455 (0.1%)	SS MCS 12 - 4096-QAM 3/4	0 (0%)
DS MCS 11 - 1024-QAM 5/6	439 (0%)	SS MCS 11 - 1024-QAM 5/6	0 (0%)
DS MCS 10 - 1024-QAM 3/4	590 (0.1%)	SS MCS 10 - 1024-QAM 3/4	0 (0%)
DS MCS 9 - 256-QAM 5/6	27 (0%)	SS MCS 9 - 256-QAM 5/6	0 (0%)
DS MCS 8 - 256-QAM 3/4	53 (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 - 64-QAM 3/4	0 (0%)	SS MCS 6 - 64-QAM 3/4	0 (0%)
DS MCS 5 - 64-QAM 2/3	0 (0%)	SS MCS 5 - 64-QAM 2/3	0 (0%)
DS MCS 4 - 16-QAM 3/4	0 (0%)	SS MCS 4 - 16-QAM 3/4	0 (0%)
DS MCS 3 - 16-QAM 1/2	0 (0%)	SS MCS 3 - 16-QAM 1/2	0 (0%)
DS MCS 2 - QPSK 3/4	0 (0%)	SS MCS 2 - QPSK 3/4	0 (0%)
DS MCS 1 - QPSK 1/2	0 (0%)	SS MCS 1 - QPSK 1/2	0 (0%)
DS MCS 0 - BPSK 1/2	0 (0%)	SS MCS 0 - BPSK 1/2	1 (0%)

20 MHz channels, device stats: SM

MONITOR

Performance

System

Wireless

Throughput Chart

Network

System Log

Tools

Downlink Packets Per MCS

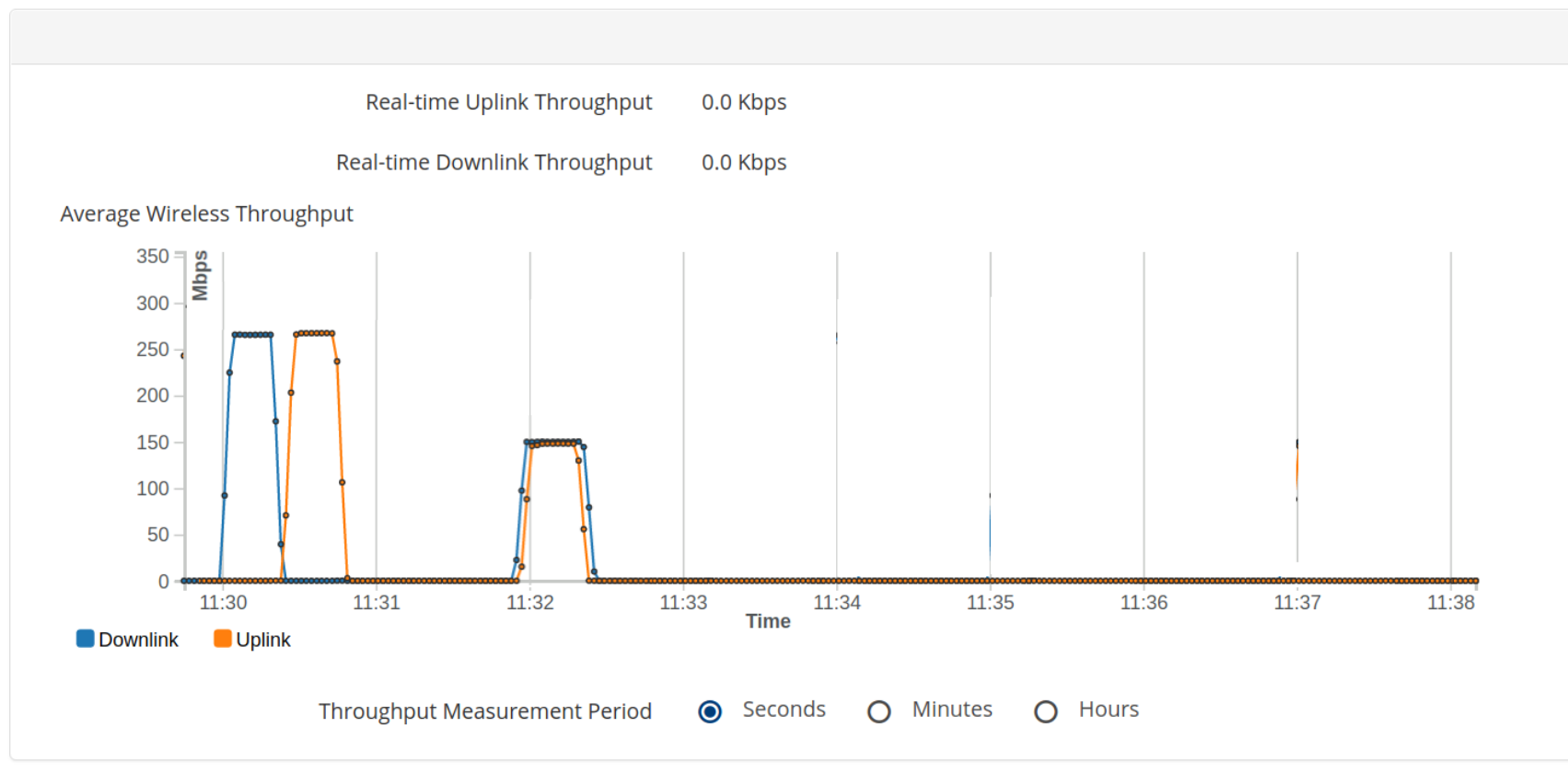
DS MCS 13 - 4096-QAM 5/6	1 505 101 (99.8%)	SS MCS 13 - 4096-QAM 5/6	0 (0%)
DS MCS 12 - 4096-QAM 3/4	2 821 (0.2%)	SS MCS 12 - 4096-QAM 3/4	0 (0%)
DS MCS 11 - 1024-QAM 5/6	1 (0%)	SS MCS 11 - 1024-QAM 5/6	0 (0%)
DS MCS 10 - 1024-QAM 3/4	2 (0%)	SS MCS 10 - 1024-QAM 3/4	0 (0%)
DS MCS 9 - 256-QAM 5/6	1 (0%)	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	3 (0%)	SS MCS 7 - 64-QAM 5/6	0 (0%)
DS MCS 6 - 64-QAM 3/4	2 (0%)	SS MCS 6 - 64-QAM 3/4	0 (0%)
DS MCS 5 - 64-QAM 2/3	0 (0%)	SS MCS 5 - 64-QAM 2/3	0 (0%)
DS MCS 4 - 16-QAM 3/4	0 (0%)	SS MCS 4 - 16-QAM 3/4	0 (0%)
DS MCS 3 - 16-QAM 1/2	0 (0%)	SS MCS 3 - 16-QAM 1/2	0 (0%)
DS MCS 2 - QPSK 3/4	0 (0%)	SS MCS 2 - QPSK 3/4	0 (0%)
DS MCS 1 - QPSK 1/2	0 (0%)	SS MCS 1 - QPSK 1/2	0 (0%)
DS MCS 0 - BPSK 1/2	0 (0%)	SS MCS 0 - BPSK 1/2	1 (0%)

Uplink Packets Per MCS

DS MCS 13 - 4096-QAM 5/6	991 144 (99.7%)	SS MCS 13 - 4096-QAM 5/6	0 (0%)
DS MCS 12 - 4096-QAM 3/4	1 463 (0.1%)	SS MCS 12 - 4096-QAM 3/4	0 (0%)
DS MCS 11 - 1024-QAM 5/6	444 (0%)	SS MCS 11 - 1024-QAM 5/6	0 (0%)
DS MCS 10 - 1024-QAM 3/4	589 (0.1%)	SS MCS 10 - 1024-QAM 3/4	0 (0%)
DS MCS 9 - 256-QAM 5/6	31 (0%)	SS MCS 9 - 256-QAM 5/6	0 (0%)
DS MCS 8 - 256-QAM 3/4	58 (0%)	SS MCS 8 - 256-QAM 3/4	0 (0%)
DS MCS 7 - 64-QAM 5/6	5 (0%)	SS MCS 7 - 64-QAM 5/6	0 (0%)
DS MCS 6 - 64-QAM 3/4	4 (0%)	SS MCS 6 - 64-QAM 3/4	0 (0%)
DS MCS 5 - 64-QAM 2/3	0 (0%)	SS MCS 5 - 64-QAM 2/3	0 (0%)
DS MCS 4 - 16-QAM 3/4	0 (0%)	SS MCS 4 - 16-QAM 3/4	0 (0%)
DS MCS 3 - 16-QAM 1/2	0 (0%)	SS MCS 3 - 16-QAM 1/2	2 (0%)
DS MCS 2 - QPSK 3/4	0 (0%)	SS MCS 2 - QPSK 3/4	0 (0%)
DS MCS 1 - QPSK 1/2	0 (0%)	SS MCS 1 - QPSK 1/2	0 (0%)
DS MCS 0 - BPSK 1/2	0 (0%)	SS MCS 0 - BPSK 1/2	0 (0%)

20 MHz channels, device performance: TPUT chart

Monitor ▶ Throughput Chart



20 MHz channels, device performance: mikrotik generator

Graph



Tx

cur: 0 bps

avg: 0 bps

max: 0 bps

Rx

cur: 266.2 Mbps

avg: 264.1 Mbps

max: 266.2 Mbps

Graph



Tx

cur: 151.0 Mbps

avg: 151.3 Mbps

max: 153.3 Mbps

Rx

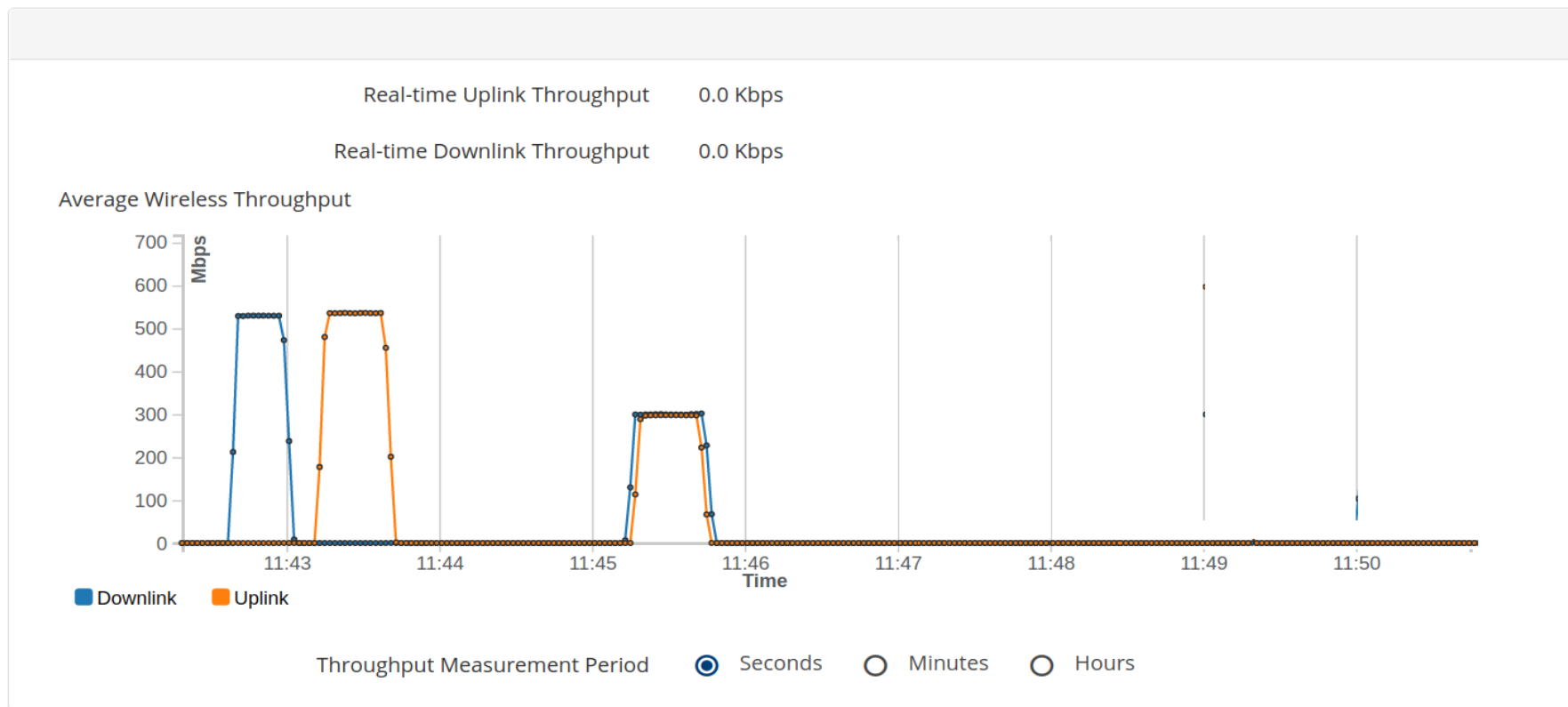
cur: 147.1 Mbps

avg: 145.6 Mbps

max: 148.3 Mbps

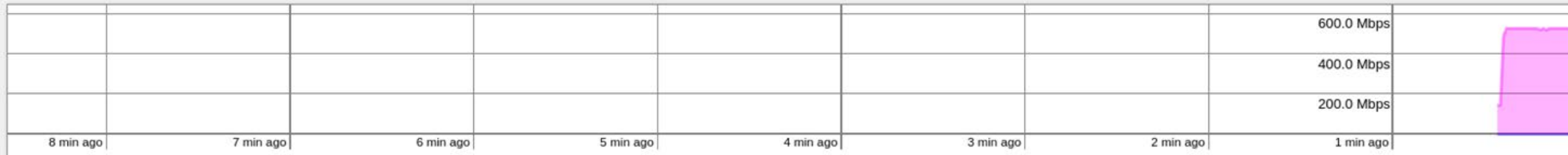
40 MHz channels, device performance: TPUT chart

Monitor > Throughput Chart



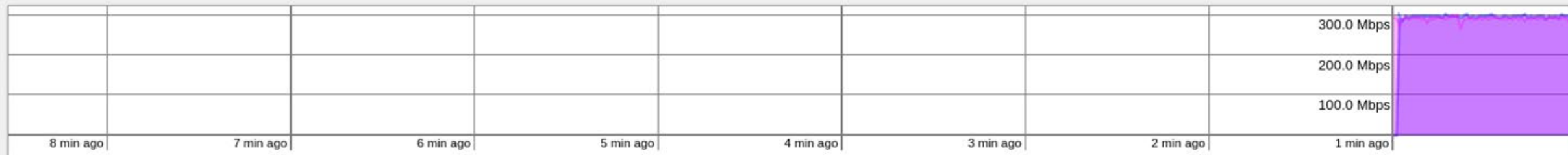
40 MHz channels, device performance: mikrotik generator

Graph



Tx cur: 0 bps avg: 0 bps max: 0 bps
 Rx cur: 526.5 Mbps avg: 499.6 Mbps max: 534.0 Mbps

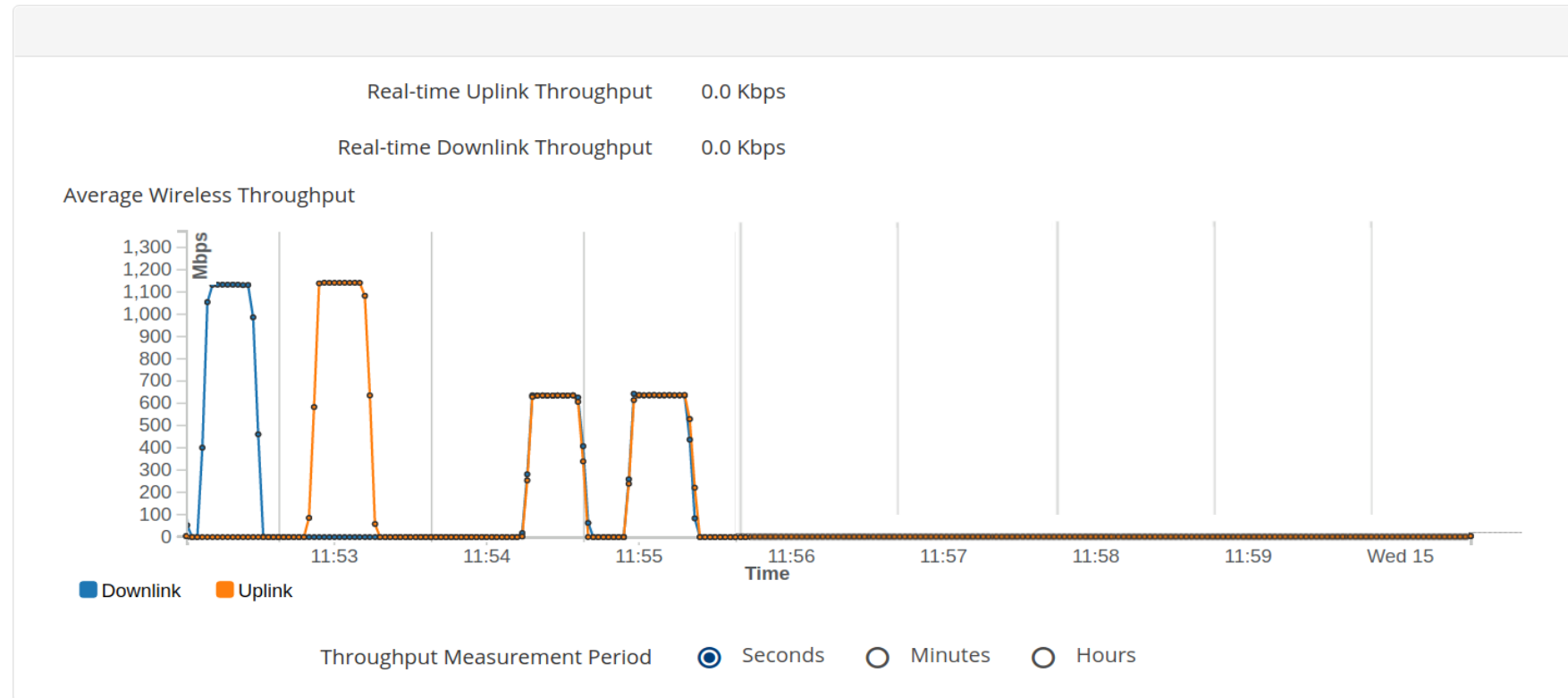
Graph



Tx cur: 301.5 Mbps avg: 289.5 Mbps max: 303.0 Mbps
 Rx cur: 293.4 Mbps avg: 294.0 Mbps max: 299.2 Mbps

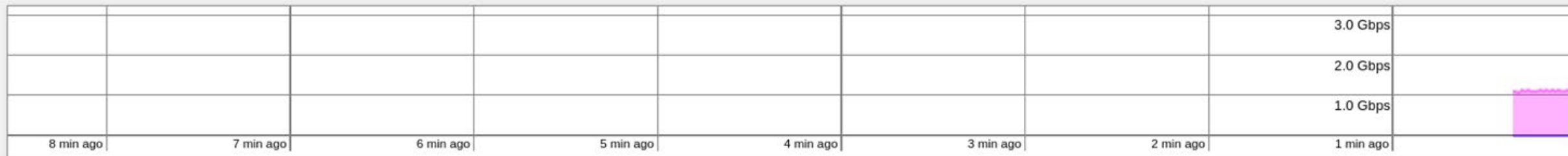
80 MHz channels, device performance: TPUT chart

Monitor ▶ Throughput Chart



80 MHz channels, device performance: mikrotik generator

Graph



Tx	cur: 0 bps	avg: 0 bps	max: 0 bps
Rx	cur: 1126.9 Mbps	avg: 1129.6 Mbps	max: 1142.6 Mbps

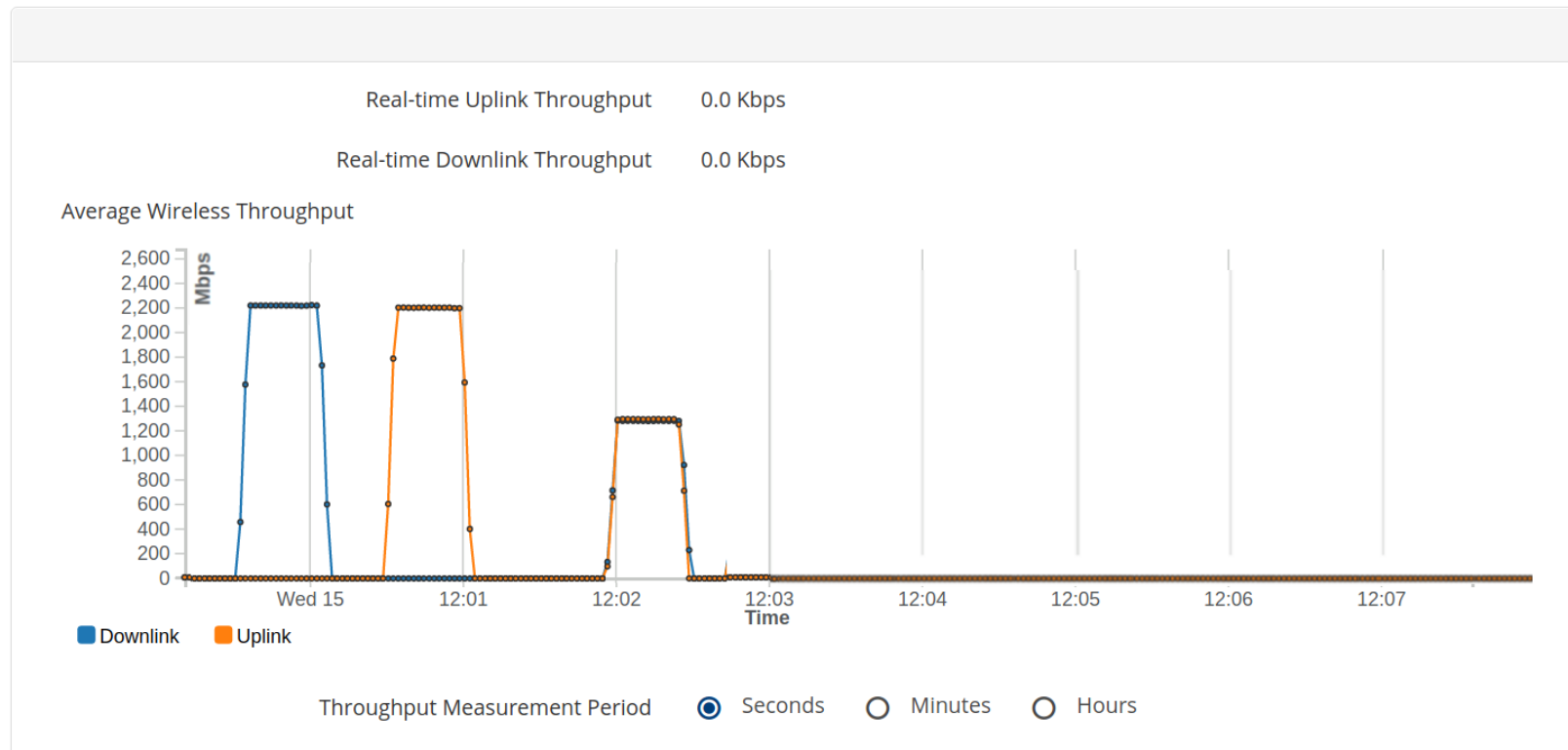
Graph



Tx	cur: 631.7 Mbps	avg: 636.9 Mbps	max: 644.8 Mbps
Rx	cur: 634.5 Mbps	avg: 626.7 Mbps	max: 636.8 Mbps

160 MHz channels, device performance: TPUT chart

Monitor > Throughput Chart



160 MHz channels, device performance: mikrotik generator

Graph



Tx	cur: 0 bps	avg: 0 bps	max: 0 bps
Rx	cur: 2.2 Gbps	avg: 2.2 Gbps	max: 2.2 Gbps

Graph



Tx	cur: 1285.3 Mbps	avg: 1281.4 Mbps	max: 1291.7 Mbps
Rx	cur: 1270.9 Mbps	avg: 1261.5 Mbps	max: 1276.2 Mbps

Questions



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