Our Genesis

Point to Multipoint (PMP) access networks + Point to Point (PTP) backhaul infrastructure =

Cambium Networks
# Cambium Networks by the Numbers

## Cambium Networks Footprint

<table>
<thead>
<tr>
<th></th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>Experienced Professionals dedicated to PTP/PMP</td>
</tr>
<tr>
<td>3,500,000+</td>
<td>Modules deployed</td>
</tr>
<tr>
<td>150+</td>
<td>Countries deployed</td>
</tr>
<tr>
<td>4,000</td>
<td>Networks deployed</td>
</tr>
<tr>
<td>14</td>
<td>International awards, including Queen’s Award (twice)</td>
</tr>
<tr>
<td>2,000+</td>
<td>Global partners actively selling</td>
</tr>
<tr>
<td>287</td>
<td>Program Certified Technicians</td>
</tr>
<tr>
<td>250+</td>
<td>Published case studies</td>
</tr>
<tr>
<td>250,000</td>
<td>Topic views per month on the Web site</td>
</tr>
</tbody>
</table>
# Key Vertical Markets

<table>
<thead>
<tr>
<th>Service Providers</th>
<th>Government, Public Safety and Administration</th>
<th>Industrial Communication</th>
<th>Federal Defense and Security</th>
<th>Enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last mile solutions for hundreds of successful WISPs and other service providers in every part of the world.</td>
<td>Mission critical connectivity for federal agencies and municipal public safety and public service departments.</td>
<td>Streamline operations for global transportation, logistics, manufacturers, and public and private utilities.</td>
<td>Rapid deployment of video surveillance and data/voice connectivity that is trusted to operate in even the most harsh environments.</td>
<td>Reliable high-speed communications for enterprise environments and industries, including business organizations, healthcare, education, hospitality and many more.</td>
</tr>
</tbody>
</table>
Applications

Outdoor Multi-Use Access Networks

Leased Line Replacement

Video Security

Residential Connectivity
# PTP 100 & 200 SERIES KEY FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>PTP 100</th>
<th>PTP 200</th>
<th>PTP 230</th>
<th>PTP 250</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Bands (GHz)</td>
<td>2.4, 5.2, 5.4, 5.8</td>
<td>4.9 – Dedicated Public Safety Band</td>
<td>5.8</td>
<td>5.4- 5.8 Dual Band¹</td>
</tr>
<tr>
<td>Max. Throughput</td>
<td>14 Mbps</td>
<td>21 Mbps</td>
<td>50 Mbps LOS</td>
<td>220 Mbps</td>
</tr>
<tr>
<td>Max. LOS Range</td>
<td>35 mi (56 km) with reflector</td>
<td>15 mi (24 km)</td>
<td>80 mi (129 km)</td>
<td>34 mi (54 km)</td>
</tr>
<tr>
<td>Max. NLOS Range</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Security</td>
<td>56-bit DES 128-bit AES</td>
<td>56-bit DES 128-bit AES</td>
<td>56-bit DES 128-bit AES</td>
<td>PTP Proprietary Encryption</td>
</tr>
<tr>
<td>Wind Speed Survival</td>
<td>118 mph (190 kph)</td>
<td>118 mph (190 kph)</td>
<td>118 mph (190 kph)</td>
<td>150 mph (240 kph)</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40° ~ 131° F (-40° ~ 55° C)</td>
<td>-40° ~ 131° F (-40° ~ 55° C)</td>
<td>-40° ~ 131° F (-40° ~ 55° C)</td>
<td>-40° ~ 140° F (-40° ~ 60° C)</td>
</tr>
</tbody>
</table>

¹ In the first release, only the 5.8 GHz band will be available in the U.S. and Canada.
# PTP 300, 500, 600 & 800 KEY FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>PTP 300</th>
<th>PTP 500</th>
<th>PTP 600</th>
<th>PTP 800</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Bands (GHz)</td>
<td>5.4, 5.8</td>
<td>5.4, 5.8</td>
<td>2.5, 4.5, 4.8, 4.9, 5.4, 5.8, 5.9</td>
<td>6 ~ 38</td>
</tr>
<tr>
<td>Max. Throughput</td>
<td>25 Mbps – 50 Mbps LOS</td>
<td>105 Mbps</td>
<td>300 Mbps</td>
<td>368 Mbps (full duplex)</td>
</tr>
<tr>
<td>Max. LOS Range</td>
<td>155 mi (250 km)</td>
<td>155 mi (250 km)</td>
<td>124 mi (200 km)</td>
<td>Depends on configuration</td>
</tr>
<tr>
<td>Max. NLOS Range</td>
<td>6 mi (10 km)</td>
<td>6 mi (10 km)</td>
<td>5 mi (8 km)</td>
<td>NA</td>
</tr>
<tr>
<td>Wind Speed Survival</td>
<td>202 mph (325 kph)</td>
<td>202 mph (325 kph)</td>
<td>202 mph (325 kph)</td>
<td>150 mph (242 kph)</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40° ~ 140° F (-40° ~ 60° C)</td>
<td>-40° ~ 140° F (-40° ~ 60° C)</td>
<td>-40° ~ 140° F (-40° ~ 60° C)</td>
<td>-27° ~ 131° F (-33° ~ 55° C)</td>
</tr>
</tbody>
</table>
NLOS AND LOS PERFORMANCE

- Line-of-Sight (LOS)
  Up to 155 miles

- near-Line-of-Sight (nLOS)
  Up to 25 miles

- Non-Line-of-Sight (NLOS)
  Up to 6 miles
CONNECT VIRTUALLY ANYWHERE

Through Trees

Around Buildings

Over Desert or Water

High-Interference Areas
PTP 300, 500, 600 NLOS TECHNOLOGY

Multiple-Input Multiple-Output (MIMO) – Only backhaul product leveraging MIMO

*Intelligent* Orthogonal Frequency Division Multiplexing (*i*-OFDM) – Resists interference and signal fading

Adaptive Modulation – Maximum throughput with highest link quality

Advanced Spectrum Management with *i*-DFS – Automatically switches to the clearest channel

High Spectral Efficiency – High throughput with minimal spectrum usage

Best-in-Class Radios – Highest system gain in the category
MITIGATE INTERFERENCE

• Automatically changes channels to avoid interference without dropping the link
• Narrow channels—5, 10, 15, 30 MHz
• Spectrum analyzer – scans the band continuously
• TDD synchronization for optimal collocation density
• Proactive channel planning
• Up to 2,500 channel combinations

Channel width options depend on region codes.
PTP-SYNC AND TDD

• PTP 500 and PTP 600 Series radios include Time Division Duplex (TDD) which allows frame timing to be synchronized with other PTP 500 and 600 radios or an external timing module:
  – GPS receiver
  – Our Cluster Management Module (CMM)
  – Other 1 Hz synchronized timing module

• TDD-synchronized radios require a PTP-SYNC synchronization unit to provide a timing reference signal for each link
IMPROVED COLLOCATION

**UNSYNCHRONIZED TDD**
WITH SIGNIFICANT CROSS INTERFERENCE

**SYNCHRONIZED TDD**
WITH GREATLY REDUCED CROSS INTERFERENCE
PTP 800 LICENCED MICROWAVE

Excellent choices for:
- Organizations that want the benefits of licensed exclusivity
- High-throughput, LOS communications
- Last-mile fiber extensions
- Video surveillance
- WiMAX and LTE backhaul
- ASTRO® / Dimetra™ backhaul

PTP 800
- Up to 368 Mbps (full duplex)
- Split-mount architecture with ODU and CMU
- Latency to <115 µs at full capacity with 64 bytes
- 1+1 HSB redundancy
- FIPS-197 128/256 AES (optional)
- 6 to 38 GHz
- IP-optimized architecture helps initiate a smooth migration to an all-IP network
- Exceptional scalability
- Optional license coordination services
CAPACITY AS YOU GROW

**Exceptional Scalability with PTP 800**

**CMU Capacity Cap Upgrades**

<table>
<thead>
<tr>
<th>Single-Step Capacity Upgrades</th>
<th>Step-by-Step Capacity Upgrades</th>
</tr>
</thead>
<tbody>
<tr>
<td>X ▶ 20 Mbps (per unit)</td>
<td>10 ▶ 20 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 30 Mbps (per unit)</td>
<td>20 ▶ 30 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 40 Mbps (per unit)</td>
<td>30 ▶ 40 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 50 Mbps (per unit)</td>
<td>40 ▶ 50 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 100 Mbps (per unit)</td>
<td>50 ▶ 100 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 150 Mbps (per unit)</td>
<td>100 ▶ 150 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 200 Mbps (per unit)</td>
<td>150 ▶ 200 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ 300 Mbps (per unit)</td>
<td>200 ▶ 300 Mbps (per unit)</td>
</tr>
<tr>
<td>X ▶ Full Capacity (per unit)</td>
<td>300 ▶ Full Capacity (per unit)</td>
</tr>
</tbody>
</table>
ASYMMETRIC CAPACITY CONTROL

- Vary Upload Versus Download Capacity
- Reduce Your CAPEX
REDUNDANCY

THREE OPTIONS:

• **1+0 Non-Redundant Link:**
  – Support non-critical applications
  – One ODU and one CMU at each link end
  – Can later upgrade to 1+1 or 2+0 redundancy if desired

• **1+1 Hot Standby Redundant Link:**
  – Support critical applications
  – Two ODUs and two CMUs at each link end
  – Share the same antenna or use two antennas

• **2+0 Two Independent Links:**
  – Support critical applications
  – Two ODUs and two CMUs at each link end
  – Share the same antenna or use two antennas
  – Requires an external switch
PTP 800 INDOOR Features

Support PTP 800i all indoor Solution with IRFU @ 6/11 GHz

Support Switch Spatial Diversity for ODU-A, ODU-B and IRFU

Support Layer-3 QoS - DSCP (Different Service Code Point) and TC (Traffic Class) of MPLS labels.

Enhanced Security Features includes:
- FIPS 140-2
- Secured Radius
- Authenticated SNTP
- Syslog

PTP 800 High-Power Indoor Unit (iRFU)
Support of All Indoor with IRFU

- Low VSWR Antenna
- Helix Elliptical Waveguide
- Fixed Tuned Connector
- Gas Distribution Manifold
- Pressure Window
- 1+1 SD iRFU
- CMU
- Dehydrator
IRFU Key Features

• Very High Tx power ➔ higher system gain
  – Guaranteed 30 dBm @128 QAM on 6 GHz

• Low Rx sensitivity ➔ higher system gain
  – Very low noise figure on IRFU

• Hitless and Errorless ACM with adaptive Tx power, QPSK to 256 QAM

• Eco-mode, offering reduced power consumption

• Flexible Upgrade Path

• Compact design, 2.75 U heights for 1+1 protected configuration
Frequency Band

- 6 GHz
  - Range: 5.925 ~ 7.125 GHz
  - Support both FCC L6, U6 and 7 GHz.
  - Support IC L6 and U6.

- 11 GHz
  - Range: 10.696 ~ 11.71 GHz
  - Support both FCC/IC 11 GHz.

10/20/25/30/40 MHz channel plan.
Paired and unpaired frequency plans
Single Tx module covers complete 6 and 7 GHz, single Tx module for 11 GHz
Why All indoor?

• Reduce OPEX cost
  – Less expensive to pay and insure ground-based personnel than the specialized personnel required to climb towers while working on active electronics, which make it popular especially for tower companies, utility and railroads and large carriers.
  – Trade unions in particular are often reluctant to approve tower climbing by their members in the United States, which makes all indoor solution more popular in the United States.

• Reduced repair time
  – All indoor solution offers convenient access to all the electronics equipment without requiring tower climbs. Technicians can repair or replace equipment on site – even in inclement weather – without the need to work outdoors.

• Ideal Long Haul Solution
  – 50 miles per hop using high power all indoor solution compare with 15-25 miles per hop using split mount radio
Target Vertical Markets

- Public safety
- Utility Companies
- Railroad
  Transportation
- Carriers
SPATIAL DIVERSITY

IDEAL OVER WATER AND FLAT TERRAIN

Wireless signals across water or hard surfaces (desert) pose performance and reliability challenges:

• Highly reflective surfaces create multi-path interference
• Varying water heights create over-sea challenges

Spatially diverse antennas can mitigate the ducting and fading that is typical over water and desert.
Why Spatial Diversity

• Spatial Diversity improves link availability by providing each end of a wireless link with multiple observations of the signal which has been transmitted from the remote end of the link.

• It is particularly effective in combating multipath fading caused by atmospheric effects such as scintillation and ducting. Both these effects can occur to a significant degree in microwave links. It also combats fading caused by reflections from water.
## BENEFITS OF OUR ACM

<table>
<thead>
<tr>
<th>Smoothest Step Changes</th>
<th>Supports 8 modulation step changes – smoothest in the industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hitless and Errorless</td>
<td>No bit errors or traffic suspension during modulation shifts</td>
</tr>
<tr>
<td>Enhanced QoS Control</td>
<td>No negative impact on high priority voice and data traffic with enhanced QoS</td>
</tr>
</tbody>
</table>
| Easy Configuration     | • Control the highest and lowest modulation modes.  
                          • ACM configuration with PTP LINKPlanner tool |
| CAPEX and OPEX Savings | • No charge to enable ACM on PTP 800 radios  
                          • Fast one-time set-up – no further intervention required  
                          • Reduce antenna size  
                          • Fewer hops via increased distances  
                          • Use existing site infrastructure |
Security Enhancements

• Validation to FIPS 140-2
• Secure Radius, support following authentication protocols
  – MS-CHAPv2
  – PEAP (MS-CHAPv2)
• Authenticated SNTP
  – Authentication of SNTP message using DES and MD5
  – Support of Primary and secondary SNTP servers
• Comprehensive logging of all configuration changes
  – Record general configuration and status changes
• Login information
  – Require a user of web based interface to acknowledge security notices before logging in.
## Configuration - Options

### Flexible Configurations

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+0</td>
<td>Non redundant system</td>
</tr>
<tr>
<td>1+0, MHSB Ready to</td>
<td>Non redundant system, ready to upgrade to 1+1 with Equal Splitter</td>
</tr>
<tr>
<td>Upgrade to 1+1, EQ</td>
<td></td>
</tr>
<tr>
<td>1+0, MHSB Ready to</td>
<td>Non redundant system, ready to upgrade to 1+1 with Un-Equal Splitter</td>
</tr>
<tr>
<td>Upgrade to 1+1, UNEQ</td>
<td></td>
</tr>
<tr>
<td>1+1, EQ</td>
<td>1+1, Hot Standby redundant system with Equal Splitter</td>
</tr>
<tr>
<td>1+1, UNEQ</td>
<td>1+1, Hot Standby redundant system with Un-Equal Splitter</td>
</tr>
<tr>
<td>1+1, MHSB TX / SD RX</td>
<td>1+1, Hot Standby redundant system with Space Diversity (SD) receive path protection</td>
</tr>
<tr>
<td>2+0, East/East</td>
<td>Two carriers in single chassis support on a single antenna port: 6</td>
</tr>
<tr>
<td>2+0, East/West - Repeater</td>
<td>Two carriers in single chassis with independent antenna ports: 6</td>
</tr>
</tbody>
</table>
AUTOMATIC BILL-OF-MATERIALS

Simplifies ordering procedures

Configuration

Path Profile

Performance

BOM

### Bill of Materials for Link

<table>
<thead>
<tr>
<th>P/N</th>
<th>Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>01010208005</td>
<td>ODU-A 11GHz. TR 490 &amp; 500, Lo, B7 (11010.0 - 112000.0 MHz), Rectangular WG, Neg Pol</td>
<td>1</td>
</tr>
<tr>
<td>01010208006</td>
<td>ODU-A 11GHz. TR 490 &amp; 500, Hi, B7 (11510.0 - 117000.0 MHz), Rectangular WG, Neg Pol</td>
<td>1</td>
</tr>
<tr>
<td>85010089000</td>
<td>6' HP Antenna, 10.70 ~ 11.70 GHz, Single Pol, Rot Inteface</td>
<td>2</td>
</tr>
<tr>
<td>WB3480</td>
<td>PTP800 Modem 1000/100BaseT with Capacity CAP 10 Mbps</td>
<td>2</td>
</tr>
<tr>
<td>WB3546</td>
<td>PTP800 Modem Capacity CAP - Full Capacity (per Unit)</td>
<td>2</td>
</tr>
<tr>
<td>WB3616</td>
<td>Coaxial Cable Installation Assembly Kits (w/ or Surge Arrestor)</td>
<td>2</td>
</tr>
<tr>
<td>WB3657</td>
<td>LPU END KIT PTP800 (1 kits required per Coaxial cable)</td>
<td>2</td>
</tr>
</tbody>
</table>
TYPICAL APPLICATIONS

• Leased-line replacement / extensions
• WiMAX and LTE backhaul
• ASTRO® / Dimetra™ backhaul
• Public safety / disaster recovery
• High-speed wireless backhaul
• Video surveillance
• Network redundancy
• Building-to-building and campus connectivity
• Last mile access
• Rapid deployment
• IP network migration
## PMP Portfolio

<table>
<thead>
<tr>
<th></th>
<th>PMP 120</th>
<th>PMP 120 900 MHZ Advantage</th>
<th>PMP 130 Advantage</th>
<th>PMP 320</th>
<th>PMP 400</th>
<th>PMP 430</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radio Frequencies (GHz)</strong></td>
<td>2.4, 5.1, 5.2, 5.4, 5.8, 5.9</td>
<td>2.4, 5.1, 5.2, 5.4, 5.8, 5.9</td>
<td>3.3, 3.5, 3.6</td>
<td>4.9GHz</td>
<td>5.4, 5.8</td>
<td></td>
</tr>
<tr>
<td><strong>Useable Throughput (Mbps)</strong></td>
<td>7</td>
<td>4</td>
<td>14</td>
<td>23 (up to 40 with MIMO B)</td>
<td>20</td>
<td>&gt;40</td>
</tr>
<tr>
<td><strong>Latency (msec)</strong></td>
<td>3.5</td>
<td>&lt;7.5</td>
<td>3.5</td>
<td>25</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>OFDM</strong></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
Continuing Innovations: PMP 450

- Increased Throughput
- Dual Platform Radio
- Software Defined Radio
- Scalable
- Interference Tolerant
Solution: PMP450 Dual Protocol AP

- **Simultaneously talks** to both FSK & OFDM SMs using Canopy MAC protocol
- Dramatically increases overall **system capacity**
- **No wholesale change-out** of SMs required to achieve benefits
- **Intelligently adapts** as OFDM loading increases to maximize performance
- OFDM MIMO data rates of **up to 90 Mbps** peak throughput
- MIMO subscribers to **maximize network capacity**
PMP450 – Access Point
# PMP450 Key Features

<table>
<thead>
<tr>
<th>Radio Performance Features</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Band (5.4 and 5.8 GHz)</td>
<td>Single SKU covers both bands!</td>
</tr>
<tr>
<td>2x2 MIMO</td>
<td>Higher spectral efficiency, throughputs and/or link budgets</td>
</tr>
<tr>
<td>Seamless operation with PMP100 and PMP430</td>
<td>Migration path to new technology, capacity gains without total system replacement</td>
</tr>
<tr>
<td>Dynamic Bandwidth Allocation by technology</td>
<td>Maximizes capacity of sector with mixed product</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Features</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000BaseT (Gig-E) interface</td>
<td>Allows for future platform enhancement</td>
</tr>
<tr>
<td>IP67 Certified Access Point Housing</td>
<td>Fully weather rated</td>
</tr>
<tr>
<td>Built-in surge suppression on AP</td>
<td>No additional parts needed</td>
</tr>
</tbody>
</table>
## PMP450 Key Features

<table>
<thead>
<tr>
<th>Cambium Features</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low, consistent latency operation</td>
<td>Network loading doesn’t affect performance</td>
</tr>
<tr>
<td>Flexible Networking Capability</td>
<td>Same GUI and Canopy features, management continuity across products</td>
</tr>
<tr>
<td>Tiered Subscriber Modules</td>
<td>Range of prices and performance to meet all WISP needs</td>
</tr>
<tr>
<td>Optional passive antenna options for the Subscriber Module</td>
<td>Enhance the SM range only when needed</td>
</tr>
<tr>
<td>A Range of Synchronization options: CMM, UGPS, embedded GPS (future)</td>
<td>Allows for synchronization at price that makes sense for the deployment</td>
</tr>
</tbody>
</table>
Definition: Area Averaged Sector Capacity

Using Integrated Patch Antenna on SM

Area Average of 21 Mbps
Across coverage area
Of ~4 miles

Assume:
• Users are uniformly distributed across coverage area
• Data usage is equally distributed across subscribers
• Sector edge is 6 miles (not to scale)
Definition: Area Averaged Sector Capacity

Using Cassegrain Antenna on SM

Area Average of 36 Mbps
Across entire coverage area

Assume:
• Users are uniformly distributed across coverage area
• Data usage is equally distributed across subscribers
• Sector edge is 6 miles (not to scale)
Definition: Area Averaged Sector Capacity

Assume:
- Users are uniformly distributed across coverage area
- Data usage is equally distributed across subscribers
- Sector edge is 6 miles (not to scale)

Using Reflector Dish Antenna on SM

Area Average of 59 Mbps
Across entire coverage area

30 Mbps
Flexible Deployment Options

60° sector  
FSK replacement

90° sector*

120° sector*
### PMP450 Platform Opportunities

<table>
<thead>
<tr>
<th>Possible Future Enhancement</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual sector SISO support</td>
<td>Could support 2 sectors with single radio</td>
</tr>
<tr>
<td>40 MHz channel bandwidth</td>
<td>Effectively double the aggregate throughput</td>
</tr>
<tr>
<td>256 QAM modulation (4x)</td>
<td>Enhanced throughput at close range</td>
</tr>
<tr>
<td>Embedded GPS</td>
<td>Remove need for external device to synchronize network</td>
</tr>
<tr>
<td>PTP product release based on PMP450</td>
<td>Further enhance the low end PTP portfolio</td>
</tr>
</tbody>
</table>

*Not currently committed features*
Thank You!

Cambium Networks

www.cambiumnetworks.com