Ethernet indiscards	This indicates the number of Ethernet packets discarded in the IN queue.
Ethernet outdiscards	This indicates the number of Ethernet packets discarded in the OUT queue.
Radio indiscards	This indicates the number of packets discarded over radio in the IN queue.
Radio outdiscards	This indicates the number of packets discarded over radio in the OUT queue.

Radio Recovery

This section describes:

- How to recover a PMP/PTP 450i unit from configuration errors or software image corruption
- How to override a PMP/PTP 450 unit from forgotten IP address and password to factory default

Recovery Console – PMP/PTP 450i

Use this procedure to enter recovery console manually.

Note

The unit may enter recovery console automatically, in response to some failures.

Note

Once the unit has entered recovery, it will switch back to normal operation if no access has been made to the recovery web page within 30 seconds.

Procedure 32 Recovery mode

1. Apply power to PSU for at least 10 seconds.
2. Remove power for two seconds.
3. Re-apply power to the PSU.
4. When the unit is in recovery mode, access the web interface by entering the default IP address **169.254.1.1**. The Recovery Image Warning page is displayed.
5. Review the Boot Selection (Table 201).
6. Select a recovery option

Figure 151 Recovery Options page

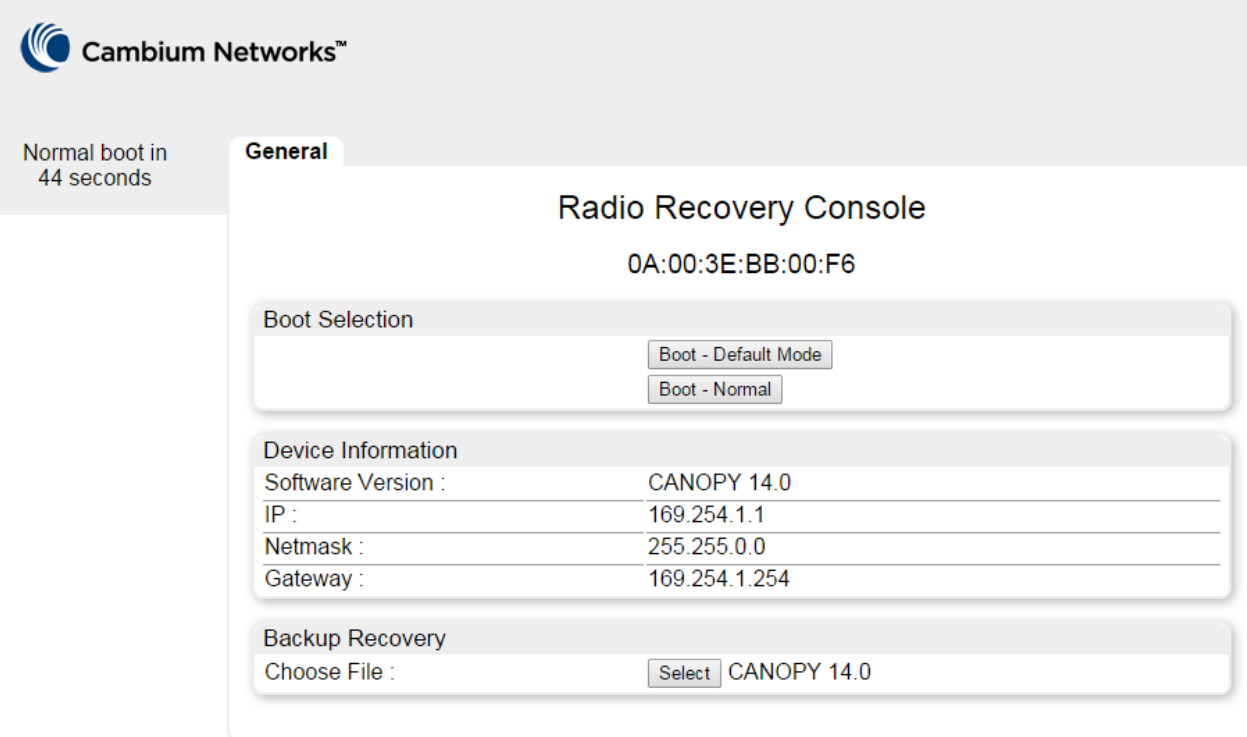

Table 201 Recovery Options attributes

Attribute	Meaning
Boot Selection	**Boot – Default Mode**: Use this option to temporarily set the IP and Ethernet attributes to factory defaults until the next reboot. **Boot – Normal**: Use this option to reboot the unit.
IP address, Netmask, Gateway	These fields display IP address, Netmask and Gateway of the radio while it is in recovery or default mode.

Overriding Forgotten IP Address or Password - PMP/PTP 450

A small adjunctive product allows to temporarily override some PMP/PTP 450 ODU settings and thereby regain control of the module by powering the module on with the plug inserted into the unit's synchronization (RJ11) port. This override plug is needed for access to the module in any of the following cases:

- You have forgotten either
  - the IP address assigned to the ODU.
  - the password that provides access to the ODU.
- The ODU has been locked by the No Remote Access feature.
- You want local access to a module that has had the 802.3 link disabled in the Configuration page.

You can configure the module such that, when it senses the override plug, it responds by either

- resetting the LAN1 IP address to 169.254.1.1, allowing access through the default configuration without *changing* the configuration, whereupon you will be able to view and reset any non-default values as you wish.
- resetting all configurable parameters to their factory default values.

Using the Default/Override Plug

The following section details usage of the override plug to regain access to PMP/PTP 450 ODU.

Note

While the override plug is connected to a PMP/PTP 450 ODU, the ODU can neither register nor allow registration of another ODU.

To regain access to the module, perform the following steps.

Procedure 33 Recovery mode

1. Insert the override plug into the RJ-11 GPS utility port of the module.
2. Power cycle by removing, then re-inserting, the Ethernet cable.
   RESULT: The module boots with the default IP address of 169.254.1.1, password fields blank, and all other configuration values as previously set.
3. Wait approximately 30 seconds for the boot to complete.
4. Remove the override plug.
5. Set passwords and IP address as desired.
6. Change configuration values if desired.
7. Click the Save Changes button.
8. Click the Reboot button.

Chapter 10: Reference Information

This chapter contains reference information and regulatory notices that apply to the PMP/PTP 450 platform Series products.

The following topics are described in this chapter:

- Equipment specifications on page 10-2 contains specifications of the PMP/PTP 450 platform, ODU specifications including RF bands, channel width and link loss.
- Data network specifications on page 10-22 shows the PMP/PTP 450 platform Ethernet interface specifications.
- Compliance with safety standards on page 4-22 lists the safety specifications against which the PMP/PTP 450 platform has been tested and certified. It also describes how to keep RF exposure within safe limits.
- Country specific radio regulations on page 10-33 describes how the PMP/PTP 450 platform complies with the radio regulations that are enforced in various countries.
- Equipment Disposal on page 10-35 describes the Equipment Disposal system for Electronic and Electric Equipment.

Equipment specifications

This section contains specifications of the AP, SM, BHM and BHS associated supplies required for PMP/PTP 450 platform installations.

Specifications for PMP 450i AP

The PMP 450i AP conforms to the specifications listed in Table 202.

Table 202 PMP 450i AP specifications

Category		Specification
Model Number		PMP 450i AP
Spectrum		
Channel Spacing		5, 7, 10 and 20 MHz Channel Bandwidth Configurable on 2.5 MHz increments
Frequency Range		902 to 928 MHz
		4900 - 5925 MHz
Channel Bandwidth	902 – 928 MHz	5, 7, 10 and 20 MHz
	4900 – 5925 MHz	5, 10 and 20 MHz
Interface		
MAC (Media Access Control) Layer		Cambium Proprietary
Physical Layer		2x2 MIMO OFDM
Ethernet Interface		10/100/1000BaseT, half/full duplex, rate auto negotiated (802.3 compliant)
Protocols Used		IPv4, UDP, TCP, IP, ICMP, Telnet, SNMP, HTTP, FTP
Network Management		HTTP, HTTPS, Telnet, FTP, SNMP v3
VLAN		802.1ad (DVLAN Q-in-Q), 802.1Q with 802.1p priority, dynamic port VID
Sensitivity		
Nominal Receive Sensitivity (w/ FEC) @	900 MHz	1x = -93 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -68 dBm

5 MHz Channel	4.9 GHz	1x = -90 dBm, 2x = -85.7 dBm, 4x = -80 dBm, 6x = -72.4 dBm, 8x = -65.7 dBm
	5.4 GHz	1x = -91 dBm, 2x = -86.3 dBm, 4x = -79.8 dBm, 6x = -73.5 dBm, 8x = -66 dBm
	5.8 GHz	1x = -91 dBm, 2x = -86.3 dBm, 4x = -79.8 dBm, 6x = -73.5 dBm, 8x = -66 dBm
Nominal Receive Sensitivity (w/ FEC) @ 7 MHz Channel	900 MHz	1x = -91 dBm, 2x = -86 dBm, 4x = -80 dBm, 6x = -74 dBm, 8x = -67 dBm
Nominal Receive Sensitivity (w/ FEC) @ 10 MHz Channel	900 MHz	1x = -90 dBm, 2x = -84 dBm, 4x = -79 dBm, 6x = -73 dBm, 8x = -66 dBm
	4.9 GHz	1x = -87.9 dBm, 2x = -84.1 dBm, 4x = -78 dBm, 6x = -71.5 dBm, 8x = -64.8 dBm
	5.4 GHz	1x = -88 dBm, 2x = -84.1 dBm, 4x = -77.1 dBm, 6x = -71.2 dBm, 8x = -64.2 dBm
	5.8 GHz	1x = -88 dBm, 2x = -84.1 dBm, 4x = -77.1 dBm, 6x = -71.2 dBm, 8x = -64.2 dBm
Nominal Receive Sensitivity (w/ FEC) @ 20 MHz Channel	900 MHz	1x = -86 dBm, 2x = -82 dBm, 4x = -75 dBm, 6x = -69 dBm, 8x = -62 dBm
	4.9 GHz	1x = -85.6 dBm, 2x = -80.4 dBm, 4x = -74.3 dBm, 6x = -68.2 dBm, 8x = -61 dBm
	5.4 GHz	1x = -86 dBm, 2x = -82 dBm, 4x = -75 dBm, 6x = -68.9 dBm, 8x = -61 dBm
	5.8 GHz	1x = -86 dBm, 2x = -82 dBm, 4x = -75 dBm, 6x = -68.9 dBm, 8x = -61 dBm

Performance			
ARQ	Yes		
Cyclic Prefix	1/16		
Frame Period	2.5 ms or 5.0 ms		
Modulation Levels (Adaptive)	Modution Levels	MCS	SNR (in dB)
	2x	QPSK	10

		4x	16QAM	17
		6x	64QAM	24
		8x	256QAM	32
Latency		3 - 5 ms		
Maximum Deployment Range		Up to 40 miles (64 km)		
GPS Synchronization		Yes, via Autosync (CMM4), via UGPS		
Quality of Service		Diffserv QoS		
Link Budget				
Antenna Beam Width	900 MHz	65° sector antenna (Dual Slant)		
	5 GHz	90° (3dB rolloff) sector for integrated (Dual polarity, H+V)		
Antenna Gain (Does not include cable loss, ~1dB)	900 MHz	13 dBi		
	5 GHz	16 dBi integrated 90° sector or external		
Transmit Power Range		40 dB dynamic range (to EIRP limit by region) (1 dB step)		
Maximum Transmit Power		+27 dBm combined output (for 5 GHz) +25 dBm combined output (for 900MHz)		
Physical				
Sync/AUX port	RJ45	• 10/100/100BASE-T Ethernet Data • PoE output (planned for future release) • Sync input or output (Connection and powering of UGPS Sync input)		
Antenna Connection		50 ohm, N-type (Connectorized version only)		
Surge Suppression EN61000-4-5		EN61000-4-5: 1.2 us/50 us, 500 V voltage waveform Recommended external surge suppressor: Cambium Networks Model # C000000L033A		
Mean Time Between Failure		> 40 Years		
Environmental		IP66, IP67		
Temperature / Humidity		-40°C to +60°C (-40°F to +140°F), 0-95% non-condensing		

Weight	Connectorized	Approx. 2.0 kg (4.5 lbs)
	Integrated	Approx. 2.5 kg (5.5 lbs)
Wind Survival	Connectorized	322 km/h (200 mi/h)
	Integrated	200 km/h (124 mi/h)
Dimension(HxWxD)	Connectorized	26.0 x 13.4 x 6.4 cm (10.3″ x 5.3″ x 3.3″)
	Integrated	37.0 x 37.0 x 6.3 cm (14.5″ x 14.5″ x 3.2″)
Power Consumption		15 W typical, 25 W max, 55 W max with Aux port PoE out enabled
Input Voltage		48-59 V DC, 802.3at compliant
Mounting		Wall or Pole mount with Cambium Networks Model # N000045L002A
Security		
Encryption		56-bit DES, FIPS-197 128-bit AES

Specifications for PMP 450i SM

The PMP 450i SM conforms to the specifications listed in Table 203.

Table 203 PMP 450i SM specifications

Category		Specification
Model Number		PMP 450i SM
Spectrum		
Channel Spacing		5, 10 and 20 MHz Channel Bandwidth Configurable on 2.5 MHz increments
Frequency Range		4900 - 5925 MHz
Channel Bandwidth	4900 – 5925 MHz	5, 10 and 20 MHz
Interface		
MAC (Media Access Control) Layer		Cambium Proprietary
Physical Layer		2x2 MIMO OFDM
Ethernet Interface		10/100/1000BaseT, half/full duplex, rate auto negotiated (802.3 compliant)
Protocols Used		IPv4, UDP, TCP, IP, ICMP, Telnet, SNMP, HTTP, FTP
Network Management		HTTP, HTTPS, Telnet, FTP, SNMP v2c and v3
VLAN		802.1ad (DVLAN Q-in-Q), 802.1Q with 802.1p priority, dynamic port VID
Sensitivity		
Nominal Receive Sensitivity (w/ FEC) @ 5 MHz Channel	4.9 GHz	1x = -93 dBm, 2x = -88.5 dBm, 4x = -81.4 dBm, 6x = -75 dBm, 8x = -67.5 dBm
	5.4 GHz	1x = -93 dBm, 2x = -88.7 dBm, 4x = -82.4 dBm, 6x = -76.1 dBm, 8x = -68.5 dBm
	5.8 GHz	1x = -93 dBm, 2x = -89.6 dBm, 4x = -82.6 dBm, 6x = -76.4 dBm, 8x = -67 dBm
Nominal Receive Sensitivity (w/ FEC) @ 10 MHz Channel	4.9 GHz	1x = -89.7 dBm, 2x = -84.6 dBm, 4x = -78.6 dBm, 6x = -71.7 dBm, 8x = -65.7 dBm
	5.4 GHz	1x = -89.5 dBm, 2x = -86.3 dBm, 4x = -79.3 dBm, 6x = -73.1 dBm, 8x = -65.4 dBm

	5.8 GHz	1x = -90 dBm, 2x = -85.2 dBm, 4x = -78.7 dBm, 6x = -73 dBm, 8x = -65.2 dBm		
Nominal Receive Sensitivity (w/ FEC) @ 20 MHz Channel	4.9 GHz	1x = -86.8 dBm, 2x = -82 dBm, 4x = -75.7 dBm, 6x = -69.4 dBm, 8x = -62.7 dBm		
	5.4 GHz	1x = -86.1 dBm, 2x = -82.3 dBm, 4x = -76 dBm, 6x = -69.3 dBm, 8x = -62.3 dBm		
	5.8 GHz	1x = -87.5 dBm, 2x = -83.1 dBm, 4x = -76.3 dBm, 6x = -69.1 dBm, 8x = -61.3 dBm		
Performance				
ARQ		Yes		
Cyclic Prefix		1/16		
Frame Period		2.5 ms or 5.0 ms		
Modulation Levels (Adaptive)		Modulation Levels	MCS	SNR (in dB)
		2x	QPSK	10
		4x	16QAM	17
		6x	64QAM	24
		8x	256QAM	32
Latency		3 - 5 ms		
Maximum Deployment Range		Up to 40 miles (64 km)		
GPS Synchronization		Yes, via Autosync (CMM4)		
Quality of Service		Diffserv QoS		
Link Budget				
Antenna Beam Width		10° azimuth for 23 dBi integrated antenna		
Antenna Gain (Does not include cable loss, ~1dB)	5 GHz	+23 dBi H+V, integrated or external		
Transmit Power Range		40 dB dynamic range (to EIRP limit by region) (1 dB step)		
Maximum Transmit Power		+27 dBm combined output (for 5 GHz)		

Physical		
Sync/AUX port	RJ45	• 10/100/1000BASE-T Ethernet Data • PoE output (planned for future release) • Sync input or output (Connection and powering of UGPS Sync input)
Antenna Connection		50 ohm, N-type (Connectorized version only)
Surge Suppression EN61000-4-5		EN61000-4-5: 1.2us/50us, 500 V voltage waveform Recommended external surge suppressor: Cambium Networks Model # C000000L033A
Mean Time Between Failure		> 40 Years
Environmental		IP66, IP67
Temperature / Humidity		-40°C to +60°C (-40°F to +140°F), 0-95% non-condensing
Weight	Connectorized	Approx. 2.0 kg (4.5 lbs)
	Integrated	Approx. 2.5 kg (5.5 lbs)
Wind Survival	Connectorized	322 km/h (200 mi/h)
	Integrated	200 km/h (124 mi/h)
Dimension(HxWxD)	Connectorized	26.0 x 13.4 x 6.4 cm (10.3″ x 5.3″ x 3.3″)
	Integrated	31.0 x 31.0 x 6.4 cm (12″ x 12″ x 2.5″)
Power Consumption		15 W typical, 25 W max, 55 W max with Aux port PoE out enabled
Input Voltage		48-59 V DC, 802.3at compliant
Mounting		Wall or Pole mount with Cambium Networks Model # N000045L002A
Security		
Encryption		56-bit DES, FIPS-197 128-bit AES

Specifications for PTP 450i BH

The PTP 450i BH conforms to the specifications listed in Table 204.

Table 204 PTP 450i BH specifications

Category		Specification
Model Number		PMP 450i BH
Spectrum		
Channel Spacing		5, 10 and 20 MHz Channel Bandwidth Configurable on 2.5 MHz increments
Frequency Range		4900 - 5925 MHz
Channel Bandwidth		5, 10 and 20 MHz
Interface		
MAC (Media Access Control) Layer		Cambium Proprietary
Physical Layer		2x2 MIMO OFDM
Ethernet Interface		10/100/1000BaseT, half/full duplex, rate auto negotiated (802.3 compliant)
Protocols Used		IPv4, UDP, TCP, IP, ICMP, Telnet, SNMP, HTTP, FTP
Network Management		HTTP, HTTPS, Telnet, FTP, SNMP v2c and v3
VLAN		802.1ad (DVLAN Q-in-Q), 802.1Q with 802.1p priority, dynamic port VID
Sensitivity		
Nominal Receive Sensitivity (w/ FEC) @ 5 MHz Channel	4.9 GHz	1x = -92.7 dBm, 2x = -88.1 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -67.8 dBm
	5.4 GHz	1x = -92.4 dBm, 2x = -88.4 dBm, 4x = -81.3 dBm, 6x = -75.5 dBm, 8x = -67.8 dBm
	5.8 GHz	1x = -92.3 dBm, 2x = -87.5 dBm, 4x = -80.4 dBm, 6x = -74 dBm, 8x = -67.2 dBm
Nominal Receive Sensitivity (w/ FEC) @ 10 MHz Channel	4.9 GHz	1x = -89.2 dBm, 2x = -85.1 dBm, 4x = -77.8 dBm, 6x = -72 dBm, 8x = -64.9 dBm
	5.4 GHz	1x = -90 dBm, 2x = -85 dBm, 4x = -78.7 dBm, 6x = -71.6 dBm, 8x = -64.4 dBm
	5.8 GHz	1x = -89.9 dBm, 2x = -84.3 dBm, 4x = -78 dBm, 6x = -71.5 dBm, 8x = -64 dBm

Nominal Receive Sensitivity (w/ FEC) @ 20 MHz Channel	4.9 GHz	1x = -87.1 dBm, 2x = -82.1 dBm, 4x = -74.7 dBm, 6x = -69.2 dBm, 8x = -61.2 dBm		
	5.4 GHz	1x = -86 dBm, 2x = -81.6 dBm, 4x = -74.9 dBm, 6x = -68.4 dBm, 8x = -61 dBm		
	5.8 GHz	1x = -86.6 dBm, 2x = -80.4 dBm, 4x = -74.7 dBm, 6x = -68.5 dBm, 8x = -61 dBm		
Performance				
ARQ		Yes		
Cyclic Prefix		1/16		
Frame Period		2.5 ms or 5.0 ms		
Modulation Levels (Adaptive)		Modulation Levels	MCS	SNR (in dB)
		2x	QPSK	10
		4x	16QAM	17
		6x	64QAM	24
		8x	256QAM	32
Latency		3 - 5 ms		
Maximum Deployment Range		Up to 40 miles (64 km)		
GPS Synchronization		Yes, via Autosync (CMM4)		
Quality of Service		Diffserv QoS		
Link Budget				
Antenna Beam Width		10° azimuth for 23 dBi integrated antenna		
Antenna Gain (Does not include cable loss, ~1dB)	5 GHz	+23 dBi H+V, integrated or external		
Transmit Power Range		40 dB dynamic range (to EIRP limit by region) (1 dB step)		
Maximum Transmit Power		+27 dBm combined output		
Physical				
Sync/AUX port	RJ45	• 10/100/1000BASE-T Ethernet Data • PoE output • Sync input or output (Connection and powering of		

		UGPS Sync input)
Antenna Connection		50 ohm, N-type (Connectorized version only)
Surge Suppression EN61000-4-5		EN61000-4-5: 1.2us/50us, 500 V voltage waveform Recommended external surge suppressor: Cambium Networks Model # C000000L033A
Mean Time Between Failure		> 40 Years
Environmental		IP66, IP67
Temperature / Humidity		-40°C to +60°C (-40°F to +140°F), 0-95% non-condensing
Weight	Connectorized	Approx. 2.0 kg (4.5 lbs)
	Integrated	Approx. 2.5 kg (5.5 lbs)
Wind Survival	Connectorized	322 km/h (200 mi/h)
	Integrated	200 km/h (124 mi/h)
Dimension(HxWxD)	Connectorized	26.0 x 13.4 x 6.4 cm (10.25″ x 5.25″ x 3.25″)
	Integrated	31.0 x 31.0 x 6.4 cm (12″ x 12″ x 2.5″)
Power Consumption		15 W typical, 25 W max, 55 W max with Aux port PoE out enabled
Input Voltage		48-59 V DC, 802.3at compliant
Mounting		Wall or Pole mount with Cambium Networks Model # N000045L002A
Security		
Encryption		56-bit DES, FIPS-197 128-bit AES

Specifications for PMP 450 AP

The PMP 450 AP conforms to the specifications listed in Table 205.

Table 205 PMP 450 AP specifications

Category		Specification
Model Number		PMP 450 AP
Spectrum		
Channel Spacing		5, 10 and 20 MHz Channel Bandwidth Configurable on 2.5 MHz increments
Frequency Range	2.4 GHz	2400 – 2483.5 MHz
	3.5 GHz	3300 – 3600 MHz
	3.65 GHz	3500 – 3850 MHz
	5 GHz	5470 – 5875 MHz
Channel Bandwidth	3.5 and 3.65 GHz	5, 7, 10 and 20 MHz
	2.4 and 5 GHz	5, 10 and 20 MHz
OFDM Subcarriers		512 FFT
Interface		
MAC (Media Access Control) Layer		Cambium Proprietary
Physical Layer		2x2 MIMO OFDM
Ethernet Interface		10/100 BaseT, half/full duplex, rate auto negotiated (802.3 compliant)
Protocols Used		IPv4, UDP, TCP, IP, ICMP, Telnet, SNMP, HTTP, FTP
Network Management		HTTP, HTTPS, Telnet, FTP, SNMP v3
VLAN		802.1ad (DVLAN Q-in-Q), 802.1Q with 802.1p priority, dynamic port VID
Sensitivity		
Nominal Receive Sensitivity (w/ FEC) @ 5 MHz Channel	2.4 GHz	1x = -91 dBm, 2x = -91 dBm, 4x = -85 dBm, 6x = -78 dBm, 8x = -70 dBm
	3.5 GHz	1x = -92 dBm, 2x = -92 dBm, 4x = -86 dBm, 6x = -79

		dBm, 8x = -71 dBm
	3.65 GHz	1x = -90 dBm, 2x = -90 dBm, 4x = -83 dBm, 6x = -76 dBm, 8x = -68 dBm
	5.4 GHz	1x = -89 dBm, 2x = -89 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -66 dBm
	5.8 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -65 dBm
Nominal Receive Sensitivity (w/ FEC) @ 7 MHz Channel	3.5 GHz	1x = -90 dBm, 2x = -90 dBm, 4x = -83 dBm, 6x = -77 dBm, 8x = -71 dBm
	3.65 GHz	1x = -89 dBm, 2x = -89 dBm, 4x = -82 dBm, 6x = -75 dBm, 8x = -67 dBm
Nominal Receive Sensitivity (w/ FEC) @ 10 MHz Channel	2.4 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -69 dBm
	3.5 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -76 dBm, 8x = -68 dBm
	3.65 GHz	1x = -86 dBm, 2x = -86 dBm, 4x = -80 dBm, 6x = -73 dBm, 8x = -66 dBm
	5.4 GHz	1x = -84 dBm, 2x = -84 dBm, 4x = -78 dBm, 6x = -72 dBm, 8x = -63 dBm
	5.8 GHz	1x = -84 dBm, 2x = -84 dBm, 4x = -77 dBm, 6x = -71 dBm, 8x = -63 dBm
Nominal Receive Sensitivity (w/ FEC) @ 20 MHz Channel	2.4 GHz	1x = -85 dBm, 2x = -85 dBm, 4x = -79 dBm, 6x = -72 dBm, 8x = -66 dBm
	3.5 GHz	1x = -85 dBm, 2x = -85 dBm, 4x = -79 dBm, 6x = -72 dBm, 8x = -65 dBm
	3.65 GHz	1x = -86 dBm, 2x = -86 dBm, 4x = -78 dBm, 6x = -71 dBm, 8x = -63 dBm
	5.4 GHz	1x = -81 dBm, 2x = -81 dBm, 4x = -75 dBm, 6x = -68 dBm, 8x = -59 dBm
	5.8 GHz	1x = -82 dBm, 2x = -82 dBm, 4x = -75 dBm, 6x = -69 dBm, 8x = -60 dBm
Performance		
Subscribers Per Sector		Up to 238
ARQ		Yes

Cyclic Prefix		1/16		
Frame Period		2.5 ms or 5.0 ms		
Modulation Levels (Adaptive)		Modulation Levels	MCS	SNR (in dB)
		2x	QPSK	10
		4x	16QAM	17
		6x	64QAM	24
		8x	256QAM	32
Latency		3 - 5 ms for 2.5 ms Frame Period 6-10 ms for 5.0 ms Frame Period		
Maximum Deployment Range		Up to 40 miles (64 km)		
Packets Per Second		12,500		
GPS Synchronization		Yes, via CMM3, CMM4 or UGPS		
Quality of Service		Diffserv QoS		
Link Budget				
Antenna Gain (Does not include cable loss, ~1dB)	2.4 GHz	18 dBi Dual Slant		
	3.5 GHz	16 dBi Dual Slant		
	3.65 GHz	16 dBi Dual Slant		
	5 GHz	17 dBi Horizontal and Vertical		
Combined Transmit Power		-30 to +22 dBm (to EIRP limit by region) in 1 dB-configurable intervals (2.4 GHz, 5 GHz) -30 to +25 dBm (to EIRP limit by region) in 1 dB-configurable intervals (3.5 GHz) -30 to +25 dBm (to EIRP limit by region and channel bandwidth) in 1 dB-configurable intervals (3.6 GHz)		
Maximum Transmit Power		22 dBm combined OFDM (2.4 GHz, 5 GHz) (dependent upon Region Code setting) 25 dBm combined OFDM (3.5 GHz, 3.6 GHz), (dependent upon Region Code setting)		
Physical				
Wind Survival	2.4 GHz	216 km/hour (135 mi/hour)		

	3.5 GHz	216 km/hour (135 mi/hour)
	3.65 GHz	216 km/hour (135 mi/hour)
	5 GHz	190 km/hour (118 mi/hour)
Antenna Connection		50 ohm, N-type (Connectorized version only)
Environmental		IP66, IP67
Temperature / Humidity		-40°C to +60°C (-40°F to +140°F) / 0-95% non-condensing
Weight	2.4 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	3.5 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	3.6 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	5 GHz	5.9 kg (13 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
Dimension(HxWxD)	2.4 GHz	Radio: 27 x 21 x 7 cm (10.6″ x 8.3″ x 2.8″) Antenna: 112.2 x 24.5 x 11.7 cm (44.2″ x 9.6″ x 4.6″)
	3.5 GHz	
	3.6 GHz	
	5 GHz	Radio: 27 x 21 x 7 cm (10.6″ x 8.3″ x 2.8″) Antenna: 51 x 13 x 7.3 cm (20.2″ x 5.1″ x 2.9″)
Power Consumption		14 W
Input Voltage		22 to 32 VDC
Security		
Encryption		56-bit DES, AES

Specifications for PMP 450 SM

The PMP 450 SM conforms to the specifications listed in Table 206.

Table 206 PMP 450 SM specifications

Category		Specification
Model Number		PMP 450 SM
Spectrum		
Channel Spacing		5, 7, 10 and 20 MHz Channel Bandwidth Configurable on 2.5 MHz increments
Frequency Range	900 MHz	902 – 928 MHz
	2.4 GHz	2400 – 2483.5 MHz
	3.5 GHz	3300 – 3600 MHz
	3.65 GHz	3500 – 3850 MHz
	5 GHz	5470 – 5875 MHz
Channel Bandwidth	900 MHz, 3.5 GHz and 3.65 GHz	5, 7, 10 and 20 MHz
	2.4 and 5 GHz	5, 10 and 20 MHz
OFDM Subcarriers		512 FFT
Interface		
MAC (Media Access Control) Layer		Cambium Proprietary
Physical Layer		2x2 MIMO OFDM
Ethernet Interface		10/100 BaseT, half/full duplex, rate auto negotiated (802.3 compliant)
Protocols Used		IPv4, UDP, TCP, IP, ICMP, Telnet, SNMP, HTTP, FTP
Network Management		HTTP, HTTPS, Telnet, FTP, SNMP v3
VLAN		802.1ad (DVLAN Q-in-Q), 802.1Q with 802.1p priority, dynamic port VID
Sensitivity		
Nominal Receive Sensitivity (w/ FEC) @	900 MHz	1x = -91 dBm, 2x = -91 dBm, 4x = -85 dBm, 6x = -78 dBm, 8x = -70 dBm

5 MHz Channel	2.4 GHz	1x = -91 dBm, 2x = -91 dBm, 4x = -85 dBm, 6x = -78 dBm, 8x = -70 dBm
	3.5 GHz	1x = -92 dBm, 2x = -92 dBm, 4x = -86 dBm, 6x = -79 dBm, 8x = -71 dBm
	3.65 GHz	1x = -90 dBm, 2x = -90 dBm, 4x = -83 dBm, 6x = -76 dBm, 8x = -68 dBm
	5.4 GHz	1x = -89 dBm, 2x = -89 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -66 dBm
	5.8 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -65 dBm
Nominal Receive Sensitivity (w/ FEC) @ 7 MHz Channel	900 MHz	1x = -91 dBm, 2x = -84 dBm, 4x = -83 dBm, 6x = -77 dBm, 8x = -71 dBm
	3.5 GHz	1x = -90 dBm, 2x = -90 dBm, 4x = -83 dBm, 6x = -77 dBm, 8x = -71 dBm
	3.65 GHz	1x = -89 dBm, 2x = -89 dBm, 4x = -82 dBm, 6x = -75 dBm, 8x = -67 dBm
Nominal Receive Sensitivity (w/ FEC) @ 10 MHz Channel	900 MHz	1x = -90 dBm, 2x = -83 dBm, 4x = -80 dBm, 6x = -74 dBm, 8x = -68 dBm
	2.4 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -75 dBm, 8x = -69 dBm
	3.5 GHz	1x = -88 dBm, 2x = -88 dBm, 4x = -81 dBm, 6x = -76 dBm, 8x = -68 dBm
	3.65 GHz	1x = -86 dBm, 2x = -86 dBm, 4x = -80 dBm, 6x = -73 dBm, 8x = -66 dBm
	5.4 GHz	1x = -84 dBm, 2x = -84 dBm, 4x = -78 dBm, 6x = -72 dBm, 8x = -63 dBm
	5.8 GHz	1x = -84 dBm, 2x = -84 dBm, 4x = -77 dBm, 6x = -71 dBm, 8x = -63 dBm
Nominal Receive Sensitivity (w/ FEC) @ 20 MHz Channel	900 MHz	1x = -87 dBm, 2x = -80 dBm, 4x = -77 dBm, 6x = -72 dBm, 8x = -65 dBm
	2.4 GHz	1x = -85 dBm, 2x = -85 dBm, 4x = -79 dBm, 6x = -71 dBm, 8x = -62 dBm
	3.5 GHz	1x = -85 dBm, 2x = -85 dBm, 4x = -79 dBm, 6x = -72 dBm, 8x = -65 dBm
	3.65 GHz	1x = -86 dBm, 2x = -86 dBm, 4x = -78 dBm, 6x = -71 dBm, 8x = -63 dBm
	5.4 GHz	1x = -81 dBm, 2x = -81 dBm, 4x = -75 dBm, 6x = -68

		dBm, 8x = -59 dBm		
	5.8 GHz	1x = -82 dBm, 2x = -82 dBm, 4x = -75 dBm, 6x = -69 dBm, 8x = -60 dBm		
Performance				
Subscribers Per Sector		Up to 238		
ARQ		Yes		
Cyclic Prefix		1/16		
Frame Period		2.5 ms or 5.0 ms		
Modulation Levels (Adaptive)		Modulation Levels	MCS	SNR (in dB)
		2x	QPSK	10
		4x	16QAM	17
		6x	64QAM	24
		8x	256QAM	32
Latency		3 - 5 ms for 2.5 ms Frame Period 6-10 ms for 5.0 ms Frame Period		
Maximum Deployment Range		Up to 40 miles (64 km)		
GPS Synchronization		Yes		
Quality of Service		Diffserv QoS		
Link Budget				
Antenna Gain (Does not include cable loss, ~1dB)	900 MHz	12 dBi Yagi antenna		
	2.4 GHz	7 dBi Dual Slant, integrated patch		
	3.5 GHz	8 dBi Dual Slant, integrated patch		
	3.65 GHz	8 dBi Dual Slant, integrated patch		
	5 GHz	9 dBi H+V, integrated patch		
Combined Transmit Power		-30 to +22 dBm (to EIRP limit by region) – 2.4 GHz, 5 GHz -30 to +25 dBm (to EIRP limit by region) – 3.5 GHz, 3.6 GHz		
Maximum Transmit Power		22 dBm combined OFDM (2.4 GHz, 5 GHz) (dependent upon Region Code setting)		

		25 dBm combined OFDM (900 MHz, 3.5 GHz, 3.6 GHz), (dependent upon Region Code setting)
Reflector antenna gain	2.4 GHz	+12 dBi
	3.5 GHz	+11 dBi
	3.65 GHz	+11 dBi
	5 GHz	+15 dBi
Other antenna (5 GHz only)	CLIP Gain	+8 dBi
	LENS Gain	+5.5 dBi
	Dish	+17 dBi
Physical		
Wind Survival		190 km/hour (118 mi/hour)
Antenna Connection		50 ohm, N-type (Connectorized version only)
Environmental		IP55
Temperature / Humidity		-40°C to +60°C (-40°F to +140°F) / 0-95% non-condensing
Weight	2.4 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	3.5 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	3.6 GHz	15 kg (33 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
	5 GHz	5.9 kg (13 lbs) with antenna 2.5 kg (5.5 lbs) without antenna
Dimensions (H x W x D)		30 x 9 x 9 cm (11.75" x 3.4" x 3.4")
Power Consumption		12 W
Input Voltage		20 to 32 VDC
Security		
Encryption		56-bit DES, AES

PSU specifications

The PMP/PTP 450i AC+DC Enhanced Power Injector conforms to the specifications listed in Table 207.

Table 207 PMP/PTP 450i AC power Injector specifications

Category	Specification
Dimensions	137 mm (5.4 in) x 56 mm (2.2 in) x 38 mm (1.5 in)
Weight	0.240 Kg (0.5 lbs)
Temperature	0°C to +40°C
Humidity	90% non-condensing
Waterproofing	Not waterproof
Altitude	Sea level to 5000 meters (16000 ft)
AC Input	Min 90 V AC, 57 – 63 Hz, max 264 V AC, 47 – 53 Hz.
DC output voltage to the ODU	55V +/- 5%
AC connector	IEC-320-C8
Efficiency	Better than 85%, efficiency level 'V'
Over Current Protection	Hiccup current limiting, trip point set between 120% to 150% of full load current
Hold up time	At least 10 milliseconds

Warning

Do not use above PSU to power up other than 450 platform radios.

The PMP/PTP 450 power supply conforms to the specifications listed in Table 208.

Table 208 PMP/PTP 450 power supply specifications (part number: N000900L001A)

Category	Specification
Dimensions	118 mm (4.66 in) x 45 mm (1.75 in) x 32 mm (1.25 in)
Weight	0.240 Kg (0.5 lbs)
Temperature	0°C to +40°C
Humidity	20 to 90%
AC Input	90-264 VAC, 47 – 63 Hz, 0.5 A rms at 120 VAC, 0.25 A rms at 240 VAC.

DC output voltage to the ODU	30 V ± 5%
AC connector	IEC-320-C8
Efficiency	Better than 85%, efficiency level 'V'
Over Current Protection	Short circuit, with auto recovery; Should restart between every 0.5 to 2 sec.
Hold up time	10mS min at max load, 120VAC

Note

The 30V PSU (part number: #N000900L001A) has to be used for PMP 450 900 MHz SM.

Data network specifications

This section contains specifications of the PMP/PTP 450 platform Ethernet interface.

Ethernet interface

PMP/PTP 450i

The PMP/PTP 450i Ethernet port conforms to the specifications listed in Table 209.

Table 209 PMP/PTP 450i Main and Aux Ethernet bridging specifications

Ethernet Bridging	Specification
Protocol	IEEE 802.3 compatible
QoS	IEEE 802.1p, IEEE 802.1Q, IEEE 802.1ad, DSCP IPv4
Main Ethernet port	10/100/1000 BaseT, half/full duplex, rate auto negotiated
Aux Ethernet port	10/100 BaseT, half/full duplex, rate auto negotiated
Maximum Ethernet Frame Size	1700 Bytes

PMP/PTP 450

Table 210 PMP/PTP 450 Ethernet bridging specifications

Ethernet Bridging	Specification
Protocol	IEEE 802.3 compatible
QoS	IEEE 802.1p, IEEE 802.1Q, IEEE 802.1ad, DSCP IPv4
Interface	10/100/1000 BaseT, half/full duplex, rate auto negotiated
Maximum Ethernet Frame Size	1700 Bytes

Note

Practical Ethernet rates depend on network configuration, higher layer protocols and platforms used.

Over the air throughput is restricted to the rate of the Ethernet interface at the receiving end of the link.

Wireless specifications

This section contains specifications of the PMP/PTP 450 platform wireless interface. These specifications include RF bands, channel bandwidth, spectrum settings, maximum power and link loss.

General wireless specifications

The wireless specifications that apply to all PMP/PTP 450 platform variants are listed under Table 211.

Table 211 PMP/PTP 450 platform wireless specifications

Item	Specification		
Channel selection	Manual selection (fixed frequency).		
Manual power control	To avoid interference to other users of the band, maximum power can be set lower than the default power limit.		
Duplex scheme	Adaptive TDD		
Range	Band	Platform	Range
	900 MHz	PMP 450i AP PMP 450 SM	40 mi / 64 km
	2.4 GHz	PMP 450	40 mi / 64 km
	3.5 GHz	PMP/PTP 450	40 mi / 64 km
	3.65 GHz	PMP/PTP 450	40 mi / 64 km
	5 GHz	PMP/PTP 450 and 450i	40 mi / 64 km
Over-the-air encryption	DES, AES		
Error Correction	Rate 3/4 RS coder		

Link Range

Example of the link ranges for PMP and PTP modes are provided in below tables. These assume the transmit power is not limited by the country of operation for the selected band.

PMP 450i

Table 212 Link range – PMP 5.8 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 17 dBi at AP and 23 dBi at the SM

Parameter	Range Details (km)				
	1x	2x	4x	6x	8x
Modulation	QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	239.6	68.3	35.4	16.8	6.7
Max. nLOS (additional 5 dB link loss)	134.8	38.4	19.9	9.4	3.8
Max. NLOS1 (additional 15 dB link loss)	42.6	12.1	6.3	3.0	1.2
Max. NLOS2 (additional 25 dB link loss)	13.5	3.8	2.0	0.9	0.4

PTP 450i

Table 213 Link range – PTP 5.8 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 23 dBi at each end

Parameter	Range Details (km)				
	1x	2x	4x	6x	8x
Modulation	QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	239.6	136.3	70.7	33.5	13.3
Max. nLOS (additional 5 dB link loss)	134.8	76.7	39.8	18.8	7.5
Max. NLOS1 (additional 15 dB link loss)	42.6	24.2	12.6	6.0	2.4
Max. NLOS2 (additional 25 dB link loss)	13.5	7.7	4.0	1.9	0.7

PMP 450

Table 214 Link range – PMP 5.8 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 17 dBi at AP

Parameter	SM type	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	Integrated	7.0 mi / 11.3 km	5.0 mi / 8.0 km	2.3 mi / 3.6 km	1.1 mi / 1.8 km	0.4 mi / 0.6 km
	Integrated Dish (+17 dB) SM 450d	40.0 mi / 64.0 km	31.5 mi / 50.4 km	14.2 mi / 22.8 km	7.1 mi / 11.4 km	2.5 mi / 4.0 km
	CLIP (+8 dB)	19.9 mi / 31.8 km	14.1 mi / 22.5 km	6.4 mi / 10.2 km	3.2 mi / 5.1 km	1.1 mi / 1.8 km
	Reflector Dish (+16 dB)	40.0 mi / 64.0 km	31.5 mi / 50.4 km	14.2 mi / 22.8 km	7.1 mi / 11.4 km	2.5 mi / 4.0 km
Max. nLOS (additional 5 dB link loss)	Integrated	4.0 mi / 6.3 km	2.8 mi / 4.5 km	1.3 mi / 2.0 km	0.6 mi / 1.0 km	0.2 mi / 0.4 km
	Integrated Dish (+17 dB) SM 450d	25.0 mi / 40.0 km	17.7 mi / 28.3 km	8.0 mi / 12.8 km	4.0 mi / 6.4 km	1.4 mi / 2.2 km
	CLIP (+8 dB)	11.2 mi / 17.9 km	7.9 mi / 12.7 km	3.6 mi / 5.7 km	1.8 mi / 2.9 km	0.6 mi / 1.0 km
	Reflector Dish (+16 dB)	25.0 mi / 40.0 km	17.7 mi / 28.3 km	8.0 mi / 12.8 km	4.0 mi / 6.4 km	1.4 mi / 2.2 km
Max. NLOS1 (additional 15 dB link loss)	Integrated	1.3 mi / 2.0 km	0.9 mi / 1.4 km	0.4 mi / 0.6 km	0.2 mi / 0.3 km	0.1 mi / 0.1 km
	Integrated Dish (+17 dB) SM 450d	7.9 mi / 12.7 km	5.6 mi / 9.0 km	2.5 mi / 4.0 km	1.3 mi / 2.0 km	0.4 mi / 0.7 km
	CLIP (+8 dB)	3.5 mi / 5.7 km	2.5 mi / 4.0 km	1.1 mi / 1.8 km	0.6 mi / 0.9 km	0.2 mi / 0.3 km
	Reflector Dish (+16 dB)	7.9 mi / 12.7 km	5.6 mi / 9.0 km	2.5 mi / 4.0 km	1.3 mi / 2.0 km	0.4 mi / 0.7 km
Max. NLOS2 (additional 25 dB link loss)	Integrated	0.4 mi / 0.6 km	0.3 mi / 0.4 km	0.1 mi / 0.2 km	0.1 mi / 0.1 km	0.0 mi / 0.0 km
	Integrated Dish (+17 dB) SM 450d	2.5 mi / 4.0 km	1.8 mi / 2.8 km	0.8 mi / 1.3 km	0.4 mi / 0.6 km	0.1 mi / 0.2 km
	CLIP	1.1 mi /	0.8 mi /	0.4 mi /	0.2 mi /	0.1 mi /

	(+8 dB)	1.8 km	1.3 km	0.6 km	0.3 km	0.1 km
	Reflector Dish (+16 dB)	2.5 mi / 4.0 km	1.8 mi / 2.8 km	0.8 mi / 1.3 km	0.4 mi / 0.6 km	0.1 mi / 0.2 km

Table 215 Link range – PMP 5.4 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 17 dBi at AP

Parameter	SM type	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	Integrated	6.6 mi / 10.6 km	4.7 mi / 7.5 km	2.4 mi / 3.9 km	1.0 mi / 1.6 km	0.4 mi / 0.6 km
	Integrated Dish (+17 dB) SM 450d	40.0 mi / 64.0 km	29.5 mi / 47.2 km	15.2 mi / 24.3 km	6.5 mi / 10.4 km	2.3 mi / 3.7 km
	CLIP (+8 dB)	16.6 mi / 26.5 km	11.7 mi / 18.8 km	6.1 mi / 9.7 km	2.6 mi / 4.1 km	0.9 mi / 1.5 km
	Reflector Dish (+16 dB)	40.0 mi / 64.0 km	29.5 mi / 47.2 km	15.2 mi / 24.3 km	6.5 mi / 10.4 km	2.3 mi / 3.7 km
Max. nLOS (additional 5 dB link loss)	Integrated	3.7 mi / 5.9 km	2.6 mi / 4.2 km	1.4 mi / 2.2 km	0.6 mi / 0.9 km	0.2 mi / 0.3 km
	Integrated Dish (+17 dB) SM 450d	23.4 mi / 37.5 km	16.6 mi / 26.5 km	8.6 mi / 13.7 km	3.7 mi / 5.9 km	1.3 mi / 2.1 km
	CLIP (+8 dB)	9.3 mi / 14.9 km	6.6 mi / 10.6 km	3.4 mi / 5.4 km	1.5 mi / 2.3 km	0.5 mi / 0.8 km
	Reflector Dish (+16 dB)	23.4 mi / 37.5 km	16.6 mi / 26.5 km	8.6 mi / 13.7 km	3.7 mi / 5.9 km	1.3 mi / 2.1 km
Max. NLOS1 (additional 15 dB link loss)	Integrated	1.2 mi / 1.9 km	0.8 mi / 1.3 km	0.4 mi / 0.7 km	0.2 mi / 0.3 km	0.1 mi / 0.1 km
	Integrated Dish (+17 dB) SM 450d	7.4 mi / 11.9 km	5.2 mi / 8.4 km	2.7 mi / 4.3 km	1.2 mi / 1.9 km	0.4 mi / 0.7 km
	CLIP (+8 dB)	2.9 mi / 4.7 km	2.1 mi / 3.3 km	1.1 mi / 1.7 km	0.5 mi / 0.7 km	0.2 mi / 0.3 km
	Reflector Dish (+16 dB)	7.4 mi / 11.9 km	5.2 mi / 8.4 km	2.7 mi / 4.3 km	1.2 mi / 1.9 km	0.4 mi / 0.7 km
Max. NLOS2 (additional 25 dB	Integrated	0.4 mi / 0.6 km	0.3 mi / 0.4 km	0.1 mi / 0.2 km	0.1 mi / 0.1 km	0.0 mi / 0.0 km

link loss)	Integrated Dish (+17 dB) SM 450d	2.3 mi / 3.7 km	1.7 mi / 2.7 km	0.9 mi / 1.4 km	0.4 mi / 0.6 km	0.1 mi / 0.2 km
	CLIP (+8 dB)	0.9 mi / 1.5 km	0.7 mi / 1.1 km	0.3 mi / 0.5 km	0.1 mi / 0.2 km	0.1 mi / 0.1 km
	Reflector Dish (+16 dB)	2.3 mi / 3.7 km	1.7 mi / 2.7 km	0.9 mi / 1.4 km	0.4 mi / 0.6 km	0.1 mi / 0.2 km

Table 216 Link range – PMP 2.4 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 18 dBi at AP

Parameter	SM type	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	Integrated	22.1 mi / 35.4 km	15.7 mi / 25.1 km	7.6 mi / 12.1 km	3.6 mi / 5.7 km	1.7 mi / 2.8 km
	Reflector Dish (+12 dB)	40.0 mi / 64.0 km	40.0 mi / 64.0 km	30.2 mi / 48.4 km	14.3 mi / 22.9 km	6.8 mi / 11.0 km
Max. nLOS (additional 5 dB link loss)	Integrated	12.5 mi / 19.9 km	8.8 mi / 14.1 km	4.3 mi / 6.8 km	2.0 mi / 3.2 km	1.0 mi / 1.5 km
	Reflector Dish (+12 dB)	40.0 mi / 64.0 km	35.1 mi / 56.2 km	17.0 mi / 27.2 km	8.0 mi / 12.9 km	3.8 mi / 6.2 km
Max. NLOS1 (additional 15 dB link loss)	Integrated	3.9 mi / 6.3 km	2.8 mi / 4.5 km	1.3 mi / 2.2 km	0.6 mi / 1.0 km	0.3 mi / 0.5 km
	Reflector Dish (+12 dB)	15.7 mi / 25.1 km	11.1 mi / 17.8 km	5.4 mi / 8.6 km	2.5 mi / 4.1 km	1.2 mi / 1.9 km
Max. NLOS2 (additional 25 dB link loss)	Integrated	1.2 mi / 2.0 km	0.9 mi / 1.4 km	0.4 mi / 0.7 km	0.2 mi / 0.3 km	0.1 mi / 0.2 km
	Reflector Dish (+12 dB)	5.0 mi / 7.9 km	3.5 mi / 5.6 km	1.7 mi / 2.7 km	0.8 mi / 1.3 km	0.4 mi / 0.6 km

Table 217 Link range – PMP 3.5 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 16 dBi at AP

Parameter	SM type	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	Integrated	18.7 mi / 29.9 km	13.2 mi / 21.1 km	6.5 mi / 10.5 km	2.9 mi / 4.7 km	1.0 mi / 1.6 km
	Reflector Dish (+11 dB)	40.0 mi / 64.0 km	40.0 mi / 64.0 km	23.2 mi / 37.2 km	10.4 mi / 16.6 km	3.6 mi / 5.8 km
Max. nLOS (additional 5 dB link loss)	Integrated	10.5 mi / 16.8 km	7.4 mi / 11.9 km	3.7 mi / 5.9 km	1.6 mi / 2.6 km	0.6 mi / 0.9 km
	Reflector Dish (+11 dB)	37.3 mi / 59.6 km	26.4 mi / 42.2 km	13.1 mi / 20.9 km	5.8 mi / 9.3 km	2.0 mi / 3.3 km
Max. NLOS1 (additional 15 dB link loss)	Integrated	3.3 mi / 5.3 km	2.4 mi / 3.8 km	1.2 mi / 1.9 km	0.5 mi / 0.8 km	0.2 mi / 0.3 km
	Reflector Dish (+11 dB)	11.8 mi / 18.8 km	8.3 mi / 13.3 km	4.1 mi / 6.6 km	1.8 mi / 3.0 km	0.6 mi / 1.0 km
Max. NLOS2 (additional 25 dB link loss)	Integrated	1.0 mi / 1.7 km	0.7 mi / 1.2 km	0.4 mi / 0.6 km	0.2 mi / 0.3 km	0.1 mi / 0.1 km
	Reflector Dish (+11 dB)	3.7 mi / 6.0 km	2.6 mi / 4.2 km	1.3 mi / 2.1 km	0.6 mi / 0.9 km	0.2 mi / 0.3 km

Table 218 Link range – PMP 3.5 GHz link, 20 MHz Channel Bandwidth, 2.5 ms frame duration, antenna gain of 16 dBi at AP

Parameter	SM type	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
Max. LOS (no fade margin)	Integrated	20.3 mi / 32.5 km	14.4 mi / 23.0 km	5.7 mi / 9.2 km	2.6 mi / 4.1 km	0.8 mi / 1.3 km
	Reflector Dish (+11 dB)	40.0 mi / 64.0 km	40.0 mi / 64.0 km	20.3 mi / 32.5 km	9.1 mi / 14.5 km	2.9 mi / 4.6 km
Max. nLOS (additional 5 dB link loss)	Integrated	11.4 mi / 18.3 km	8.1 mi / 12.9 km	3.2 mi / 5.1 km	1.4 mi / 2.3 km	0.5 mi / 0.7 km
	Reflector Dish (+11 dB)	40.0 mi / 64.0 km	28.7 mi / 45.9 km	11.4 mi / 18.3 km	5.1 mi / 8.2 km	1.6 mi / 2.6 km

Max. NLOS1 (additional 15 dB link loss)	Integrated	3.6 mi / 5.8 km	2.6 mi / 4.1 km	1.0 mi / 1.6 km	0.5 mi / 0.7 km	0.1 mi / 0.2 km
	Reflector Dish (+11 dB)	12.8 mi / 20.5 km	9.1 mi / 14.5 km	3.6 mi / 5.8 km	1.6 mi / 2.6 km	0.5 mi / 0.8 km
Max. NLOS2 (additional 25 dB link loss)	Integrated	1.1 mi / 1.8 km	0.8 mi / 1.3 km	0.3 mi / 0.5 km	0.1 mi / 0.2 km	0.0 mi / 0.1 km
	Reflector Dish (+11 dB)	4.1 mi / 6.5 km	2.9 mi / 4.6 km	1.1 mi / 1.8 km	0.5 mi / 0.8 km	0.2 mi / 0.3 km

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Table 219 Link range –20 MHz Channel Bandwidth, 2.5 ms frame duration, same antenna gain for BHM and BHS

Parameter	BHS	Range Details (mi / km)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
5.8 GHz Max. LOS (no fade margin)	Integrated	3.6 mi / 5.7 km	2.5 mi / 4.0 km	1.3 mi / 2.0 km	0.6 mi / 0.9 km	0.2 mi / 0.3 km
	Reflector Dish (+16 dB)	22.5 mi / 36.1 km	16.0 mi / 25.5 km	8.0 mi / 12.8 km	3.6 mi / 5.7 km	1.1 mi / 1.8 km
5.4 GHz Max. LOS (no fade margin)	Integrated	3.7 mi / 5.9 km	2.6 mi / 4.2 km	1.3 mi / 2.1 km	0.6 mi / 0.9 km	0.2 mi / 0.3 km
	Reflector Dish (+16 dB)	23.2 mi / 37.0 km	16.4 mi / 26.2 km	8.2 mi / 13.1 km	3.7 mi / 5.9 km	1.1 mi / 1.8 km
3.65 GHz Max. LOS (no fade margin)	Integrated	7.6 mi / 12.2 km	5.4 mi / 8.6 km	2.7 mi / 4.3 km	1.2 mi / 1.9 km	0.4 mi / 0.6 km
	Reflector Dish (+11 dB)	27.1 mi / 43.3 km	19.2 mi / 30.7 km	9.6 mi / 15.4 km	4.3 mi / 6.9 km	1.4 mi / 2.2 km
3.5 GHz Max. LOS (no fade margin)	Integrated	8.8 mi / 14.1 km	6.3 mi / 10.0 km	2.9 mi / 4.6 km	1.4 mi / 2.2 km	0.5 mi / 0.7 km
	Reflector Dish (+11 dB)	31.3 mi / 50.2 km	22.2 mi / 35.5 km	10.1 mi / 16.2 km	4.9 mi / 7.9 km	1.6 mi / 2.6 km

Throughput

Example of the link budget for PMP and PTP modes are provided in below listed tables. These assumes the transmit power is not limited by the country of operation for the selected band.

PMP 450

Table 220 Link Budget – PMP 450, 1/16 Cyclic Prefix, 2.5 ms Frame Duration, 75/25 % DL/UL Ratio, AP connected to one SM

Parameter	Channel BW	Throughput (Mbps)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
5.8 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	16.2	32.4	64.7	97.1	129.5
	10 MHz Channel: (up+down)	6.9	13.9	27.9	41.8	55.7
	5 MHz Channel: (up+down)	2.2	4.5	9	13.5	18.1
5.4 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	16.2	32.4	64.7	97.1	129.5
	10 MHz Channel: (up+down)	6.9	13.9	27.9	41.8	55.7
	5 MHz Channel: (up+down)	2.2	4.5	9	13.5	18.1
3.65 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	16.6	33.2	66.4	99.5	132.7
	10 MHz Channel: (up+down)	7.1	14.3	28.7	43	57.3
	7 MHz Channel: (up+down)	4.5	9.1	18	27.1	36
	5 MHz Channel: (up+down)	2.4	4.9	9.9	14.7	19.7
3.5 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	16.6	33.2	66.4	99.5	132.7
	10 MHz Channel: (up+down)	7.1	14.3	28.7	43	57.3
	7 MHz Channel: (up+down)	4.5	9.1	18	27.1	36

	5 MHz Channel: (up+down)	2.4	4.9	9.9	14.7	19.7
2.4 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	16.2	32.4	64.7	97.1	129.5
	10 MHz Channel: (up+down)	6.9	13.9	27.9	41.8	55.7
	5 MHz Channel: (up+down)	2.2	4.5	9	13.5	18.1

PTP 450

Table 221 Link Budget – PTP 450, 1/16 Cyclic Prefix, 2.5 ms Frame Duration, 75/25 % DL/UL Ratio

Parameter	Channel BW	Throughput (Mbps)				
		1x	2x	4x	6x	8x
Modulation→		QPSK-MIMO-A	QPSK-MIMO-B	16QAM-MIMO-B	64QAM-MIMO-B	256QAM-MIMO-B
5.8 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	17	34	68	102	136
	10 MHz Channel: (up+down)	7.5	15.2	30.3	45.5	60.6
	5 MHz Channel: (up+down)	2.8	5.7	11.5	17.2	23
5.4 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	17	34	68	102	136
	10 MHz Channel: (up+down)	7.5	15.2	30.3	45.5	60.6
	5 MHz Channel: (up+down)	2.8	5.7	11.5	17.2	23
3.65 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	17	34	68	102	136
	10 MHz Channel: (up+down)	7.5	15.2	30.3	45.5	60.6
	7 MHz Channel: (up+down)	4.9	9.9	19.6	29.5	39.3
	5 MHz Channel: (up+down)	2.8	5.7	11.5	17.2	23
3.5 GHz Max. Aggregate Throughput	20 MHz Channel: (up+down)	17	34	68	102	136
	10 MHz Channel: (up+down)	7.5	15.2	30.3	45.5	60.6
	7 MHz Channel: (up+down)	4.9	9.9	19.6	29.5	39.3
	5 MHz Channel: (up+down)	2.8	5.7	11.5	17.2	23

Country specific radio regulations

This section describes how the PMP/PTP 450 platform complies with the radio regulations that are enforced in various countries.

Caution

Changes or modifications not expressly approved by Cambium could void the user's authority to operate the system.

Type approvals

This system has achieved Type Approval in various countries around the world. This means that the system has been tested against various local technical regulations and found to comply. The frequency bands in which the system operates may be 'unlicensed' and, in these bands, the system can be used provided it does not cause interference. The system is not guaranteed protection against interference from other products and installations.

The radio specification type approvals that have been granted for PMP 450 frequency variants are listed in Table 222.

Table 222 Radio certifications

Variant	Region	Specification (Type Approvals)
2.4 GHz PMP 450	Canada	RSS Gen and RSS 210
	USA	FCC Part 15 Class B
3.5 GHz PMP/PTP 450	Canada	RSS Gen and RSS 192
	Europe	ETSI EN 302 326-2 V1.2.2
3.6 GHz PMP/PTP 450	Canada	RSS Gen and RSS 192
	USA	FCC Part 15 Class B
5.4 GHz PMP/PTP 450 and 450i	Europe	ETSI EN 301 893 v1.6.1
	USA	FCC Part 15 Class B
5.8 GHz PMP/PTP 450 and 450i	Canada	RSS Gen and RSS 210
	USA	FCC Part 15 Class B
	Europe	ETSI EN 302 502 v1.2.1
900 MHz PMP 450i	Canada	RSS Gen and RSS 210
	USA	FCC Part 15.247
	Mexico	NOM-121-SCT1-2009

DFS for 2.4 and 5 GHz Radios

Dynamic Frequency Selection (DFS) is a requirement in several countries and regions for 2.4 and 5 GHz unlicensed systems to detect radar systems and avoid co-channel operation.

The details of DFS operation and channels available for each Country Code, including whether DFS is active on the AP, SM, which DFS regulation apply, and any channel restrictions are shown in Table 223 on page 10-34.

Table 223 Country & Bands DFS setting

Region Code	Country Code	Band	AP	SM	Weather Radar Notch-Out
North America	Mexico	2.4 GHz	No effect	No effect	No
		5.4 GHz	ETSI EN 301 893 v1.6.1 DFS	No effect	No
		5.8 GHz	No effect	No effect	No
South America	Brazil	5.4 GHz	ETSI EN 301 893 v1.6.1 DFS	No effect	No
		5.8 GHz	No effect	No effect	No
Europe	ETSI	5.4 GHz	ETSI EN 301 893 v1.8.1 DFS	ETSI EN 301 893 v1.8.1 DFS	Yes
		5.8 GHz	ETSI EN 302 502 v1.2.1 DFS	ETSI EN 302 502 v1.2.1 DFS	Yes
Other-Regulatory	Other-FCC	2.4 GHz	No effect	No effect	No
		5.4 GHz	FCC DFS	No effect	No
		5.8-GHz	No effect	No effect	No
	Other-ETSI	5.4 GHz	ETSI EN 301 893 v1.6.1 DFS	ETSI EN 301 893 v1.6.1 DFS	No
		5.8 GHz	ETSI EN 302 502 v1.2.1 DFS	ETSI EN 302 502 v1.2.1 DFS	No

Equipment Disposal

Waste (Disposal) of Electronic and Electric Equipment

Waste (Disposal) of Electronic and Electric Equipment

Please do not dispose of Electronic and Electric Equipment or Electronic and Electric Accessories with your household waste. In some countries or regions, collection systems have been set up to handle waste of electrical and electronic equipment. In European Union countries, please contact your local equipment supplier representative or service center for information about the waste collection system in your country.

Country specific maximum transmit power

Maximum transmit power 900 MHz band

Table 224 Default combined transmit power per country – 900 MHz band PMP 450i

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Mexico, Canada, Other FCC	AP	Sector	5 MHz	24	40
			7 MHz	24	40
			10 MHz	24	40
			20 MHz	23	39
		Yagi	5 MHz	24	35
			7 MHz	24	40
			10 MHz	24	36
			20 MHz	23	35
	SM, BH	Yagi	5 MHz	24	51
			7 MHz	24	51
			10 MHz	24	51
			20 MHz	23	50

Brazil	Any	Any	5 MHz	23	54
			7 MHz	27	57
			10 MHz	27	57
			20 MHz	27	60
Other	Any	Any	Any	27	-

Maximum transmit power 4.9 GHz band

Table 225 Default combined transmit power per country – 4.9 GHz band PMP/PTP 450i

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Mexico, Canada, Other FCC	AP	Sector	5 MHz	24	40
			10 MHz	24	40
			20 MHz	23	39
		Omni	5 MHz	24	35
			10 MHz	24	36
			20 MHz	23	35
	SM, BH	Flate plate	5 MHz	24	51
			10 MHz	24	51
			20 MHz	23	50
		4ft parabolic	5 MHz	24	52
			10 MHz	24	55
			20 MHz	23	56
		6ft parabolic	5 MHz	24	52
			10 MHz	24	55
			20 MHz	23	58
Brazil	Any	Any	5 MHz	23	54
			10 MHz	27	57
			20 MHz	27	60
Other	Any	Any	Any	27	-

Maximum transmit power 5.1 GHz band

Table 226 Default combined transmit power per Country – 5.1 GHz band PMP/PTP 450i

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Other FCC	AP	Sector	5 MHz	12	30
			10 MHz	15	30
			20 MHz	16	30
		Omni	5 MHz	16	30
			10 MHz	17	30
			20 MHz	17	30
	SM, BH	Flat plate	5 MHz	-2	30
			10 MHz	1	30
			20 MHz	3	30
		4ft parabolic	5 MHz	6	30
			10 MHz	9	30
			20 MHz	9	30
Mexico	Any	Any	5 MHz	-	17
			10 MHz	-	20
			20 MHz	-	23
Other	Any	Any	Any	27	-

Maximum transmit power 5.2 GHz band

Table 227 Default combined transmit power per country – 5.2 GHz band

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Other FCC	AP	Sector	5 MHz	-	22
			10 MHz	-	25
			20 MHz	-	28
		Omni	5 MHz	-	22
			10 MHz	-	25
			20 MHz	-	28
	SM, BH	Flat plate	5 MHz	-	20
			10 MHz	-	23
			20 MHz	-	26
		4ft parabolic	5 MHz	-	19
			10 MHz	-	22
			20 MHz	-	25
Mexico	Any	Any	5 MHz	-	24
			10 MHz	-	27
			20 MHz	-	30
Other	Any	Any	Any	27	-

Maximum transmit power 5.4 GHz band

Table 228 Default combined transmit power per country – 5.4 GHz band PMP/PTP 450i

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Other FCC	AP	Sector	5 MHz	12	30
			10 MHz	15	30
			20 MHz	16	30
		Omni	5 MHz	16	30
			10 MHz	17	30
			20 MHz	17	30
	SM, BH	Flat plate	5 MHz	-2	30
			10 MHz	1	30
			20 MHz	3	30
		4ft parabolic	5 MHz	6	30
			10 MHz	9	30
			20 MHz	9	30
Brazil	Any	Any	10 MHz	19	30
			20 MHz	23	30
Mexico	Any	Any	10 MHz	-	30
			20 MHz	-	30
Other	Any	Any	Any	27	-

Table 229 Default combined transmit power per country – 5.4 GHz band PMP 450

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
United States, Canada, Brazil, Australia, Denmark, Finaland, Germany, Greece, Liechtenstein, Norway, Portugal, Spain, UK, Vietnam	AP	Sector (18 dBi – 1dB cable loss)	10 MHz	10	27
			20 MHz	13	30
Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, France, , Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia , Sweden	AP	Sector (18 dBi – 1dB cable loss)	10 MHz	10	27[4]
			20 MHz	13	30
Algeria	AP	Sector (18 dBi – 1dB cable loss)	10 MHz	10	27
			20 MHz	13	30
Other	AP	Sector (18 dBi – 1dB cable loss)	10 MHz	19	No EIRP limit
			20 MHz	19	No EIRP limit

Maximum transmit power 5.8 GHz band

Table 230 Default combined transmit power per country – 5.8 GHz band PMP/PTP 450i

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
USA, Canada, Brazil, Other FCC	AP	Sector, Omni	5 MHz	-	36
			10 MHz	-	36
			20 MHz	-	36
	SM, BH	Flat plate,	5 MHz	27	-

[4] At 5.4 GHz, EU regulations are harmonized. 5600 – 5650 MHz excluded, as ten minute Channel Availability Check (CAC) is required

		4ft parabolic, 6ft parabolic	10 MHz	27 (26 for 5733 MHz and below)	-
			20 MHz	27	-
Mexico	Any	Any	5 MHz	-	30
			10 MHz	-	33
			20 MHz	-	36
Other	Any	Any	5 MHz	27	-

Table 231 Default combined transmit power per country – 5.8 GHz band PMP 450

Countries	Device Type	Antenna Type	Channel BW	Conducted Power Limit (dBm)	EIRP Limit (dBm)
Australia, India, United States	AP	Sector (18 dBi – 1dB cable loss)	5 MHz	19	36
			10 MHz	19	36
			20 MHz	19	36
Brazil, Vietnam	AP	Sector (18 dBi – 1dB cable loss)	5 MHz	7	24
			10 MHz	10	27
			20 MHz	13	30
Canada	AP	Sector (18 dBi – 1dB cable loss)	5 MHz	9	26
			10 MHz	19	36
			20 MHz	19	36
Denmakr, Finland, Germany, Greece, Iceland, Ireland, Liechtenstein, Norway, Portugal, Serbia, Spain, Switzerland, United Kingdom,	AP	Sector (18 dBi – 1dB cable loss)	5 MHz	-	-
			10 MHz	16	33
			20 MHz	19	36
Indonesia	AP	Sector (18 dBi – 1dB cable loss)	5 MHz	13	30
			10 MHz	19	36
			20 MHz	19	36

Country specific frequency range

Frequency range 900 MHz band

Table 232 Frequency range per country – 900 MHz band

Region	Country	Channel center Frequency limits (MHz)	
		Lower	Upper
Other	Other	902	928
	Other-FCC	902	928
North America	Canada	902	928
	United States	902	928
	Mexico	902	928
	Puerto Rico	902	928
Oceania	Australia	918	926
	New Zealand	921 (7 MHz) 921.5 (5 MHz)	928 (7 MHz) 928 (5 MHz)
	Brazil	902 915	907.5 928
	Ecuador	902	928
	Colombia	902	928
	Venezuela	902	928

Frequency range 4.9 GHz band

Table 233 Frequency range per country – 4.9 GHz band PMP/PTP 450i

Countries	Antenna Type	Channel BW	Channel center Frequency limits (MHz)	
			Lower	Upper
USA, Mexico, Canada, Other FCC	Any	5 MHz	4942.5	4987.5
		10 MHz	4945	4985
		20 MHz	4950	4980
Brazil	Any	5 MHz	4912.5	4987.5
		10 MHz	4915	4985
		20 MHz	4920	4980
Other	Any	5 MHz	4902.5	4997.5
		10 MHz	4905	4995
		20 MHz	4910	4990

Frequency range 5.4 GHz band

Table 234 Frequency range per country – 5.4 GHz band PMP/PTP 450i

Countries	Antenna Type	Channel BW	Channel center Frequency limits (MHz)	
			Lower	Upper
Brazil	Any	10 MHz	5475	5720
		20 MHz	5480	5715
Mexico	Any	10 MHz	5475	5595
			5655	5720
		20 MHz	5480	5590
			5660	5710
Other	Any	5 MHz	5742.5	5722.5
		10 MHz	5475	5720
		20 MHz	5480	5715

Table 235 Frequency range per country – 5.4 GHz band PMP/PTP 450

Region code	Country Code	Channel BW	Channel center Frequency limits (MHz)	
			Lower	Upper
Other	Any	5 MHz	5472.5	5722.5
		10 MHz	5475	5720
		20 MHz	5480	5715
	Other-FCC (Any non-US country that follows FCC rules	10 MHz	5475	5595
			5645	5720
		20 MHz	5465	5490
			5640	5715
	Other-ETSI (Any country that follows ETSI rules	10 MHz	5475	5595
			5645	5720
		20 MHz	5465	5490
			5640	5715
Oceania	Australia	10 MHz	5475	5595
			5645	5720
		20 MHz	5465	5490
			5640	5715
North America	Canada	10 MHz	5475	5595
			5645	5720
		20 MHz	5465	5490
			5640	5715
South America	Brazil	10 MHz	5475	5720
		20 MHz	5480	5715
Asia	Vietnam	10 MHz	5475	5720
		20 MHz	5480	5715
Africa	Algeria	5 MHz	5472.5	5597.5
		10 MHz	5475	5595
		20 MHz	5465	5490
Europe	Europe (Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Norway, Portugal, Serbia, Spain, Switzerland, United Kingdom)	10 MHz	5475	5595
			5645	5720
		20 MHz	5465	5490
			5640	5715

Frequency range 5.8 GHz band

Table 236 Frequency range per country – 5.8 GHz band PMP/PTP 450i

Countries	Antenna Type	Channel BW	Channel center Frequency limits (MHz)	
			Lower	Upper
USA, Canada, Brazil, Other FCC	Any	5 MHz	5730	5845
		10 MHz	5730	5845
		20 MHz	5735	5840
Mexico	Any	5 MHz	5727.5	5847.5
		10 MHz	5730	5845
		20 MHz	5735	5840
Other	Any	5 MHz	5727.5	5897.5
		10 MHz	5730	5895
		20 MHz	5735	5890

Table 237 Frequency range per country – 5.8 GHz band PMP/PTP 450

Countries	Antenna Type	Channel BW	Channel center Frequency limits (MHz)	
			Lower	Upper
Denmark, Norway, United Kingdom, Finland	Any	10 MHz	5730	5790
			5820	5845
		20 MHz	5735	5785
			5825	5840
Germany	Any	10 MHz	5760	5870
		20 MHz	5765	5865
Spain	Any	10 MHz	5730	5790
			5820	5850
		20 MHz	5735	5785
			5825	5845
Greece	Any	10 MHz	5730	5790
		20 MHz	5735	5785
Portugal, Iceland, Serbia	Any	10 MHz	5730	5870
		20 MHz	5735	5865

Switzerland, Liechtenstein	Any	10 MHz	5730	5790
			5820	5870
		20 MHz	5735	5785
			5825	5865
Australia	Any	5 MHz	5727.5	5847.5
		10 MHz	5730	5845
		20 MHz	5735	5840
Canada, United States	Any	5 MHz	5730	5845
		10 MHz	5730	5845
		20 MHz	5735	5845
India	Any	5 MHz	5727.5	5872.5
		10 MHz	5730	5870
		20 MHz	5735	5865
Brazil, Vietnam	Any	5 MHz	5727.5	5847.5
		10 MHz	5730	5845
		20 MHz	5735	5840
Indonesia	Any	5 MHz	5727.5	5822.5
		10 MHz	5730	5820
		20 MHz	5735	5815
Malaysia	Any	5 MHz	5727.5	5872.5
		10 MHz	5830	5870
		20 MHz	5835	5865

FCC specific information

FCC compliance testing

With GPS synchronization installed, the system has been tested for compliance to US (FCC) specifications. It has been shown to comply with the limits for emitted spurious radiation for a Class B digital device, pursuant to Part 15 of the FCC Rules in the USA. These limits have been designed to provide reasonable protection against harmful interference. However the equipment can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to other radio communications. There is no guarantee that interference does not occur in a particular installation.

Note

A Class B Digital Device is a device that is marketed for use in a residential environment, notwithstanding use in commercial, business and industrial environments.

Note

Notwithstanding that Cambium has designed (and qualified) the PMP/PTP 450 platform products to generally meet the Class B requirement to minimize the potential for interference, the PMP/PTP 450 platform product range is not marketed for use in a residential environment.

FCC IDs

Table 238 US FCC IDs

FCC ID	Product	Frequency Band	Channel Bandwidth	Frequencies	Maximum Combined Tx Output Power
QWP-50450I	5 GHz AP, SM & BH	4.9 GHz	5 MHz	4942.5 – 4987.5 MHz	24 dBm
			10 MHz	4945.0 – 4985.0 MHz	24 dBm
			20 MHz	4950.0 – 4980.0 MHz	23.5 dBm
		5.1 GHz	5 MHz	5156.0 – 5247.5 MHz	16 dBm
			10 MHz	5160.0 – 5164.75 MHz	17 dBm
			20 MHz	5165.0 – 5245.0 MHz	19 dBm
		5.2 GHz	5 MHz	5252.5 – 5343.0 MHz	10 dBm
			10 MHz	5255.0 – 5340.5 MHz	13 dBm
			20 MHz	5260.0 – 5333.75 MHz	16 dBm
		5.4 GHz	5 MHz	5473.0 – 5721.25 MHz	10 dBm
			10 MHz	5475.5 – 5719.25 MHz	13 dBm

FCC ID	Product	Frequency Band	Channel Bandwidth	Frequencies	Maximum Combined Tx Output Power
			20 MHz	5480.0 – 5715.0 MHz	16 dBm
		5.8 GHz	5 MHz	5730.0 – 5845.0 MHz	28 dBm
			10 MHz	5730.0 – 5845.0 MHz	28 dBm
			20 MHz	5735.0 – 5840.0 MHz	28 dBm

FCC approved antenna list

The lists of antennas which have been approved for operation by the FCC are provided in:

- Table 239 for 4.9 GHz
- Table 240 for 5.1 and 5.2 GHz
- Table 241 for 5.4 GHz
- Table 242 for 5.8 GHz

Note

Any antenna of the same type and of gain equal or lower than the one approved by the FCC can be used in the countries following the FCC rules.

Table 239 USA approved antenna list 4.9 GHz

Directivity	Type	Manufacturer	Reference	Stated Gain (dBi)
Directional	Integrated flat plate	Cambium Networks	N/A	23.0
	2 ft dual polarised flat plate	Mars Antennas	MA-WA56-DP-28N	28.0
	4 ft parabolic dual polarised	Gabriel Antennas	Dual QuickFire QFD4-49-N	33.7
	6 ft Parabolic dual polarised	Gabriel Antennas	QuickFire QF6-49-N	37.2
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16.0
	90° sectorised	Cambium Networks	#85009324001	17.0
	60° sectorised	Cambium Networks	#85009325001	17.0
Omni-directional	Dual polar omni-directional	KP	KPPA-5.7-DPOMA	13.0

Table 240 USA approved antenna list 5.1 and 5.2 GHz

Directivity	Type	Manufacturer	Reference	Stated Gain (dBi)
Directional	Integrated flat plate	Cambium Networks	N/A	23.0
	2ft dual polarised flat plate	Mars Antennas	MA-WA56-DP-28N	28.5
	4ft parabolic dual polarised	Gabriel Antennas	PX4F-52-N7A/A	34.5
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16.0
	90° sectorised	Cambium Networks	#85009324001	17.0
Omni-directional	Dual polar omni-directional	KP	KPPA-5.7-DPOMA	13.0
	Dual polar omni-directional	Mars Antennas	MA-WO56-DP10	10.0

Table 241 USA approved antenna list 5.4 GHz

Directivity	Type	Manufacturer	Reference	Stated Gain (dBi)
Directional	Integrated flat plate	Cambium Networks	N/A	23.0
	2 ft dual polarised flat plate	Mars Antennas	MA-WA56-DP-28N	28.5
	2 ft dual polarised parabolic	MTI	MT-486013-NVH	28.5
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16.0
	90° sectorised	Cambium Networks	#85009324001	17.0
Omni-directional	Dual polar omni-directional	KP	KPPA-5.7-DPOMA	13.0
	Dual polar omni-directional	Mars Antennas	MA-WO56-DP10	10.0

Table 242 USA approved antenna list 5.8 GHz

Directivity	Type	Manufacturer	Reference	Stated Gain (dBi)
Directional	Integrated flat plate	Cambium Networks	N/A	23.0
	2 ft dual polarised flat plate	Mars Antennas	MA-WA56-DP-28N	28.0
	4 ft parabolic dual polarised	Gabriel Antennas	PX4F-52-N7A/A	35.3
	6 ft Parabolic dual polarised	Gabriel Antennas	PX6F-52/A	38.1
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16.0
	90° sectorised	Cambium Networks	#85009324001	17.0
	60° sectorised	Cambium Networks	#85009325001	17.0
Omni-directional	Dual polar omni-directional	KP	KPPA-5.7-DPOMA	13.0

Industry Canada (IC) specific information

4.9 GHz IC notification

The system has been approved under Industry Canada RSS-111 for Public Safety Agency usage. The installer or operator is responsible for obtaining the appropriate site licenses before installing or using the system.

Utilisation de la bande 4.9 GHz FCC et IC

Le système a été approuvé en vertu d'Industrie Canada RSS-111 pour l'utilisation par l'Agence de la Sécurité publique. L'installateur ou l'exploitant est responsable de l'obtention des licences de appropriées avant d'installer ou d'utiliser le système.

5.2 GHz and 5.4 GHz IC notification

This device complies with Industry Canada RSS-247. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation. Users should be cautioned to take note that high power radars are allocated as primary users (meaning they have priority) of 5250 – 5350 MHz and 5650 – 5850 MHz and these radars could cause interference and/or damage to license-exempt local area networks (LELAN).

For the connectorized version of the product and in order to reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that permitted by the regulations. The transmitted power must be reduced to achieve this requirement.

Utilisation de la bande 5.2 and 5.4 GHz IC

Cet appareil est conforme à Industrie Canada RSS-247. Son fonctionnement est soumis aux deux conditions suivantes: (1) Ce dispositif ne doit pas causer d'interférences nuisibles, et (2) Cet appareil doit tolérer toute interférence reçue, y compris les interférences pouvant entraîner un fonctionnement indésirable. Les utilisateurs doivent prendre garde au fait que les radars à haute puissance sont considères comme les utilisateurs prioritaires de 5250 à 5350 MHz et 5650 à 5850 MHz et ces radars peuvent causer des interférences et / ou interférer avec un réseau local ne nécessitant pas de licence.

Pour la version du produit avec antenne externe et afin de réduire le risque d'interférence avec d'autres utilisateurs, le type d'antenne et son gain doivent être choisis afin que la puissance isotrope rayonnée équivalente (PIRE) ne soit pas supérieure à celle permise par la règlementation. Il peut être nécessaire de réduire la puissance transmise doit être réduite pour satisfaire cette exigence.

IC notification 5.8 GHz

RSS-GEN issue 3 (7.1.3) Licence-Exempt Radio Apparatus:

> This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

In Canada, high power radars are allocated as primary users (meaning they have priority) of the 5600 – 5650 MHz spectrum. These radars could cause interference or damage to license-exempt local area network (LE-LAN) devices.

Utilisation de la bande 5.8 GHz IC

RSS-GEN issue 3 (7.1.3) appareil utilisant la bande sans licence:

> *Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

Au Canada, les radars à haute puissance sont désignés comme utilisateurs principaux (ils ont la priorité) dans la bande 5600 à 5650 MHz. Ces radars peuvent causer des interférences et / ou interférer avec un réseau local ne nécessitant pas de licence.

IC certification numbers

Table 243 Industry Canada Certification Numbers

IC Cert.	Product	Frequency Band	Channel Bandwidth	Frequencies	Maximum Combined Tx Output Power
109AO-50450I (Pending)	5 GHz AP, SM & BHM	4.9 GHz	5 MHz	4942.5 – 4987.5 MHz	24 dBm
			10 MHz	4945.0 – 4985.0 MHz	24 dBm
			20 MHz	4950.0 – 4980.0 MHz	23.5 dBm
		5.8 GHz	5 MHz	5730.0 – 5845.0 MHz	28 dBm
			10 MHz	5730.0 – 5845.0 MHz	28 dBm
			20 MHz	5735.0 – 5840.0 MHz	28 dBm

Canada approved antenna list

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain must be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

This radio transmitter (identify the device by certification number) has been approved by Industry Canada to operate with the antenna types listed in Country specific radio regulations, Industry Canada (IC) , Table 244 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (identifier le dispositif par son numéro de certification) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans la section Country specific radio regulations, Industry Canada (IC) , Table 244 et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Table 244 Canada approved antenna list 4.9 and 5.8 GHz

Antenna type	Description	Manufacturer	Reference	Gain (dBi)	
				4.9 GHz	5.8 GHz
Directional	Integrated flat plate	Cambium Networks	N/A	23	23
	2 ft dual polarised flat plate	MARS Antennas	MA-WA56-DP-28N	28.5	28
	4 ft parabolic dual polarised	Andrews Antennas	PX4F-52-N7A/A	N/A	35.3
	6 ft Parabolic dual polarised	Gabriel Antennas	QF6-49-N	37.2	N/A
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16	16
	90°sector	Cambium Networks	85009324001	17	17
	60° sectorised	Cambium Networks	#85009325001	16	16
Omni-directional	Omni-directional	KP Antennas	KPPA-5.7-DPOMA	13	13
	Omni-directional	MARS Antennas	MA-WO56-DP10	10	10

Table 245 Canada approved antenna list 5.2 and 5.4 GHz

Directivity	Type	Manufacturer	Reference	Stated Gain (dBi)
Directional	Integrated flat plate	Cambium Networks	N/A	23.0
	2ft dual polarised flat plate	Mars Antennas	MA-WA56-DP-28N	28.5
	2ft dual polarised parabolic	MTI	MT-486013-NVH	28.5
Sector	Integrated 90° sector flat plate	Cambium Networks	N/A	16.0
	90° sectorised	Cambium Networks	#85009324001	17.0
Omni-directional	Dual polar omni-directional	KP	KPPA-5.7-DPOMA	13.0
	Dual polar omni-directional	Mars Antennas	MA-WO56-DP10	10.0

Chapter 11: Troubleshooting

This chapter contains procedures for identifying and correcting faults in a PMP/PTP 450 platform link. These procedures can be performed either on a newly installed link, or on an operational link if communication is lost, or after a lightning strike.

The following topics are described in this chapter:

General troubleshooting procedure

General planning for troubleshooting

Effective troubleshooting depends in part on measures that you take before you experience trouble in your network. Cambium recommends the following measures for each site:

- Identify troubleshooting tools that are available at your site (such as a protocol analyzer).
- Identify commands and other sources that can capture baseline data for the site. These may include:
  - Ping
  - Tracert or traceroute
  - Link Capacity Test results
  - Throughput data
  - Configuration tab captures
  - Status tab captures
  - Session logs
  - Web browser used
- Start a log for the site.
- Include the following information in the log:
  - Operating procedures
  - Site-specific configuration records
  - Network topology
  - Software releases, boot versions and FPGA firmware versions
  - Types of hardware deployed
  - Site-specific troubleshooting processes
  - Escalation procedures
- Capture baseline data into the log from the sources listed above

General fault isolation process

Effective troubleshooting also requires an effective fault isolation methodology that includes the following:

- Attempting to isolate the problem to the level of a system, subsystem, or link, such as
  - AP to SM
  - AP to CMM4
  - AP to GPS
  - Backhaul(BH)
  - Backhaul(BH) to CMM4
  - Power
- Researching Event Logs of the involved equipment
- Interpreting messages in the Event Log
- Answering the questions listed in the following sections.
- Reversing the last previous corrective attempt before proceeding to the next.
- Performing only one corrective attempt at a time.

Questions to help isolate the problem

When a problem occurs, attempt to answer the following questions:

- What is the history of the problem?
  - Have we changed something recently?
  - Have we seen other symptoms before this?
- How wide-spread is the symptom?
  - Is the problem on only a single SM? (If so, focus on that SM.)
  - Is the problem on multiple SMs? If so

    is the problem on one AP in the cluster? (If so, focus on that AP)

    is the problem on multiple, but not all, APs in the cluster? (If so, focus on those APs)

    is the problem on all APs in the cluster? (If so, focus on the CMM4 and the GPS signal.)
- Based on data in the Event Log
  - does the problem correlate to External Hard Resets with no WatchDog timers? (If so, this indicates a loss of power. Correct your power problem.)
  - is intermittent connectivity indicated? (If so, verify your configuration, power level, cables and connections and the speed duplex of both ends of the link).
  - does the problem correlate to loss-of-sync events?
- Are connections made via *shielded* cables?
- Does the GPS antenna have an *unobstructed* view of the entire horizon?
- Has the site grounding been verified?

Secondary Steps

After preliminary fault isolation is completed through the above steps, follow these:

- Check the Canopy knowledge base (https://support.cambiumnetworks.com/forum) to find whether other network operators have encountered a similar problem.
- Proceed to any appropriate set of diagnostic steps. These are organized as follows:
  - Module has lost or does not establish connectivity on page 11-26
  - NAT/DHCP-configured SM has lost or does not establish connectivity on page 11-28
  - SM Does Not Register to an AP on page 11-30
  - Module has lost or does not gain sync on page 11-31
  - Module does not establish Ethernet connectivity on page 11-32
  - CMM4 does not pass proper GPS sync to connected modules on page 11-33
  - Module Software Cannot be Upgraded on page 11-34
  - Module Functions Properly, Except Web Interface Became Inaccessible on page 11-34

Troubleshooting procedures

Proceed to any appropriate set of diagnostic steps. These are organized as follows:

Module has lost or does not establish connectivity

To troubleshoot a loss of connectivity, perform the following steps:

Procedure 34 Troubleshooting loss of connectivity

1. Isolate the end user/SM from peripheral equipment and variables such as routers, switches and firewalls.
2. Set up the minimal amount of equipment.
3. On each end of the link:
   - Check the cables and connections.
   - Verify that the cable/connection scheme—straight-through or crossover—is correct.
   - Verify that the LED labeled LNK is green.
   - Access the General Status tab in the Home page of the module.
   - Verify that the SM is registered.
   - Verify that Received Power Level is -87 dBm or higher.
   - Access the IP tab in the Configuration page of the module.
   - Verify that IP addresses match and are in the same subnet.
   - If RADIUS authentication is configured, ensure that the RADIUS server is operational

4 On the SM end of the link:

- Verify that the PC that is connected to the SM is correctly configured to obtain an IP address through DHCP.
- Execute **ipconfig** (Windows) or **ifconfig** (linux)
- Verify that the PC has an assigned IP address.

5 On each end of the link:

- Access the **General** tab in the Configuration page of each module.
- Verify that the setting for **Link Speeds** (or negotiation) matches that of the other module.
- Access the **Radio** tab in the Configuration page of each module.
- Verify that the **Radio Frequency Carrier** setting is checked in the Custom Radio Frequency Scan Selection List.
- Verify that the **Color Code** setting matches that of the other module.
- Access the browser LAN settings (for example, at **Tools > Internet Options > Connections > LAN Settings** in Internet Explorer).
- Verify that none of the settings are selected.
- Access the **Link Capacity Test** tab in the Tools page of the module.
- Perform a link test
- Verify that the link test results show efficiency greater than 90% in both the uplink and downlink
- Execute **ping**.
  - Verify that no packet loss was experienced.
  - Verify that response times are not significantly greater than
    - 4 ms from AP to SM
    - 15 ms from SM to AP
  - Replace any cables that you suspect may be causing the problem.

Note

A ping size larger than 1494 Bytes to a module times out and fails. However, a ping of this size or larger to a system that is behind a Canopy module typically succeeds. It is generally advisable to ping such a system, since Canopy handles that ping with the same priority as is given all other transport traffic. The results are unaffected by ping size and by the load on the Canopy module that brokers this traffic.

6 After connectivity has been re-established, reinstall network elements and variables that you removed in Step 1.

NAT/DHCP-configured SM has lost or does not establish connectivity

Before troubleshooting this problem, identify the NAT/DHCP configuration from the following list:

- NAT with DHCP Client (**DHCP** selected as the **Connection Type** of the WAN interface) and DHCP Server
- NAT with DHCP Client (**DHCP** selected as the **Connection Type** of the WAN interface)
- NAT with DHCP Server
- NAT without DHCP

To troubleshoot a loss of connectivity for a SM configured for NAT/DHCP, perform the following steps.

Procedure 35 Troubleshooting loss of connectivity for NAT/DHCP-configured SM

1. Isolate the end user/SM from peripheral equipment and variables such as routers, switches and firewalls.
2. Set up the minimal amount of equipment.
3. On each end of the link:
   - Check the cables and connections.
   - Verify that the cable/connection scheme—straight-through or crossover—is correct.
   - Verify that the LED labeled LNK is green.
4. At the SM:
   - Access the NAT Table tab in the Logs web page.
   - Verify that the correct NAT translations are listed.
     RESULT: NAT is eliminated as a possible cause if these translations are correct.
5. If this SM is configured for NAT with DHCP, then at the SM:
   - Execute **`ipconfig`** (Windows) or **`ifconfig`** (Linux)
   - Verify that the PC has an assigned IP address.
   - If the PC *does not* have an assigned IP address, then
     - enter ipconfig /release *"Adapter Name"*.
     - enter ipconfig /renew *"Adapter Name"*.
     - reboot the PC.
     - after the PC has completed rebooting, execute **`ipconfig`**
     - if the PC has an assigned IP address, then
     - access the NAT DHCP Statistics tab in the Statistics web page of the SM.
     - verify that DHCP is operating as configured.
6. After connectivity has been re-established, reinstall network elements and variables that you removed in Step 1.

SM Does Not Register to an AP

To troubleshoot a SM failing to register to an AP, perform the following steps.

Procedure 36 Troubleshooting SM failing to register to an AP

1. Access the Radio tab in the Configuration page of the SM.
2. Note the **Color Code** of the SM.
3. Access the Radio tab in the Configuration page of the AP.
4. Verify that the **Color Code** of the AP matches that of the SM.
5. Note the **Radio Frequency Carrier** of the AP.
6. Verify that the value of the **RF Frequency Carrier** of the AP is selected in the **Custom Radio Frequency Scan Selection List** parameter in the SM.
7. In the AP, verify that the **Max Range** parameter is set to a distance slightly greater than the distance between the AP and the furthest SM that must register to this AP.
8. Verify that no obstruction significantly penetrates the Fresnel zone of the attempted link.
9. Access the **General Status** tab in the Home page of each module.
10. Remove the bottom cover of the SM to expose the LEDs.
11. Power cycle the SM.
    RESULT: Approximately 25 seconds after the power cycle, the green LED labeled LNK must light to indicate that the link has been established. If the orange LED labeled SYN is lit instead, then the SM is in Alignment mode because the SM failed to establish the link.
12. If the AP is configured to require authentication, ensure proper configuration of RADIUS or Pre-shared AP key.
13. In this latter case and if the SM has encountered no customer-inflicted damage, then request an RMA for the SM.

Module has lost or does not gain sync

To troubleshoot a loss of sync, perform the following steps.

Procedure 37 Troubleshooting loss of sync

1. Access the Event Log tab in the Home page of the SM
2. Check for messages with the following format:
   RcvFrmNum =
   ExpFrmNum =
3. If these messages are present, check the Event Log tab of another SM that is registered to the same AP for messages of the same type.
4. If the Event Log of this second SM *does not* contain these messages, then the fault is isolated to the first SM.

   If the Event Log page of this second SM contains these messages, access the GPS Status page of the AP.
5. If the **Satellites Tracked** field in the GPS Status page of the AP indicates fewer than 4 or the **Pulse Status** field does not indicate Generating Sync, check the GPS Status page of another AP in the same AP cluster for these indicators. GPS signal acquisition must not take longer than 5 minutes from unit startup.
6. If these indicators are present in the second AP, then:
   - Verify that the GPS antenna still has an unobstructed view of the entire horizon.
   - Visually inspect the cable and connections between the GPS antenna and the CMM4. If this cable is not shielded, replace the cable with shielded cable
7. If these indicators *are not* present in the second AP, visually inspect the cable and connections between the CMM4 and the AP antenna. If this cable is not shielded, replace the cable with shielded cable.

Module does not establish Ethernet connectivity

To troubleshoot a loss of Ethernet connectivity, perform the following steps:

Procedure 38 Troubleshooting loss of Ethernet connectivity

1. Verify that the connector crimps on the Ethernet cable are not loose.
2. Verify that the Ethernet cable is not damaged.
3. If the Ethernet cable connects the module to a network interface card (NIC), verify that the cable is pinned out as a straight-through cable.
4. If the Ethernet cable connects the module to a hub, switch, or router, verify that the cable is pinned out as a crossover cable.
5. Verify that the Ethernet port to which the cable connects the module is set to auto-negotiate speed.
6. Verify VLAN configuration in the network, which may cause loss of module access if the accessing device is on a separate VLAN from the radio.
7. Power cycle the module.
   RESULT: Approximately 25 seconds after the power cycle, the green LED labeled LNK must light up to indicate that the link has been established. If the orange LED labeled SYN is lit instead, then the module is in Alignment mode because the module failed to establish the link.
8. In this latter case and if the module has encountered no customer-inflicted damage, then request an RMA for the module.

CMM4 does not pass proper GPS sync to connected modules

If the Event Log tabs in all connected modules contain Loss of GPS Sync Pulse messages, perform the following steps.

Procedure 39 Troubleshooting CMM4 not passing sync

1. Verify that the GPS antenna has an unobstructed view of the entire horizon.
2. Verify that the GPS coaxial cable meets specifications.
3. Verify that the GPS sync cable meets specifications for wiring and length.
4. If the web pages of connected modules indicate any of the following, then find and eliminate the source of noise that is being coupled into the GPS sync cable:
   - In the GPS Status page:
     - anomalous number of **Satellites Tracked** (greater than 12, for example)
     - incorrect reported **Latitude** and/or **Longitude** of the antenna
   - In the Event Log page:
     - garbled GPS messages
     - large number of Acquired GPS Sync Pulse messages

   GPS signal acquisition must not take longer than 5 minutes from unit startup.
5. If these efforts fail to resolve the problem, then request an RMA for the CMM4.

Module Software Cannot be Upgraded

If your attempt to upgrade the software of a module fails, perform the following steps.

Procedure 40 Troubleshooting an unsuccessful software upgrade

1. Download the latest issue of the target release and the associated release notes.
2. Verify that the latest version of CNUT is installed.
3. Compare the files used in the failed attempt to the newly downloaded software.
4. Compare the procedure used in the failed attempt to the procedure in the newly downloaded release notes.
5. If these comparisons reveal a difference, retry the upgrade, this time with the newer file or newer procedure.
6. If, during attempts to upgrade the FPGA firmware, the following message is repeatable, then request an RMA for the module:

   ```
   Error code 6, unrecognized device
   ```

Module Functions Properly, Except Web Interface Became Inaccessible

If a module continues to pass traffic and the SNMP interface to the module continues to function, but the web interface to the module does not display, perform the following steps:

Procedure 41 Restoring web management GUI access

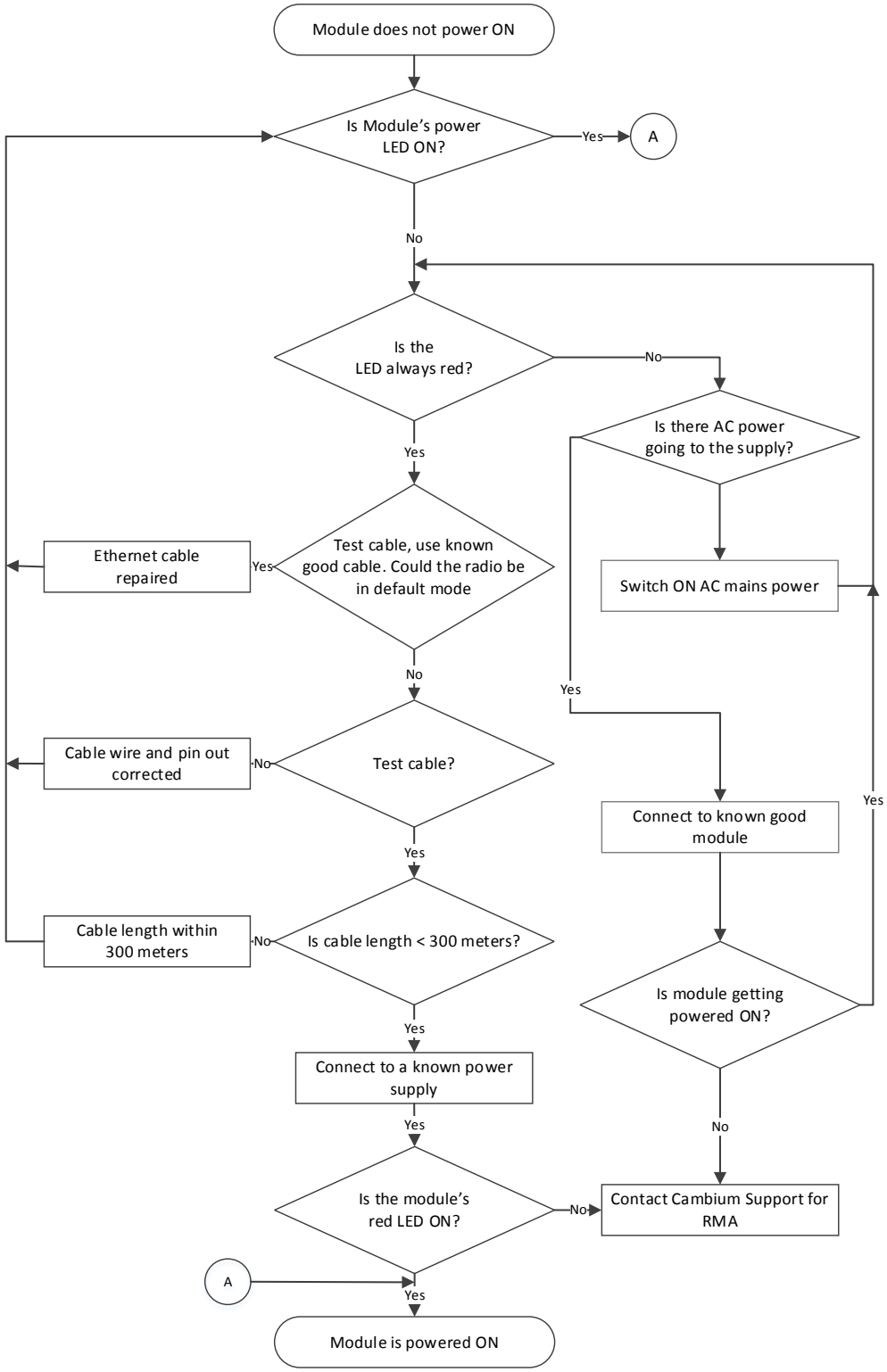
1. Enter **telnet** ***DottedIPAddress***.
   RESULT: A telnet session to the module is invoked.
2. At the Login prompt, enter **root**.
3. At the Password prompt, enter ***PasswordIfConfigured***.
4. At the Telnet +> prompt, enter **reset**.
   RESULT: The web interface is accessible again and this telnet connection is closed.

   Note

   The module may also be rebooted via an SNMP-based NMS (Wireless Manager, for example)
5. If the issue persists, turn off any SNMP-based network/radio monitoring software and repeat steps 1-4.

Power-up troubleshooting



Registration and connectivity troubleshooting

SM/BMS Registration

If no SMs are registered to this AP, then the Session Status tab displays the simple message **No sessions**. In this case, try the following steps.

1. More finely aim the SM or SMs toward the AP.
2. Recheck the Session Status tab of the AP for the presence of LUIDs.
3. If still no LUIDs are reported on the Session Status tab, click the **Configuration** button on the left side of the **Home** page.
   RESULT: The AP responds by opening the AP Configuration page.
4. Click the Radio tab.
5. Find the **Color Code** parameter and note the setting.
6. In the same sequence as you did for the AP directly under **Configuring Link for Test** on Page 5-15, connect the SM to a computing device and to power.
7. On the left side of the SM Home page, click the **Configuration** button.
   RESULT: The Configuration page of the SM opens.
8. Click the Radio tab.
9. If the transmit frequency of the AP is not selected in the **Custom Radio Frequency Scan Selection List** parameter, select the frequency that matches.
10. If the **Color Code** parameter on this page is not identical to the **Color Code** parameter you noted from the AP, change one of them so that they match.
11. At the bottom of the Radio tab for the SM, click the **Save Changes** button.
12. Click the **Reboot** button.
13. Allow several minutes for the SM to reboot and register to the AP.
14. Return to the computing device that is connected to the AP.
15. Recheck the Session Status tab of the AP for the presence of LUIDs.

Glossary

Term	Definition
10Base-T	Technology in Ethernet communications that can deliver 10 Mb of data across 328 feet (100 meters) of CAT 5 cable.
169.254.0.0	Gateway IP address default in Cambium fixed wireless broadband IP network modules.
169.254.1.1	IP address default in Cambium fixed wireless broadband IP network modules.
255.255.0.0	Subnet mask default in Cambium fixed wireless broadband IP network modules and in Microsoft and Apple operating systems.
802.3	An IEEE standard that defines the contents of frames that are transferred through Ethernet connections. Each of these frames contains a preamble, the address to which the frame is sent, the address that sends the frame, the length of the data to expect, the data, and a checksum to validate that no contents were lost.
Access Point Cluster	Two to six Access Point Modules that together distribute network or Internet services to a community of subscribers. Each Access Point Module covers a 60° or 90° sector. This cluster covers as much as 360°. Also known as AP cluster.
Access Point Module	Also known as AP. One module that distributes network or Internet services in a 60° or 90° sector.
ACT/4	Second-from-left LED in the module. In the operating mode, this LED is lit when data activity is present on the Ethernet link.
Address Resolution Protocol	Protocol defined in RFC 826 to allow a network element to correlate a host IP address to the Ethernet address of the host. See http://www.faqs.org/rfcs/rfc826.html.
Aggregate Throughput	The sum of the throughputs in the uplink and the downlink.
AP	Access Point Module. One module that distributes network or Internet services to subscriber modules.
ARP	Address Resolution Protocol. A protocol defined in RFC 826 to allow a network element to correlate a host IP address to the Ethernet address of the host. See http://www.faqs.org/rfcs/rfc826.html.
APs MIB	Management Information Base file that defines objects that are specific to the Access Point Module. See also Management

Term	Definition
	Information Base.
ASN.1	Abstract Syntax Notation One language. The format of the text files that compose the Management Information Base.
Attenuation	Reduction of signal strength caused by the travel from the transmitter to the receiver, and caused by any object between. In the absence of objects between, a signal that has a short wavelength experiences a high degree of attenuation nevertheless.
BER	Bit Error Rate. The ratio of incorrect data received to correct data received.
Bit Error Rate	Ratio of incorrect data received to correct data received.
Box MIB	Management Information Base file that defines module-level objects. See also Management Information Base.
Bridge	Network element that uses the physical address (not the logical address) of another to pass data. The bridge passes the data to either the destination address, if found in the simple routing table, or to all network segments other than the one that transmitted the data. Modules are Layer 2 bridges except that, where NAT is enabled for an SM, the SM is a Layer 3 switch. Compare to Switch and Router, and see also NAT.
Buckets	Theoretical data repositories that can be filled at preset rates or emptied when preset conditions are experienced, such as when data is transferred.
Burst	Preset amount limit of data that may be continuously transferred.
CAT 5 Cable	Cable that delivers Ethernet communications from module to module. Later modules auto-sense whether this cable is wired in a straight-through or crossover scheme.
CIR	Committed Information Rate. For an SM or specified group of SMs, a level of bandwidth that can be guaranteed to never fall below a specified minimum (unless oversubscribed). In the Cambium implementation, this is controlled by the Low Priority Uplink CIR, Low Priority Downlink CIR, High Priority Uplink CIR, and High Priority Downlink CIR parameters.
Cluster Management Module	Module that provides power, GPS timing, and networking connections for an AP cluster. Also known as CMM4.
CMM	Cluster Management Module. A module that provides power, GPS timing, and networking connections for an Access Point cluster.
CodePoint	See DiffServ.
Color Code Field	Module parameter that identifies the other modules with which

Term	Definition
	communication is allowed. The range of valid values is 0 to 255.
Community String Field	Control string that allows a network management station to access MIB information about the module.
Country Code	A parameter that offers multiple fixed selections, each of which automatically implements frequency band range restrictions for the selected country. Units shipped to countries other than the United States must be configured with the corresponding Region Code and Country Code to comply with local regulatory requirements.
CRCError Field	This field displays how many CRC errors occurred on the Ethernet controller.
Data Encryption Standard	Over-the-air link option that uses secret 56-bit keys and 8 parity bits. Data Encryption Standard (DES) performs a series of bit permutations, substitutions, and recombination operations on blocks of data.
Demilitarized Zone	Internet Protocol area outside of a firewall. Defined in RFC 2647. See http://www.faqs.org/rfcs/rfc2647.html.
DES	Data Encryption Standard. An over-the-air link option that uses secret 56-bit keys and 8 parity bits. DES performs a series of bit permutations, substitutions, and recombination operations on blocks of data.
DFS	See Dynamic Frequency Selection
DHCP	Dynamic Host Configuration Protocol, defined in RFC 2131. Protocol that enables a device to be assigned a new IP address and TCP/IP parameters, including a default gateway, whenever the device reboots. Thus DHCP reduces configuration time, conserves IP addresses, and allows modules to be moved to a different network within the system. See http://www.faqs.org/rfcs/rfc2131.html. See also Static IP Address Assignment.
DiffServ	Differentiated Services, consistent with RFC 2474. A byte in the type of service (TOS) field of packets whose values correlates to the channel on which the packet should be sent. The value is a numeric code point. Cambium modules map each of 64 code points to values of 0 through 7. Three of these code points have fixed values, and the remaining 61 are settable. Values of 0 through 3 map to the low-priority channel; 4 through 7 to the high-priority channel. The mappings are the same as 802.1p VLAN priorities. (However, configuring DiffServ does not automatically enable the VLAN feature.) Among the settable parameters, the values are set in the AP for all downlinks within the sector and in the SM for each uplink.

Term	Definition
DMZ	Demilitarized Zone as defined in RFC 2647. An Internet Protocol area outside of a firewall. See http://www.faqs.org/rfcs/rfc2647.html.
Dynamic Frequency Selection	A requirement in certain countries and regions for systems to detect interference from other systems, notably radar systems, and to avoid co-channel operation with these systems.
Dynamic Host Configuration Protocol	See DHCP.
Electronic Serial Number	Hardware address that the factory assigns to the module for identification in the Data Link layer interface of the Open Systems Interconnection system. This address serves as an electronic serial number. Same as MAC Address.
ESN	Electronic Serial Number. The hardware address that the factory assigns to the module for identification in the Data Link layer interface of the Open Systems Interconnection system. This address serves as an electronic serial number. Same as MAC Address.
Ethernet Protocol	Any of several IEEE standards that define the contents of frames that are transferred from one network element to another through Ethernet connections.
ETSI	European Telecommunications Standards Institute
Fade Margin	The difference between strength of the received signal and the strength that the receiver requires for maintaining a reliable link. A higher fade margin is characteristic of a more reliable link. Standard operating margin.
FCC	Federal Communications Commission of the U.S.A.
Field-programmable Gate Array	Array of logic, relational data, and wiring data that is factory programmed and can be reprogrammed.
File Transfer Protocol	Utility that transfers of files through TCP (Transport Control Protocol) between computing devices that do not operate on the same platform. Defined in RFC 959. See http://www.faqs.org/rfcs/rfc959.html.
FPGA	Field-programmable Gate Array. An array of logic, relational data, and wiring data that is factory programmed and can be reprogrammed.
Free Space Path Loss	Signal attenuation that is naturally caused by atmospheric conditions and by the distance between the antenna and the receiver.
Fresnel Zone	Space in which no object should exist that can attenuate, diffract, or reflect a transmitted signal before the signal reaches the target

Term	Definition
	receiver.
FTP	File Transfer Protocol, defined in RFC 959. Utility that transfers of files through TCP (Transport Control Protocol) between computing devices that do not operate on the same platform. See http://www.faqs.org/rfcs/rfc959.html.
Global Positioning System	Network of satellites that provides absolute time to networks on earth, which use the time signal to synchronize transmission and reception cycles (to avoid interference) and to provide reference for troubleshooting activities.
GPS	Global Positioning System. A network of satellites that provides absolute time to networks on earth, which use the time signal to synchronize transmission and reception cycles (to avoid interference) and to provide reference for troubleshooting activities.
GPS/3	Third-from-left LED in the module. In the operating mode for an Access Point Module, this LED is continuously lit as the module receives sync pulse. In the operating mode for a Subscriber, this LED flashes on and off to indicate that the module is not registered.
GUI	Graphical user interface.
High-priority Channel	Channel that supports low-latency traffic (such as Voice over IP) over low-latency traffic (such as standard web traffic and file downloads). To recognize the latency tolerance of traffic, this channel reads the IPv4 Type of Service DiffServ Control Point (DSCP) bits. Enabling the high-priority channel reduces the maximum number of SMs that can be served in the sector.
HTTP	Hypertext Transfer Protocol, used to make the Internet resources available on the World Wide Web. Defined in RFC 2068. See http://www.faqs.org/rfcs/rfc2068.html.
HTTPS	Hypertext Transfer Protocol Secure (HTTPS)
ICMP	Internet Control Message Protocols defined in RFC 792, used to identify Internet Protocol (IP)-level problems and to allow IP links to be tested. See http://www.faqs.org/rfcs/rfc792.html.
IP	Internet Protocol defined in RFC 791. The Network Layer in the TCP/IP protocol stack. This protocol is applied to addressing, routing, and delivering, and re-assembling data packets into the Data Link layer of the protocol stack. See http://www.faqs.org/rfcs/rfc791.html.
IP Address	32-bit binary number that identifies a network element by both network and host. See also Subnet Mask.

Term	Definition
IPv4	Traditional version of Internet Protocol, which defines 32-bit fields for data transmission.
ISM	Industrial, Scientific, and Medical Equipment radio frequency band, in the 900-MHz, 2.4-GHz, and 5.8-GHz ranges.
L2TP over IPSec	Level 2 Tunneling Protocol over IP Security. One of several virtual private network (VPN) implementation schemes. Regardless of whether Subscriber Modules have the Network Address Translation feature (NAT) enabled, they support VPNs that are based on this protocol.
Late Collision Field	This field displays how many late collisions occurred on the Ethernet controller. A normal collision occurs during the first 512 bits of the frame transmission. A collision that occurs after the first 512 bits is considered a late collision. A late collision is a serious network problem because the frame being transmitted is discarded. A late collision is most commonly caused by a mismatch between duplex configurations at the ends of a link segment.
Line of Sight	Wireless path (not simply visual path) direct from module to module. The path that results provides both ideal aim and an ideal Fresnel zone.
LNK/5	Furthest left LED in the module. In the operating mode, this LED is continuously lit when the Ethernet link is present. In the aiming mode for a Subscriber Module, this LED is part of a bar graph that indicates the quality of the RF link.
Logical Unit ID	Final octet of the 4-octet IP address of the module.
LOS	Line of sight. The wireless path (not simply visual path) direct from module to module. The path that results provides both ideal aim and an ideal Fresnel zone.
LUID	Logical Unit ID. The final octet of the 4-octet IP address of the module.
MAC Address	Media Access Control address. The hardware address that the factory assigns to the module for identification in the Data Link layer interface of the Open Systems Interconnection system. This address serves as an electronic serial number.
Management Information Base	Space that allows a program (agent) in the network to relay information to a network monitor about the status of defined variables (objects).
Maximum Information Rate (MIR)	The cap applied to the bandwidth of an SM or specified group of SMs. In the Cambium implementation, this is controlled by the Sustained Uplink Data Rate, Uplink Burst Allocation, Sustained

Term	Definition
	Downlink Data Rate, and Downlink Burst Allocation parameters.
MIB	Management Information Base. Space that allows a program (agent) in the network to relay information to a network monitor about the status of defined variables (objects).
MIR	See Maximum Information Rate.
NAT	Network Address Translation defined in RFC 1631. A scheme that isolates Subscriber Modules from the Internet. See http://www.faqs.org/rfcs/rfc1631.html.
NEC	National Electrical Code. The set of national wiring standards that are enforced in the U.S.A.
NetBIOS	Protocol defined in RFC 1001 and RFC 1002 to support an applications programming interface in TCP/IP. This interface allows a computer to transmit and receive data with another host computer on the network. RFC 1001 defines the concepts and methods. RFC 1002 defines the detailed specifications. See http://www.faqs.org/rfcs/rfc1001.html and http://www.faqs.org/rfcs/rfc1002.html.
Network Address Translation	Scheme that defines the Access Point Module as a proxy server to isolate registered Subscriber Modules from the Internet. Defined in RFC 1631. See http://www.faqs.org/rfcs/rfc1631.html.
Network Management Station	See NMS.
NMS	Network Management Station. A monitor device that uses Simple Network Management Protocol (SNMP) to control, gather, and report information about predefined network variables (objects). See also Simple Network Management Protocol.
Default Mode	Device that enables the operator to regain control of a module that has been locked by the No Remote Access feature, the 802.3 Link Disable feature, or a password or IP address that cannot be recalled. This device can be either fabricated on site or ordered.
PMP	See Point-to-Multipoint Protocol.
Point-to-Multipoint Protocol	Defined in RFC 2178, which specifies that data that originates from a central network element can be received by all other network elements, but data that originates from a non-central network element can be received by only the central network element. See http://www.faqs.org/rfcs/rfc2178.html. Also referenced as PMP.
PPPoE	Point to Point Protocol over Ethernet. Supported on SMs for operators who use PPPoE in other parts of their network operators

Term	Definition
	who want to deploy PPPoE to realize per-subscriber authentication, metrics, and usage control.
PPS	Packet Per Second
PPTP	Point to Point Tunneling Protocol. One of several virtual private network implementations. Regardless of whether the Network Address Translation (NAT) feature enabled, Subscriber Modules support VPNs that are based on this protocol.
Protective Earth	Connection to earth (which has a charge of 0 volts). Also known as ground.
Proxy Server	Network computer that isolates another from the Internet. The proxy server communicates for the other computer, and sends replies to only the appropriate computer, which has an IP address that is not unique or not registered.
Radio Signal Strength Indicator	Relative measure of the strength of a received signal. An acceptable link displays a Radio Signal Strength Indicator (RSSI) value of greater than 700.
Reflection	Change of direction and reduction of amplitude of a signal that encounters an object larger than the wavelength. Reflection may cause an additional copy of the wavelength to arrive after the original, unobstructed wavelength arrives. This causes partial cancellation of the signal and may render the link unacceptable. However, in some instances where the direct signal cannot be received, the reflected copy may be received and render an otherwise unacceptable link acceptable.
Region Code	A parameter that offers multiple fixed selections, each of which automatically implements frequency band range restrictions for the selected region. Units shipped to regions other than the United States must be configured with the corresponding Region Code to comply with local regulatory requirements.
RF	Radio frequency. How many times each second a cycle in the antenna occurs, from positive to negative and back to positive amplitude.
RJ-12	Standard cable that is typically used for telephone line or modem connection.
RJ-45	Standard cable that is typically used for Ethernet connection. This cable may be wired as straight-through or as crossover. Later modules auto-sense whether the cable is straight-through or crossover.
Router	Network element that uses the logical (IP) address of another to

Term	Definition
	pass data to only the intended recipient. Compare to Switch and Bridge.
RSSI	Radio Signal Strength Indicator. A relative measure of the strength of a received signal. An acceptable link displays an RSSI value of greater than 700.
Self-interference	Interference with a module from another module in the same network.
Simple Network Management Protocol	Standard that is used for communications between a program (agent) in the network and a network management station (monitor). Defined in RFC 1157. See http://www.faqs.org/rfcs/rfc1157.html.
SM	Customer premises equipment (CPE) device that extends network or Internet services by communication with an Access Point Module or an Access Point cluster.
SNMP	See Simple Network Management Protocol, defined in RFC 1157.
SNMPv3	SNMP version 3
SNMP Trap	Capture of information that informs the network monitor through Simple Network Management Protocol of a monitored occurrence in the module.
Static IP Address Assignment	Assignment of Internet Protocol address that can be changed only manually. Thus static IP address assignment requires more configuration time and consumes more of the available IP addresses than DHCP address assignment does. RFC 2050 provides guidelines for the static allocation of IP addresses. See http://www.faqs.org/rfcs/rfc2050.html. See also DHCP.
Subnet Mask	32-bit binary number that filters an IP address to reveal what part identifies the network and what part identifies the host. The number of subnet mask bits that are set to 1 indicates how many leading bits of the IP address identify the network. The number of subnet mask bits that are set 0 indicate how many trailing bits of the IP address identify the host.
Subscriber Module	Customer premises equipment (CPE) device that extends network or Internet services by communication with an Access Point Module or an Access Point cluster.
Sustained Data Rate	Preset rate limit of data transfer.
Switch	Network element that uses the port that is associated with the physical address of another to pass data to only the intended recipient. Compare to Bridge and Router.

Term	Definition
Sync	GPS (Global Positioning System) absolute time, which is passed from one module to another. Sync enables timing that prevents modules from transmitting or receiving interference. Sync also provides correlative time stamps for troubleshooting efforts.
TCP	Alternatively known as Transmission Control Protocol or Transport Control Protocol. The Transport Layer in the TCP/IP protocol stack. This protocol is applied to assure that data packets arrive at the target network element and to control the flow of data through the Internet. Defined in RFC 793. See http://www.faqs.org/rfcs/rfc793.html.
TDD	Time Division Duplexing. Synchronized data transmission with some time slots allocated to devices transmitting on the uplink and some to the device transmitting on the downlink.
telnet	Utility that allows a client computer to update a server. A firewall can prevent the use of the telnet utility to breach the security of the server. See http://www.faqs.org/rfcs/rfc818.html, http://www.faqs.org/rfcs/rfc854.html and http://www.faqs.org/rfcs/rfc855.html.
Tokens	Theoretical amounts of data. See also Buckets.
TxUnderrun Field	This field displays how many transmission-underrun errors occurred on the Ethernet controller.
UDP	User Datagram Protocol. A set of Network, Transport, and Session Layer protocols that RFC 768 defines. These protocols include checksum and address information but does not retransmit data or process any errors. See http://www.faqs.org/rfcs/rfc768.html.
udp	User-defined type of port.
U-NII	Unlicensed National Information Infrastructure radio frequency band, in the 5.1GHz through 5.8 GHz ranges.
VID	VLAN identifier. See also VLAN.
VLAN	Virtual local area network. An association of devices through software that contains broadcast traffic, as routers would, but in the switch-level protocol.
VPN	Virtual private network for communication over a public network. One typical use is to connect remote employees, who are at home or in a different city, to their corporate network over the Internet. Any of several VPN implementation schemes is possible. SMs support L2TP over IPSec (Level 2 Tunneling Protocol over IP Security) VPNs and PPTP (Point to Point Tunneling Protocol) VPNs, regardless of whether the Network Address Translation (NAT)

Term	Definition
	feature enabled.