
ePMP™
BY CAMBIUM NETWORKS

Who Is Cambium Networks?

Industry leader in Point-to-Multipoint and Point-to-Point IP Wireless Broadband Solutions

Independent company since 2011
(Formerly part of Motorola Solutions)

More than 4.0 million nodes shipped totaling over $1B to thousands of networks in over 150 countries

Uniquely positioned to deliver breakthrough Wireless Solutions globally

Financially healthy and profitable company with a strong equity investor, Vector Capital

Cambium Networks Solutions

Orthogon Point-to-Point (PTP) Access and Backhaul Links

- Market leader in unlicensed Cognitive Radio Technology
- Spectrally agile using Dynamic Spectrum Optimization™
- Used for the most challenging links globally!

Canopy Point-to-Multipoint (PMP) Access Networks

- Market leader in unlicensed & licensed PMP
- Ideal for enterprise access
- Voice, video and data capable

ePMP™ BY CAMBIUM NETWORKS

- The new Standard in Wireless Broadband
- Affordable Scalability and Reliability

Goals for the ePMP Product

- **Priced** to help your business grow:
  - Low priced CPE
  - Access Point equipment with <= 6 month payback for <= 10 low ARPU subs
- **Features and Capabilities**:
  - Each Radio can be AP, SM, PTP - 5GHz ver covers all sub-bands
  - 2x2 MIMO in 20 / 40 MHz channels
  - Incorporating Signature Capabilities of Cambium's PMP Solutions
    - GPS Synchronized – to allow for frequency reuse
    - High Scalability and Performance Consistency
    - eFortify – to maintain performance in external interference
    - Effective QoS for support of prioritized data, voice and video
    - eCommand – to help Plan, Provision and Monitor your Network
    - Designed for Reliability following the Cambium Quality Process

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Solution Overview

ePMP Solution Overview

GPS Synchronized Radio

Unsynchronized Radios

High Performance GPS-Synchronized MAC

- Precision Timing
- Dynamic Tx Range w/ AutoTx Power Control
- 3 Level QoS w/ Auto VoIP Prioritization

Sector Antennas

90 degree Sector

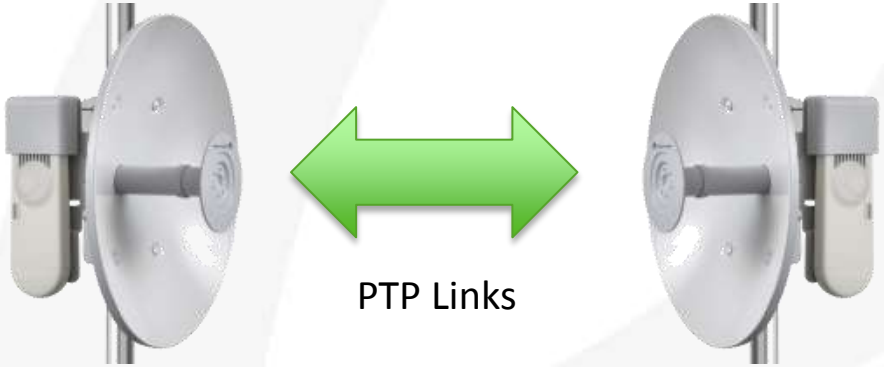
120 degree Sector

Reflector Dish for Integrated Radios

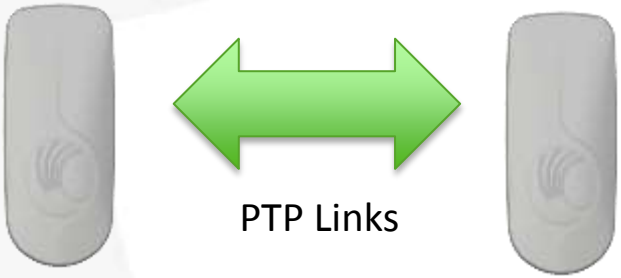
SW Platform including GUI & Element Management System

Deployment Configurations

Synchronized & Unsynchronized



Unsynchronized



Synchronized & Unsynchronized PMP

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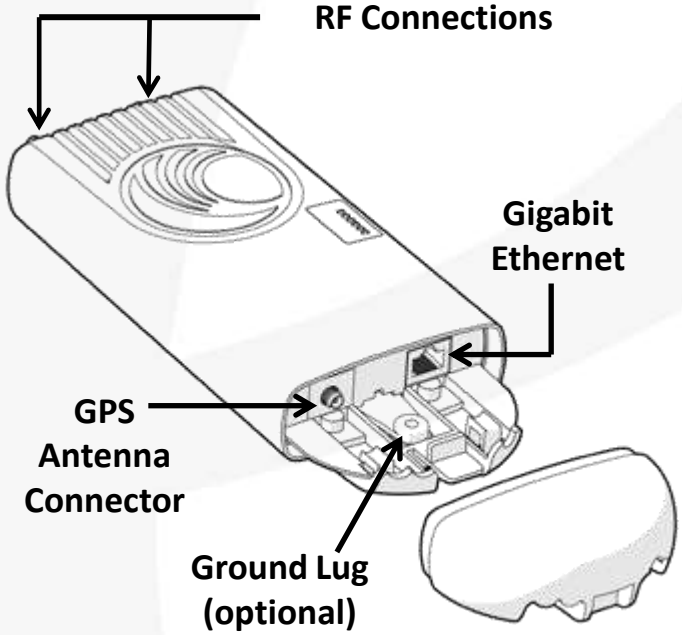
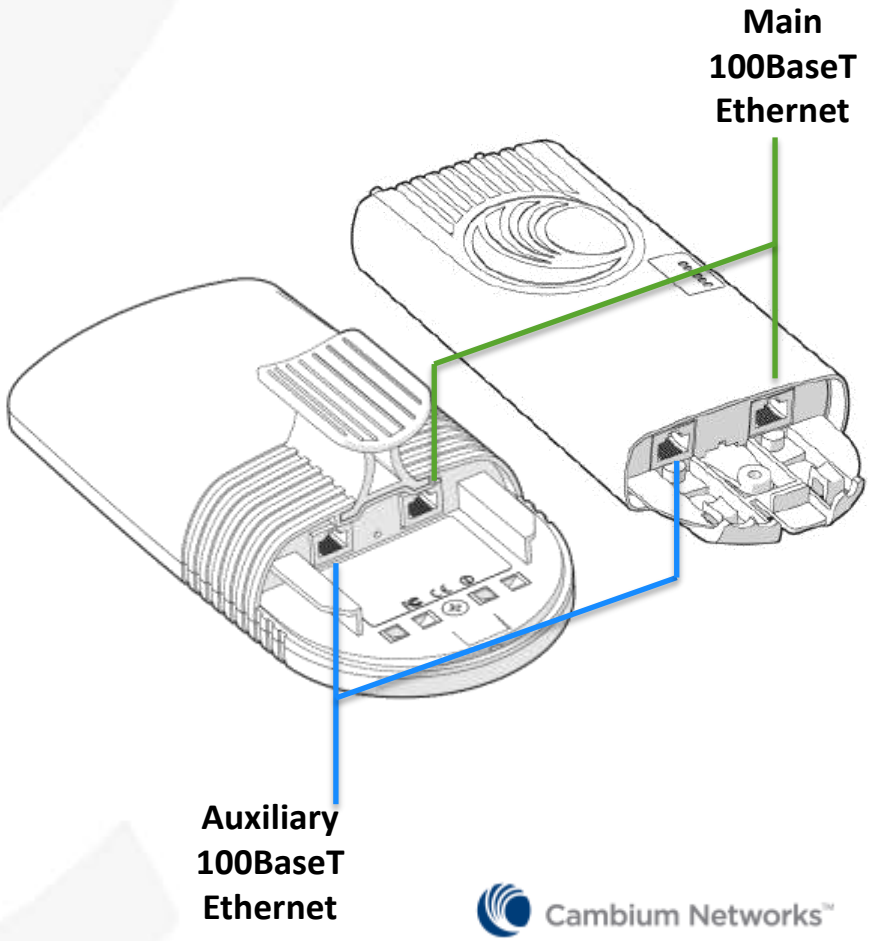
Radio Interconnections

GPS Synchronized Connectorized Radio



Unsynchronized Radios



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Sector Antennas

Slot for GPS Antenna (5 GHz)

Removable Protective Cover

Grounding and Mechanical Connection via screw

Adjustable Brackets

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ePMP Reflector Dish

- Designed for Integrated Radio
- Same Dish works for 2.4 GHz and 5 GHz
- Increases Aggregate Gain to 19 dBi
  - Adds 6 dBi of gain for 5 GHz
  - Adds 7 dBi of gain for 2.4 GHz

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New ePMP Force 100!

- New Dish Antenna Accessory custom-designed to easily connect to the ePMP Connectorized Radios
  - Conn Radio Mounts to Bracket via the mounting screw at bottom of radio
- Dish Antenna includes:
  - Mounting Bracket that allows for pole mounting on *either* side
  - RP-SM to N-Conn RF Cables
  - Protective Cover for RF Connections
- Ordering Now for September Availability:
  - Dish Antenna may be ordered alone
  - Dish Antenna and Conn Unsync Radio (CSM) Bundle -

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Solution Specifications

Parameter	Specification
Frequency Bands	5 GHz: 5150 – 5970 MHz* 2.4 GHz: 2402 – 2472 MHz
Headline Throughput (40 MHz Channel)	200+ Mbps
Maximum # SMs	120
Maximum Tx Power	5 GHz – Global: 30 dBm (5.8 - 5.4), 27 dBm (5.2 - 5.1 GHz)* 5 GHz – FCC: 23 dBm (5.8), 14 dBm (5.4-5.2), 20 dBm (5.1) 2.4 GHz: 30 dBm*
Power Consumption	8.5 W Maximum
Environmental	-30C to +60C Operating Temp
Antenna Gains	**5 GHz** / **2.4 GHz** Integrated: 13 dBi / 12 dBi Integrated + Ref 19 dBi / 19 dBi ePMP Force 25 dBi 90 deg Sector: 15 dBi / 15 dBi 120 deg Sector: 14 dBi

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* Subject to regulatory restrictions

What Makes ePMP Different?

ePMP Key Differentiating Features

- GPS Synchronized provides for frequency reuse
- High Scalability and Performance Consistency
- eFortify – to maintain performance in external interference
- Effective QoS for support of prioritized data, voice and video
- eCommand – to help Plan, Provision and Monitor your Network
- Designed for Reliability per the Cambium Quality Process

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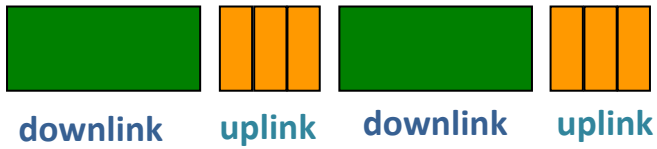
How Does GPS Synchronization Work?

- Synchronized TDD Frames
  - Fixed DL / UL ratios , precision Tx timing

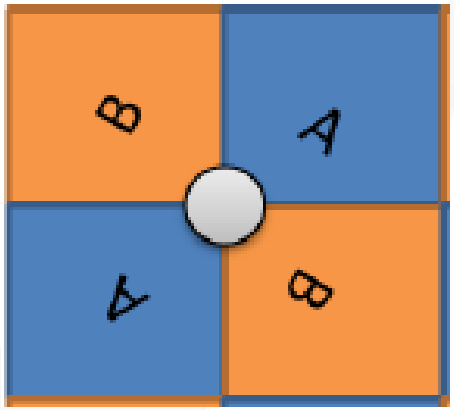


- Automatic AP control of SM Tx Power
  - SM Tx Pwr set to Achieve same optimal Target Receive Level at AP

- Sector Antennas with High (> 30 dB) F/B Ratio

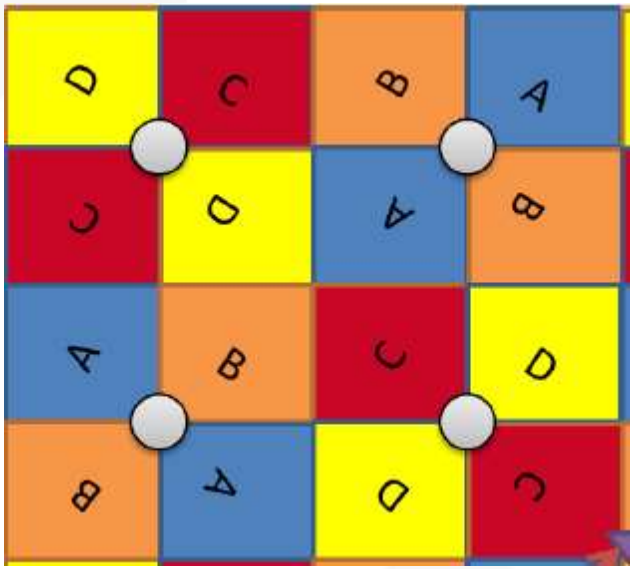
What Does it Do For You?

Within A Sectorized Site



One Site with 2 Channels

Across A Contiguous Network



The Entire Network with 4 Channels

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- For More Information
- See the whitepaper on GPS Synchronization ROI at:
- www.cambiumnetworks.com

Scalable and Consistent Performance: 120 SMs per ACCESS POINT !

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How Does ePMP Delivery Highly Scalable and Consistent Performance?

Frequency Reuse and No Self-Interference

ePMP MAC Protocol Efficiency

“Air Fairness” Adaptive Scheduler

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ePMP MAC Protocol Efficiency

- Efficient Use of RF Capacity
- Allows for High SM Scalability
- Allows for Consistent Performance even in High Interference Environments

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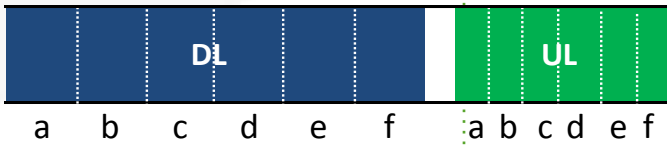
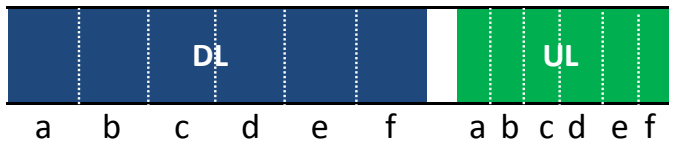
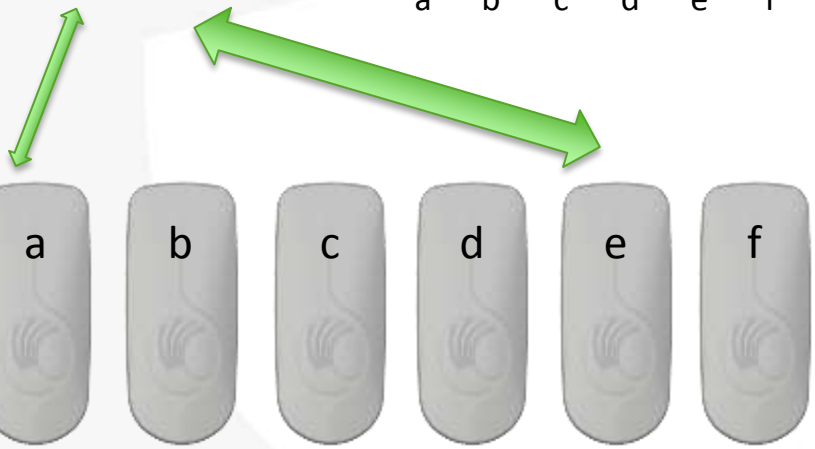
Air Fairness Adaptive Scheduler

- "Air Fairness" Scheduler Prevents a few "Bad" SMs from dragging down the entire Access Point
- Resource Allocations based on Time, not Throughput







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eFortify
High Performance in
High Interference Environments

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eFortify – Recognize and React

- You are not Alone out there
- Spectrum is Congested
- GPS Sync: Provides a Solid Foundation on which to build a Network
- eFortify:
  - Builds on GPS Sync
  - By providing higher performance operation in the face of External Interference
  - Maintains Consistent Latency

eFortify – How Does it Work?

ePMP MAC Protocol Efficiency

“Air Fairness” Adaptive Scheduler

Interference Optimized Rate Adapt Algorithms

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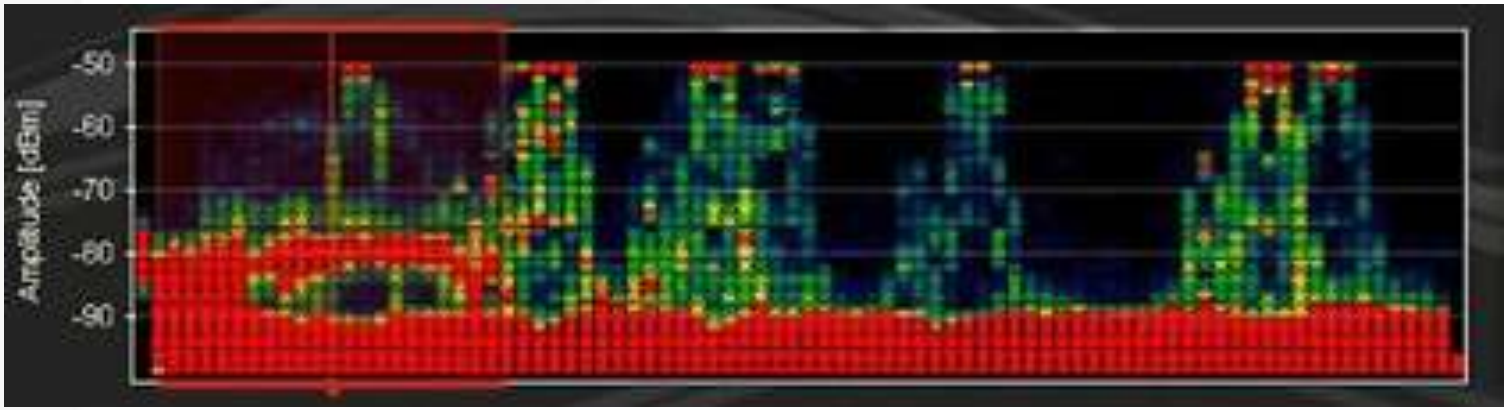
Interference Optimized Rate Adapt Algorithms

- Adaptive Modulation Algorithms optimized to address the bursty nature of Interference
- Making the right choice between error recovery by Retransmissions or down-shifting modulations



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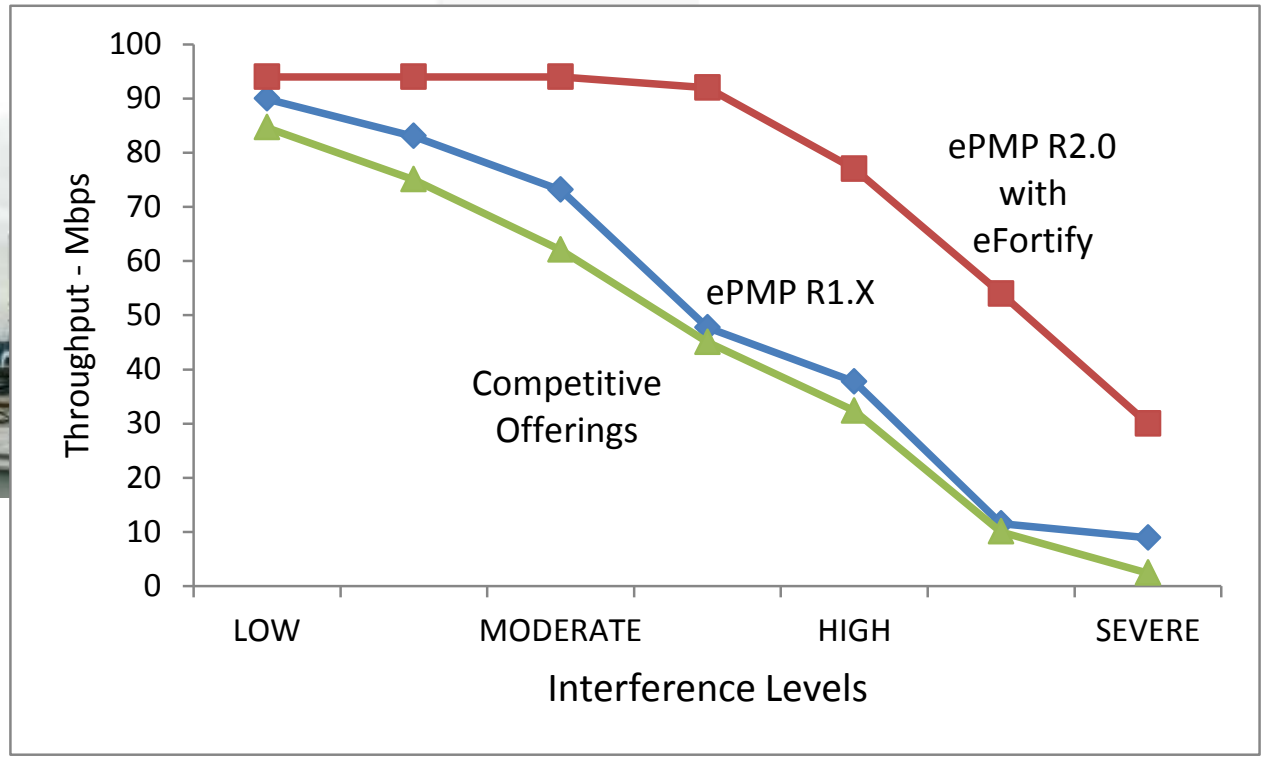
Real Advantages in High Interference



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Effective QoS for High Value Services

- Three level priority scheme for packets: Voice, High, Low
- VoIP Packets are Automatically detected (CoS = 5 or DSCP = 46) and given the highest priority
  - High Priority treatment within Radios and in Media Access
- User can configure rules to classify High Priority Packets
  - Both L2 and L3 Classifiers
- All other Packets given Lowest Priority
- Prioritization is managed by a Air Fairness Scheduler

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eCommand

eCommand – Plan, Provision and Monitor

- A suite of management tools to plan, provision and monitor the ePMP network
- Providing operators with the ability to confidently deploy high performance networks, with greater visibility and control
- An Area of Focus for future Software Enhancements for the ePMP Portfolio

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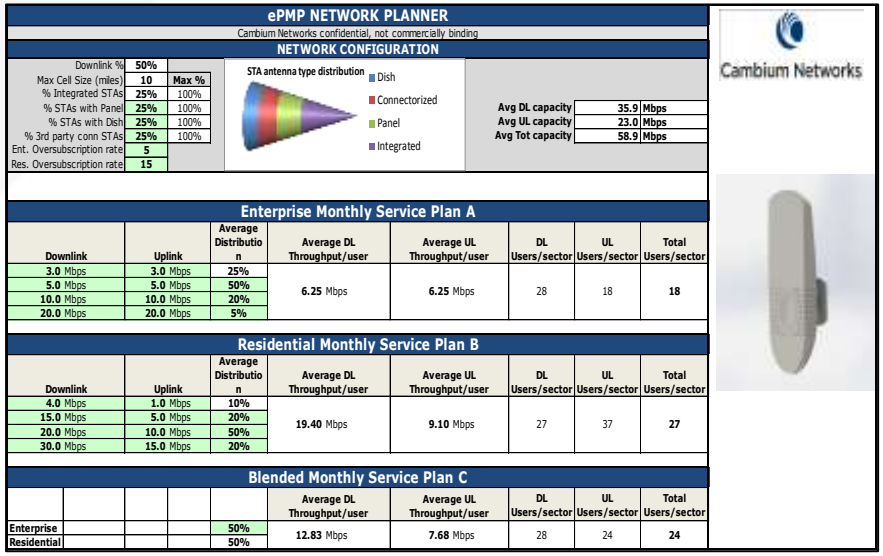
Estimate Performance the ePMP Capacity Planner

- Excel-based Tool that provides a details about the performance you can expect from the ePMP.
- Estimate the throughput and capacity that an ePMP Access Point can provide based on:
  - Distance of SMs from the AP
  - Transmit power levels
  - Antenna gains and
  - Expected level of interference in the environment.



ePMP NETWORK PLANNER

Cambium Networks confidential, not commercially binding

NETWORK CONFIGURATION

Downlink %	50%	
Max Cell Size (miles)	10	Max %
% Integrated STAs	25%	100%
% STAs with Panel	25%	100%
% STAs with Dish	25%	100%
% 3rd party conn STAs	25%	100%
Ent. Oversubscription rate	5	
Res. Oversubscription rate	15	

STA antenna type distribution: Dish, Connectorized, Panel, Integrated

Avg DL capacity	35.9	Mbps
Avg UL capacity	23.0	Mbps
Avg Tot capacity	58.9	Mbps

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Enterprise Monthly Service Plan A

Downlink	Uplink	Average Distribution	Average DL Throughput/user	Average UL Throughput/user	DL Users/sector	UL Users/sector	Total Users/sector
3.0 Mbps	3.0 Mbps	25%	6.25 Mbps	6.25 Mbps	28	18	18
5.0 Mbps	5.0 Mbps	50%					
10.0 Mbps	10.0 Mbps	20%					
20.0 Mbps	20.0 Mbps	5%					

Residential Monthly Service Plan B

Downlink	Uplink	Average Distribution	Average DL Throughput/user	Average UL Throughput/user	DL Users/sector	UL Users/sector	Total Users/sector
4.0 Mbps	1.0 Mbps	10%	19.40 Mbps	9.10 Mbps	27	37	27
15.0 Mbps	5.0 Mbps	20%					
20.0 Mbps	10.0 Mbps	50%					
30.0 Mbps	15.0 Mbps	20%					

Blended Monthly Service Plan C

					Average DL Throughput/user	Average UL Throughput/user	DL Users/sector	UL Users/sector	Total Users/sector
Enterprise				50%	12.83 Mbps	7.68 Mbps	28	24	24
Residential				50%					

Download the Tool and User Guide from:
https://support.cambiumnetworks.com/files/epmp

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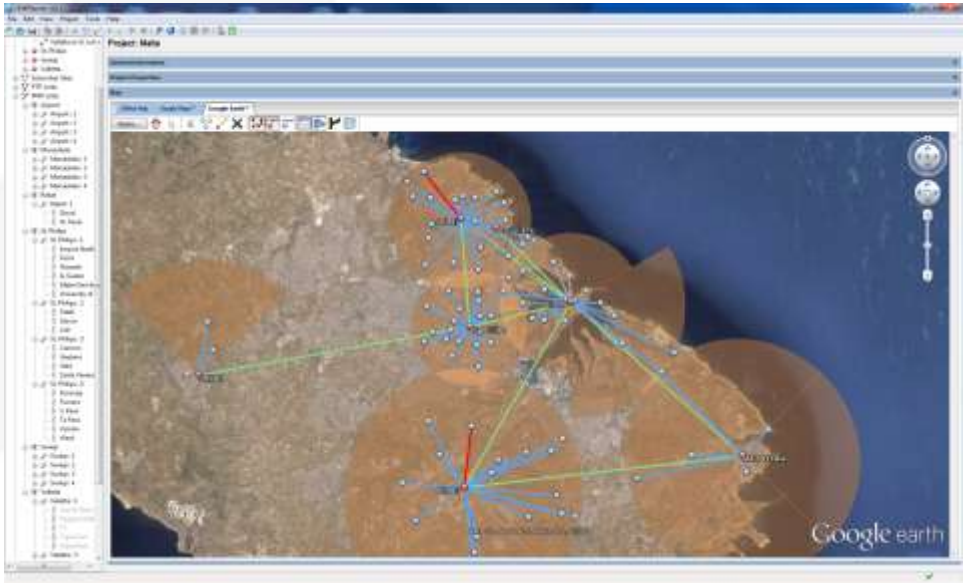
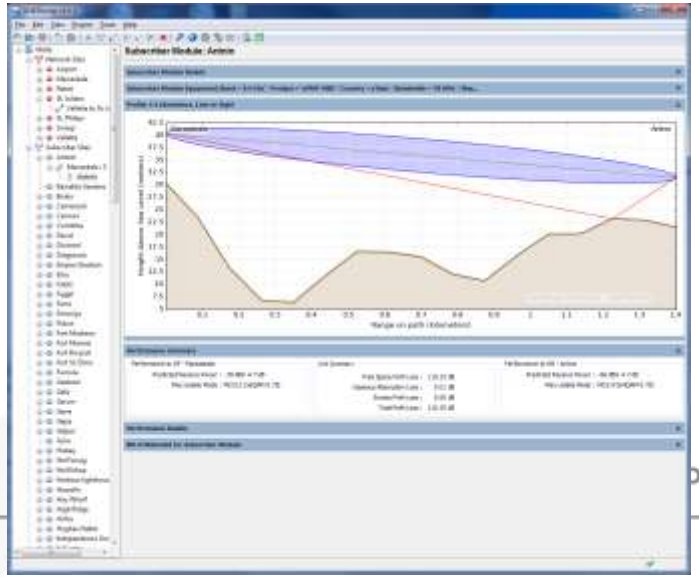
Plan your Network with LINKPlanner

- Easily Import Location Information of AP and SM Modules

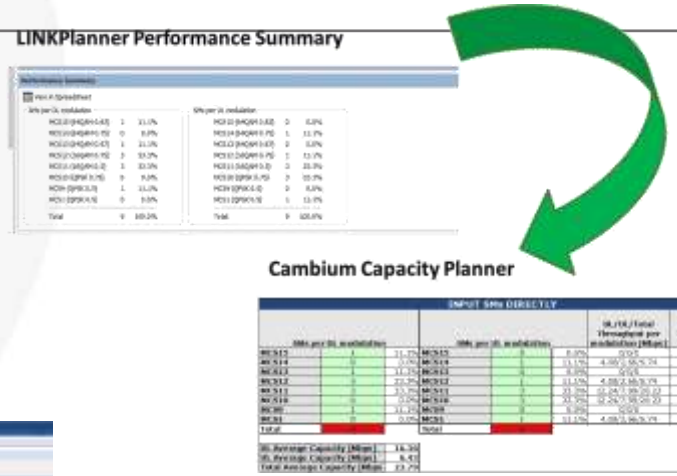


- View Path Profiles

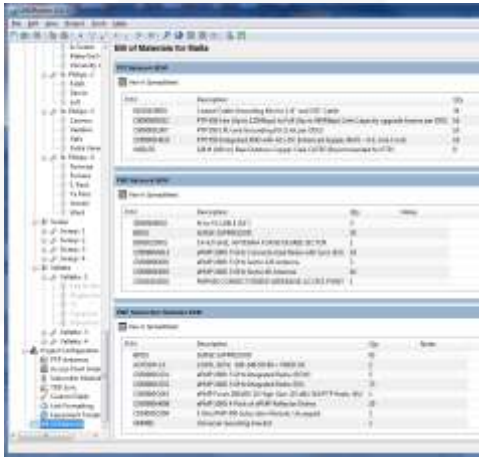


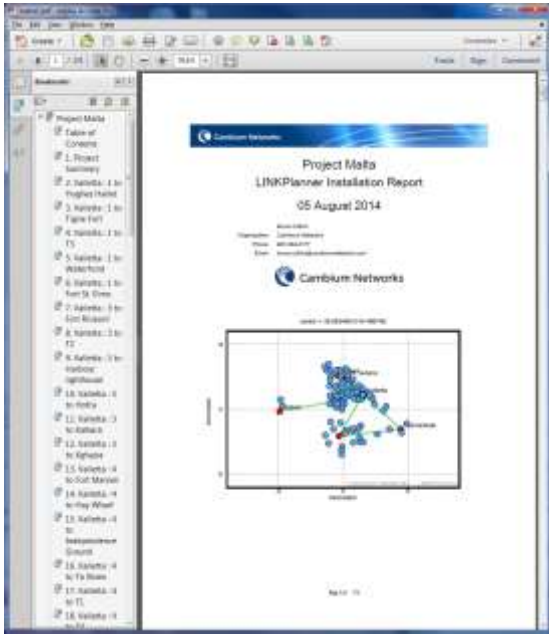
- Adjust Configuration and Optimize

- **Estimate Capacity with Export to Capacity Planner**



- **Create Bill of Materials**





- **Generate Proposals**

Monitor with eDetect

- A new tool that runs with no impact to normal operation
- Measures the level of co-channel interference that each Radio detects
- Provides “Stop Light” Status:
  - Green: C/I > 25 dB
  - Yellow: 10 dB < C/I < 25 dB
  - Red: C/I < 10 dB
- Provides a quick Visual Indication of the potential trouble spots in the network

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Monitor with CNS – Cambium Networks Services

- Device Discovery and Monitoring
- Software Upgrade
- Device Configuration

ePMP Reliability

Cambium Reliability Recipe

Ingredient	ePMP
Design with Margin	
High Quality Components	
ESD / Surge Protection	
Robust Enclosure	
Robust Design Verification	
Reliability Testing (ALT)	
High Quality Manufacturing	

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ePMP™

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Applications

Migrating Competing Low Cost Solutions to ePMP

- Silo Wireless, Ontario, Canada used a mix of Cambium PMP and competing low cost solutions for access
- Needed a technology upgrade for their low cost solution
- Chose ePMP due to:
  - GPS Sync and Frequency Reuse
  - Effective QoS to allow for Voice Communications
  - High Performance even under conditions of external interference

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Reliable CCTV on a Small Budget

- Seattle, Washington, USA
- Economic Development Zone
- ePMP Delivers Affordable Security

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Technology Upgrade to Meet Increasing Bandwidth Demands

- Sao Paolo, Brazil
- Cost Effective Bandwidth Upgrade to keep High Value Customers
- Heavy VoIP and Video Streaming Usage
- Fast, Efficient Deployment to Minimize Impact to Customers

Station	Distance (m)	Current Throughput	ePMP Throughput
A	2100	7 MBPS	97 MBPS
B	200	39 MBPS	99 MBPS
C	1300	24 MBPS	99 MBPS

More than 2X the Subscriber Density of Competing Solutions means Removing Barriers to Growth

- Miskolc, Hungary
- High Subscriber Density in Town Center
- Existing Solution had reached its limit at 20 subs / AP
- ePMP Scales to over 50 subs / AP with consistent performance

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Summary

ePMP™
BY CAMBIUM NETWORKS

Summary

- ePMP is a new family of PMP / PTP Products from Cambium Networks
- An alternative to competitive offerings in the low cost category but with Cambium Quality and Reliability
- ePMP Incorporating Signature Capabilities of Cambium's PMP Solutions
  - GPS Synchronized provides for frequency reuse
  - High Scalability and Performance Consistency
  - eFortify – to maintain performance in external interference
  - Effective QoS for support of prioritized data, voice and video
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