

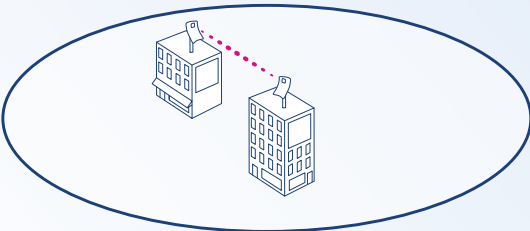


PTP Playbook

YOUR DATA: HOW FAST? HOW FAR? HOW CRITICAL?

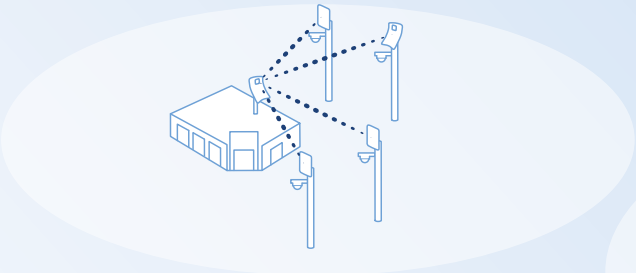
Table of Contents

Cambium ONE Network	3
1 Getting Started: PTP Selection Criteria	4
Capacity	5
Range	5
Availability	5
2 Key Terminology	6
3 Unique Features for PTP	7
Key Advantages of cnMaestro™	7
Link Planning	8
Support and Repair Maintenance	9
4 Fixed Wireless PTP Complements and/or Extends Fiber	10
5 Bridge-in-a-Box (PTP Simplified)	11
6 PTP Use Cases and Applications	12
7 Understanding Multi-Band Radio	13
8 Distance vs Capacity Tables	14
About Cambium Networks	21



POINT TO POINT

- » 100 Mbps to 20 Gbps
- » 100 meters to 60+ kilometers
- » Street-level or tower-height installations
- » Licensed or unlicensed spectrum (5 GHz, 6 GHz, 60 GHz, 80 GHz, 6/11/18/23 GHz Licensed)



POINT TO MULTIPOINT

- » 100 Mbps to 2 Gbps
- » 100 meters to 10 kilometers
- » Economically scalable (few devices to thousands of devices)
- » Spectrum diversity (5 GHz, 6 GHz, 60 GHz)



DISTRIBUTED

- » Resilient mesh
- » Ad hoc expansion; street-level deployments
- » Economically scalable (few devices to thousands of devices)
- » 60 GHz complements Wi-Fi deployments



- » ALL MANAGED IN cnMAESTRO
- » ALL PLANNED WITH LINKPlanner
- » SIMPLE LAYER 2 NETWORK INTEGRATION
- » DESIGN FOR UP TO 99.999% AVAILABILITY
- » SECURITY VETTED
- » TAILORED SUPPORT OPTIONS

Getting Started: PTP Selection Criteria

CAPACITY, RANGE & AVAILABILITY

Between the three selection criteria of **capacity**, **range** and **availability**, there is always a tradeoff, so it's important to understand which parameters are of priority.

- **Range** is typically driven by the application, such as connecting one building to another. Relay nodes, distributed networks, or the choice of operating spectrum are driven by the range requirement. Range can also be increased by installing a larger antenna.

Higher frequencies have lower range and typically require line of sight. Lower frequencies have longer range and improved non-line of sight but at lower capacities.
- Often **capacity** is the highest priority; if so, adding multiple shorter hops or reducing availability would be beneficial.

Also consider whether the data demand is equal in both directions (symmetrical) or higher in one direction than the other (asymmetrical).
- Other times, **availability** is critical, for example, in public safety or defense. Here the customer may need to create additional links using hot standby or use shorter hops to improve availability.
 - The Availability Table (page 5) explains the amount of time a link is up and running; 99.95% availability means on average the link would be down for 4.38 hours per year.
 - Typically, enterprise customers set 99.9% availability, ISP customers set 99.95% availability, and carriers set 99.99% or 99.999% availability.

Adaptive modulation and automatic transmit power control increase availability under a variety of conditions.

CAPACITY:

What throughput do I need?

AVAILABILITY:

How critical is this data ?

RANGE:

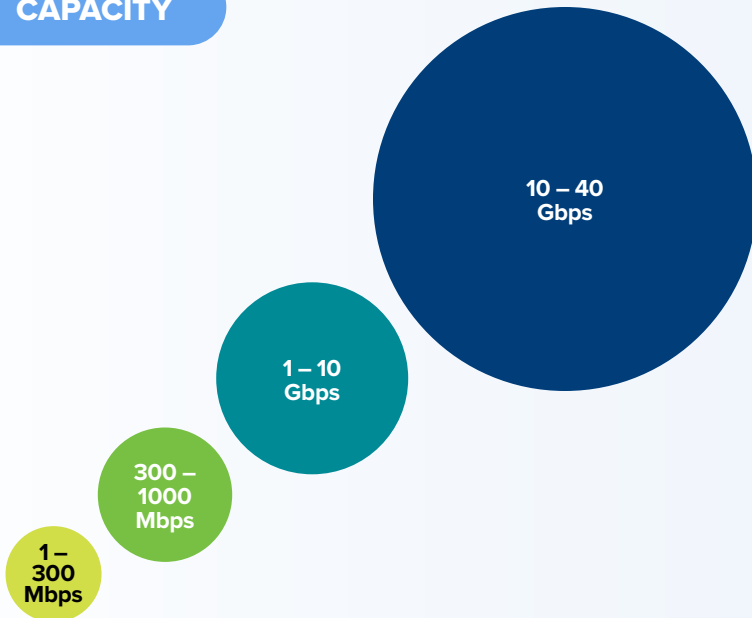
What distance do I need to reach?



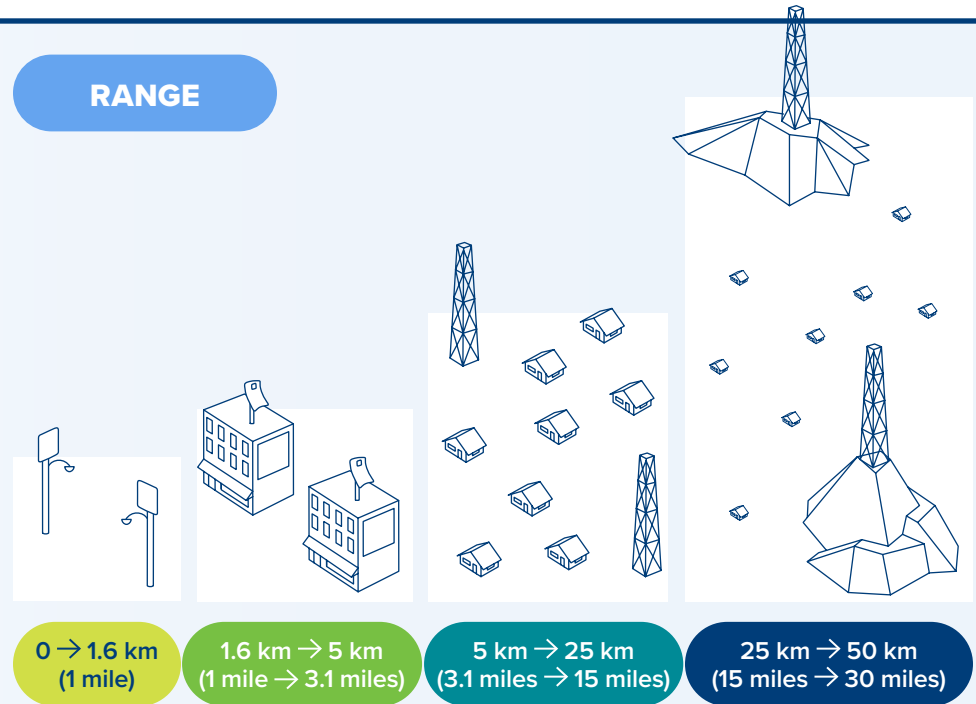
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Selection Criteria Definitions

CAPACITY



RANGE



AVAILABILITY

Availability Level (Uptime)	Allowed Unavailability Window		Application
	Per Year	Per Day	
99.90%	8.76 hours	1.44 minutes	Enterprise
99.95%	4.38 hours	43.2 seconds	ISP
99.99%	52.6 minutes	8.64 seconds	Critical Infrastructure
99.999%	5 minutes 13 seconds	0.86 seconds	Carrier

FDD VS TDD:

FDD uses two frequencies for simultaneous send/receive.

TDD uses one frequency, alternating between send and receive.

AGGREGATE CAPACITY VS ONE WAY CAPACITY:

Aggregate capacity indicates uplink (UL) capacity plus downlink (DL) capacity.

One-way capacity indicates either UL or DL capacity but not aggregate.

Most unlicensed PTP radios can be configured in 50:50 or 75:25 or other modes.

Typically, most licensed PTP radios are configured in 50:50 mode.

LICENSED VS UNLICENSED FREQUENCY:

Government agencies regulate which frequency bands can be used without any license or charge, these are known as unlicensed frequency; for example: 5 GHz, 6 GHz, 60 GHz.

Licensed frequency such as 11/18/23/80 GHz require a government license for deployment.

PTP RADIOS CAN BE SET UP IN MULTIPLE CONFIGURATIONS:

1+0: Single radio, no redundancy built in

1+1: Two radios; however, only single radio at any given time (aka hot standby)

2+0: Two radios working simultaneously

2+2: Four radios; however, only two radios are active at any point

4+0: Four radios working simultaneously

SPACE DIVERSITY:

Same signal sent through different antennas to improve reliability.

CONNECTORIZED VS INTEGRATED:

Integrated radios: The radio is permanently attached to the antenna, which cannot be changed. Simpler installation and sometimes smaller form factor.

Connectorized radios: Radio connects to various antennas, which can be adjusted per the link design to tailor capacity and availability at a given range.

XPIC:

XPIC doubles capacity using both vertical and horizontal polarity.

NARROW CHANNEL SIZE VS WIDE CHANNEL SIZE:

Narrow channel size improves receiver sensitivity and improves SNR (signal-to-noise ratio); ideal in high noise congested areas.

Wide channel size increases capacity but is susceptible to noise; ideal in low noise environments.

FADE MARGIN:

All wireless systems are subject to signal fade, which can be caused by environmental issues and/or interference. Fade margin is key to overall system availability and is the amount of fade that can be tolerated before capacity drops or the entire link drops.

MULTIPATH/REFLECTION:

When a signal is propagated from a transmitter, it will be transmitted in many directions. The signals will then travel in separate ways, bounce off objects, and spread. The signals that reach the same receiver may have taken different routes but still end up at the same destination. This is problematic for links over water; hence, those links can sometimes be improved with a special technique called space diversity (SD). SD typically sends the same data on two antennas to counteract the impact of reflective surfaces (e.g., water).

Unique Features for PTP



DSO (PTP 670):

Dynamic spectrum optimization (DSO) can improve link reliability by changing frequency selection automatically if the current channel is experiencing interference.



DCS (PTP 550):

Dynamic channel selection (DCS) can improve link reliability by changing frequency across bands and automatically selecting the best channels.



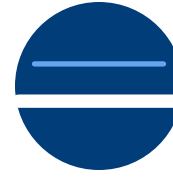
DYNAMIC DUTY CYCLE (ePMP™ 4xx and 5xx, PTP 670 and PTP 550):

Dynamically changes UL and DL ratio based on demand.



CHANNEL AGGREGATION (PTP 550) / LINK BONDING (cnWAVE™ V3000):

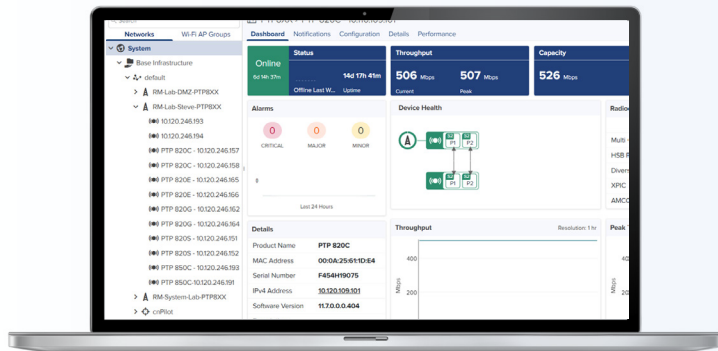
Uses two channels to effectively double the capacity of a link. The radio manages the combining of the data and re-assembly at remote end.



L1 LINK BONDING (PTP 850C/850E):

Data aggregation occurs at L1 (physical layer) rather than L2 (MAC layer). There is no requirement of VLAN or queue to monitor link use between them.

KEY ADVANTAGES OF cnMAESTRO:



- » Unified management platform:
- » All Cambium products are supported with cnMaestro Network Management.
- » Create, provision, monitor, and manage the entire network of wireless and wired devices from a single dashboard login with **key performance metrics**, alarms, and alerts.
- » Single map (logical/physical) view of the entire network showing status of all devices.
- » cnMaestro delivers enterprise-grade automatic RF management for networks with up to thousands of sites, and up to **10,000 managed devices**, from a single cnMaestro account.
- » Troubleshooting and 24/7 support available.
- » APIs and webhooks
 - » Statistics reports exported as .csv
 - » RESTful monitoring/provisioning API
 - » Export UI tables in .csv or .pdf

More information:



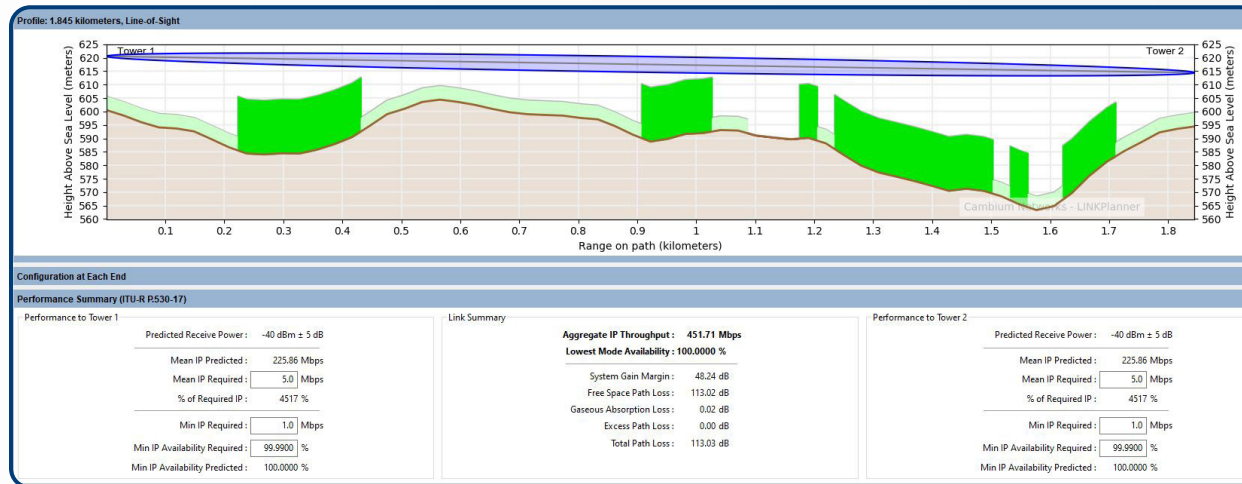
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Link Planning

LINKPlanner IS A FREE TOOL FROM CAMBIUM NETWORKS THAT PROVIDES NETWORK DESIGN CAPABILITIES.

Why is link planning important?

- › Provides estimated system performance before product purchasing.
- › Helps design complex networks for optimal deployment and cost effectiveness.
- › Generates reports that validate projected performance and serve as time-saving deployment guidelines.
- › Creates a bill of materials for PMP and PTP networks, including accessories.



Link Summary	
Aggregate IP Throughput	413.12 Mbps
Lowest Mode Availability	100.0000%
<hr/>	
System Gain Margin	30.03 dB
Free Space Path Loss	119.62 dB
Gaseous Absorption Loss	0.04 dB
Excess Path Loss	0.00 dB
Total Path Loss	119.65 dB
<hr/>	
Performance Summary	
Performance to AP-Airport	
Predicted Receive Power	-75 dBm ± 7 dB
Maximum Usable Mode	MCS-11 (16 QAM 0.5)
<hr/>	
Performance Summary (ITU-R P.530-17)	
Performance to Swieqi	
Predicted Receive Power	-47 dBm ± 5 dB
Mean IP Predicted	188.84 Mbps
Mean IP Required	150.0 Mbps
% of Required IP	126%
Minimum IP Required	100 Mbps
Min. IP Availability Required	99.9900%

More information:



Support and Repair Maintenance

SUPPORT AND WARRANTY:

All PTP devices come with a standard warranty (see table below) with an option to buy an extended warranty of up to 5 years total.

For additional peace of mind, Cambium offers All Risks Advance Replacement, which provides hardware and replacement for hardware defects covered by the Standard Warranty and additionally covers other types of equipment damage, including:

- Lightning damage
- Weather damage
- Dropped unit
- Fire damage
- Vandalism

Products	Standard Warranty
PTP 820/850	1 year
PTP 670	1 year
cnWave V1000/V2000/V3000	3 years
PTP 450/550	3 years
ePMP Force 3xx,4xx	3 years

More
information:





DEPLOYING FIBER OPTIC CABLES:

- » Is **cost prohibitive** over long distances.
- » **Slower time to revenue:** Requires extensive planning, permitting, and physical installation of cables.
- » **Cost Considerations:** In less densely populated areas or where subscriber density is low, the initial cost of deploying fiber is high.
- » **Terrain and Physical Barriers:** Geographical obstacles such as rivers, mountains, or densely populated urban environments, can be challenging for fiber optic deployment.



DEPLOYING FIXED WIRELESS:

- » **Significantly lower cost** to deploy.
- » **Faster time** to revenue.
- » **Flexibility and Scalability:** Fixed wireless networks can easily extend coverage by using more tower stations or upgrading existing equipment.
- » **Temporary or Backup Connectivity:** Fixed wireless can serve as a reliable backup solution for fiber optic networks
- » **Repair and Maintenance:** Fixed wireless provides an easier way to repair, triage and maintain links compared to fiber optics links.

5

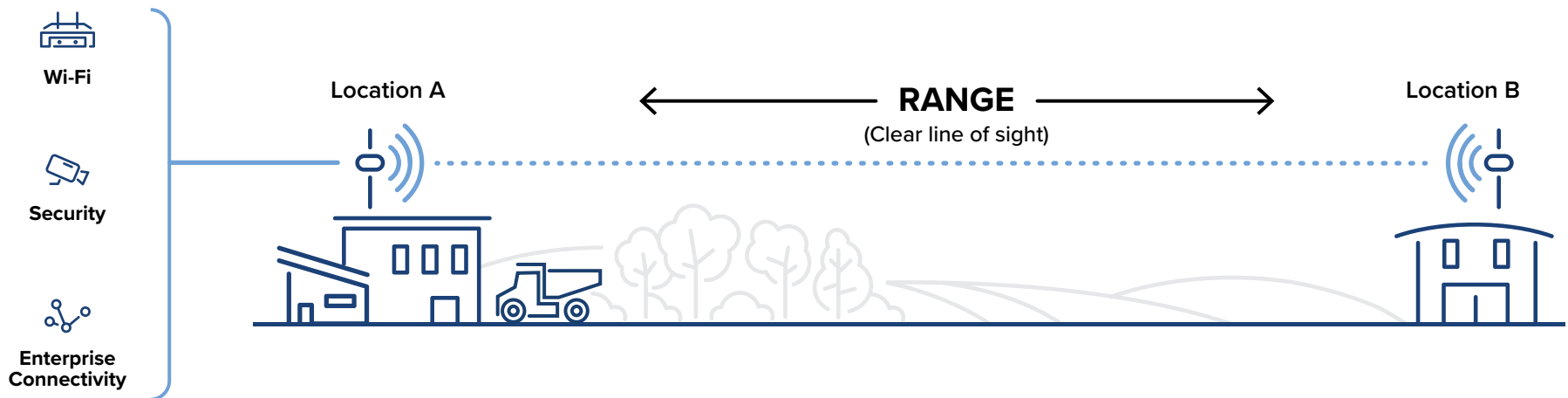
Bridge-in-a-Box (PTP Simplified)

Bridge-in-a-Box is a PTP link that comes preconfigured in a single box. Point the radios toward each other and power them on. The radios will automatically link up!

Cambium Networks has 3 Bridge-in-a-Box solutions:

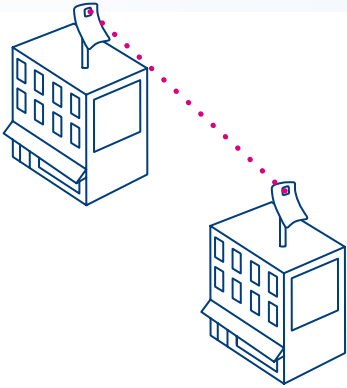


Bridge-in-a-Box	Frequency	Underlying Radio	Aggregate Capacity	Range
ePMP Bridge-in-a-Box UHD PRO 5 GHz	5 GHz	ePMP Force 300-19R	1000 Mbps	5 km
60 GHz Bridge-in-a-Box 1 Gb	60 GHz	cnWave V1000	2000 Mbps	150 meters
60 GHz Bridge-in-a-Box 2 Gb	60 GHz	cnWave V2000	3600 Mbps	250 meters

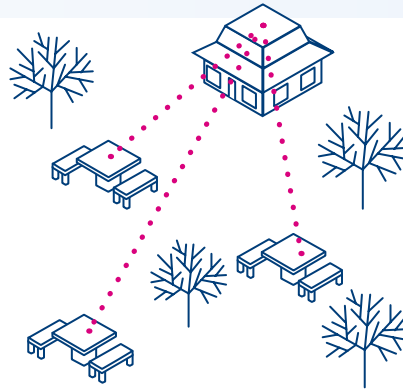


PTP Use Cases and Applications

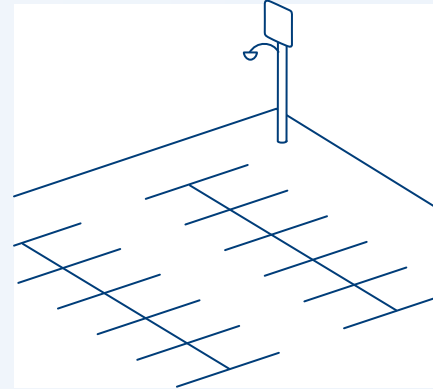
HOW ARE PEOPLE USING POINT TO POINT?



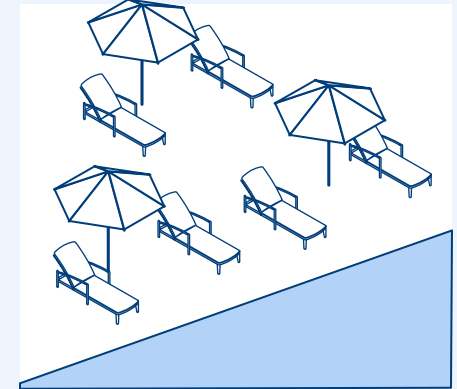
Building-to-building connectivity



Connecting outdoor Wi-Fi



Remote cameras or CCTV video feeds



Extending internet connectivity

WHAT ARE PEOPLE CONNECTING WITH POINT TO POINT?



Machine shops
/ garages /
storage sheds



Docks /
boat ramps



Any remote
or outlying
buildings



Remote
parking lots



Campus
buildings



Building-to-
building



Cabins and
lodges



Construction
sites



Temporary
events, such
as concerts,
farmers'
markets, etc.



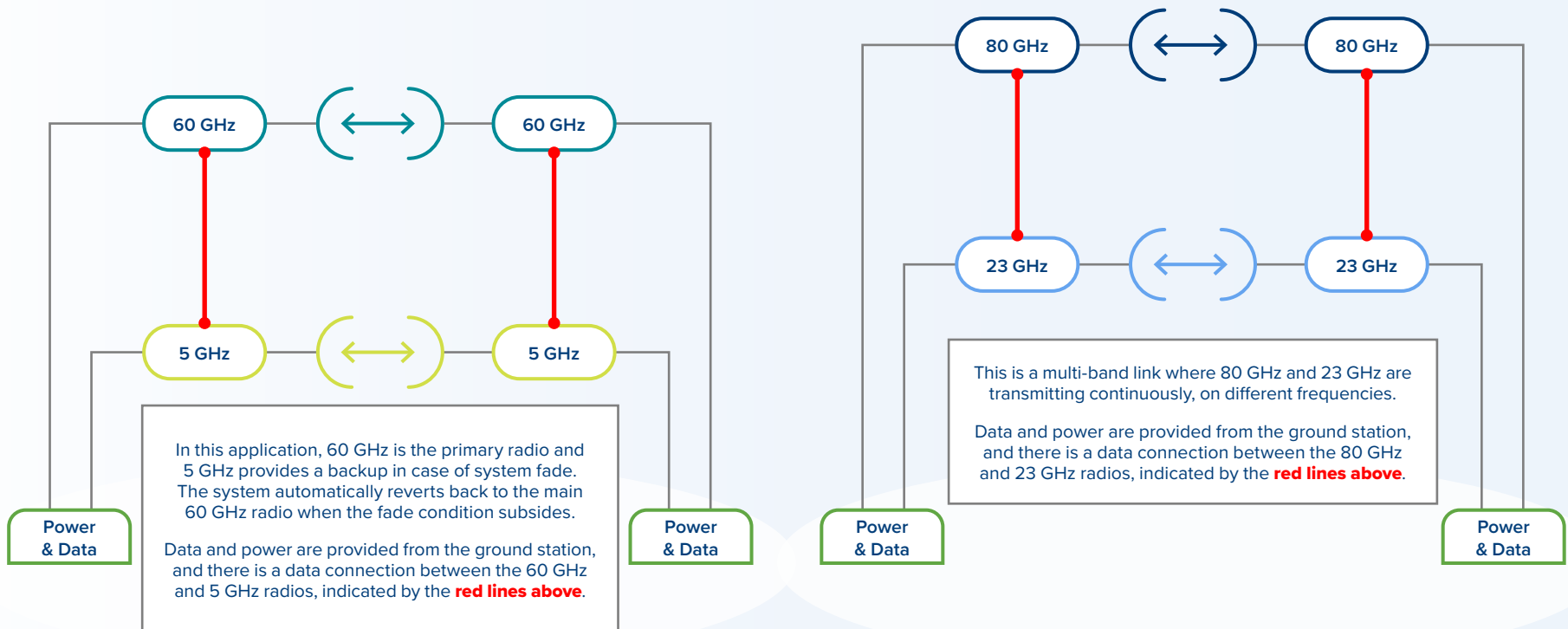
Athletic fields
and sporting
events

Understanding Multi-Band Radio

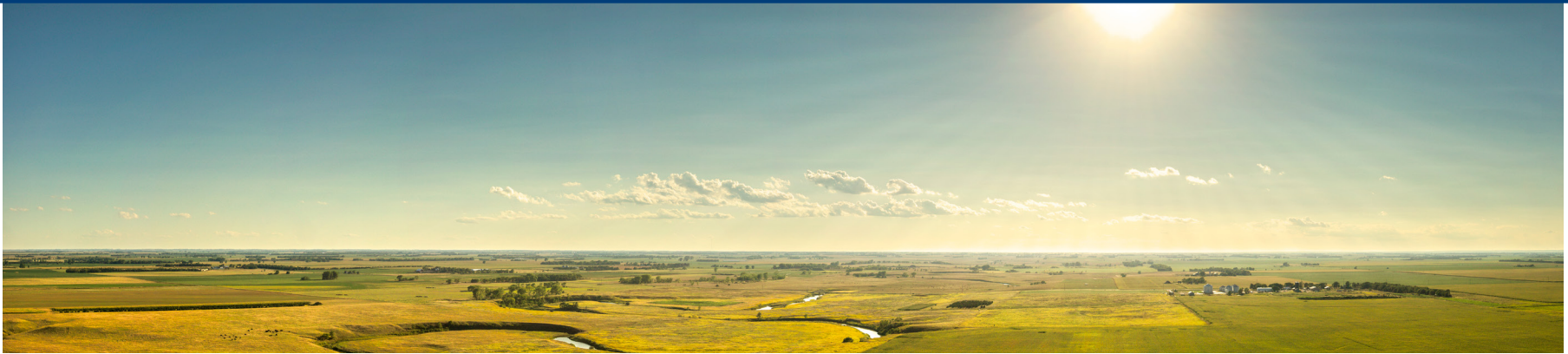
Multi-band radios are links that have two radios in different frequencies being used to transport data.

Example: 60 GHz and 5 GHz – 60 GHz has high capacity but limited range. To counter this, cnWave 60 GHz can be used with ePMP PTP solutions to provide an alternate route when the link has low availability (i.e., in case of rain).

80 GHz & 18/23 GHz – 80 GHz has high capacity but limited range. In licensed microwave, 18/23 GHz provides alternate guaranteed availability.



Distance vs Capacity



This master table links to individual tables that provide PTP radio options for the particular distance and capacity use case.

Example: If you need a list of PTP radios that can provide 300 Mbps – 1 Gbps at a distance of 1.6 km to 5 km, see Table 6

Required Aggregate Capacity (Mbps)	0–1.6 km	1.6 –5 km	5–25 km	25–50 km
1–300	Table 1	Table 2	Table 3	Table 4
300–1000	Table 5	Table 6	Table 7	Table 8
1000–10,000	Table 9	Table 10	Table 11	
10,000–40,000	Table 12			

ASSUMPTIONS FOR ALL TABLES:

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 1

**REQUIRED RANGE
Up to 1.6 km**

**REQUIRED CAPACITY
Up to 300 Mbps**

Product	MSRP	IP Rating	Port	Notes
PTP 450i	\$\$	IP67	Ethernet, Auxiliary	Support dynamic interference filtering
ePMP Force 300-19R	\$\$	IP67	Ethernet	
ePMP Force 200	\$	IP55	Ethernet	Available worldwide, except USA
cnWave V1000	\$	IP67	Ethernet	Link up to 150 meters

TABLE 2

**REQUIRED RANGE
1.6–5 km**

**REQUIRED CAPACITY
Up to 300 Mbps**

Product	MSRP	IP Rating	Port	Notes
PTP 450i	\$\$	IP67	Ethernet, Auxiliary	Support dynamic interference filtering
PTP 450b High Gain	\$	IP55	Ethernet	450b Conn IP 67 rated
ePMP Force 300-25	\$	IP55	Ethernet	
PTP 670	\$\$\$	IP67	Ethernet, Auxiliary & SFP	Support DSO
ePMP Force 300-19R	\$	IP67	Ethernet	

**ASSUMPTIONS
FOR ALL TABLES:**

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 3

**REQUIRED RANGE
5–25 km**

**REQUIRED CAPACITY
Up to 300 Mbps**

Product	MSRP	Configuration	Port
PTP 670	\$\$	Using 29dBi 2-foot dish	Ethernet, Auxiliary, SFP
PTP 820S	\$\$	Using 1+0 configuration @ 40 MHz	Ethernet, SFP
PTP 850C (1+0)	\$\$\$	Using 1+0 configuration @ 40 MHz	Ethernet, SFP+, SFP

TABLE 4

**REQUIRED RANGE
25–50 km**

**REQUIRED CAPACITY
Up to 300 Mbps**

Product	MSRP	Configuration	Port
PTP 670	\$\$	32 dBi, 3-foot dish	Ethernet, Auxiliary, SFP
PTP 820S	\$\$	Using 1+0, 38 dBi, 3-foot dish @ 40 MHz	Ethernet, SFP
PTP 850C (1+0)	\$\$\$	Using 1+0, 38 dBi, 3-foot dish @ 40 MHz	Ethernet, SFP+, SFP

**ASSUMPTIONS
FOR ALL TABLES:**

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 5

**REQUIRED RANGE
Up to 1.6 km**

**REQUIRED CAPACITY
300–1000 Mbps**

Product	MSRP	IP Rating	Notes
cnWave V1000	\$	IP67	Link up to 150 meters
ePMP Force 300-19R	\$	IP67	
ePMP Force 300-25	\$	IP55	
ePMP Force 425	\$	IP67	
ePMP Force 4525	\$	IP55	Operating in 5 GHz @ 80 MHz
ePMP Force 4625	\$\$	IP55	Operating in 6 GHz @ 80 MHz
PTP 550	\$\$	IP67	Support channel bonding

TABLE 6

**REQUIRED RANGE
1.6–5 km**

**REQUIRED CAPACITY
300–1000 Mbps**

Product	MSRP	IP Rating	Notes
PTP 670	\$\$\$	IP67	Support DSO
ePMP Force 300-19R	\$	IP67	
ePMP Force 300-25	\$	IP55	
ePMP Force 425	\$	IP67	
ePMP Force 4500C	\$\$	IP55	2-foot antenna @ 80 MHz
ePMP Force 4600C	\$\$	IP55	2-foot antenna @ 80 MHz
PTP 550	\$\$	IP67	Support channel bonding
PTP 820S	\$\$\$	IP67	2-foot antenna, 1+0, @ 40 MHz

**ASSUMPTIONS
FOR ALL TABLES:**

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 7

REQUIRED RANGE
5–25 km

REQUIRED CAPACITY
300–1000 Mbps

Product	MSRP	Configuration
PTP 670	\$\$	2-foot antenna, 29 dBi
PTP 550	\$	2-foot antenna, 29 dBi
PTP 820S	\$\$	Using 1+0, 34 dBi, 2-foot dish @ 40 MHz
PTP 850C	\$\$\$	Using 1+0, 34 dBi, 2-foot dish @ 40 MHz

TABLE 8

REQUIRED RANGE
25–50 km

REQUIRED CAPACITY
300–1000 Mbps

Product	MSRP	Configuration
PTP 670	\$\$	32 dBi, 3-foot dish
PTP 820S	\$	Using 1+0, 38 dBi, 3-foot dish @ 40 MHz
PTP 850C	\$\$\$	Using 1+0, 38 dBi, 3-foot dish @ 40 MHz

ASSUMPTIONS FOR ALL TABLES:

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 9

**REQUIRED RANGE
Up to 1.6 km**

**REQUIRED CAPACITY
1–10 Gbps**

Product	MSRP	Configuration
cnWave V2000	\$\$	Using built-in 33 dBi
cnWave V3000	\$\$\$	Using 44 dBi antenna
ePMP Force 4625	\$\$	Using 160 MHz
PTP 820S	\$\$	Using 2+0, 34 dBi, 2-foot dish @ 80 MHz
PTP 850C	\$\$\$	Using 2+0, 34 dBi, 2-foot dish @ 80 MHz
PTP 850C	\$\$\$	Using 4+0, 34 dBi, 2-foot dish @ 40 MHz
PTP 850EX	\$\$\$	Using 1+0, 44 dBi, 1-foot antenna
PTP 850E	\$\$\$	Using 1+0, 44 dBi, 1-foot antenna

TABLE 10

**REQUIRED RANGE
1.6–5 km**

**REQUIRED CAPACITY
1–10 Gbps**

Product	MSRP	Configuration
ePMP Force 4600C	\$	160 MHz, 2-foot antenna
PTP 820S	\$	Using 2+0, 38 dBi, 3-foot dish @ 80 MHz
PTP 850C	\$\$	Using 2+0, 38 dBi, 3-foot dish @ 80 MHz
PTP 850C	\$\$\$	Using 4+0, 38 dBi, 2-foot dish @ 80 MHz
PTP 850EX	\$\$	Using 1+0, 50 dBi, 2-foot antenna
PTP 850E	\$\$\$	Using 1+0, 50 dBi, 2-foot antenna

**ASSUMPTIONS
FOR ALL TABLES:**

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

TABLE 11

REQUIRED RANGE
5-50 km

REQUIRED CAPACITY
1-10 Gbps

Product	MSRP	Configuration
PTP 820S	\$\$	Using 2+0, 44 dBi, 6-foot dish @ 80 MHz
PTP 850C	\$\$	Using 2+0, 44 dBi, 6-foot dish @ 80 MHz
PTP 850C	\$\$\$	Using 4+0, 44 dBi, 6-foot dish @ 80 MHz

TABLE 12

REQUIRED RANGE
Up to 5 km

REQUIRED CAPACITY
10-40 Gbps

Product	MSRP	Configuration
PTP 850EX	\$\$	Using 2+0, 50 dBi, 2-foot antenna
PTP 850E	\$\$\$	Using 2+0, 50 dBi, 2-foot antenna

ASSUMPTIONS FOR ALL TABLES:

- Capacity is based on aggregate capacity.
- Distance for each column is wide; recommend using LINKPlanner to check availability.
- MSRP marked with \$ is to indicate relative cost difference within each table.
- There are other attributes that should be considered while designing.

About Cambium Networks

Cambium Networks enables service providers, enterprises, industrial organizations, and governments to deliver exceptional digital experiences and device connectivity with compelling economics. Our ONE Network platform simplifies management of Cambium Networks' wired and wireless broadband and network edge technologies. Our customers can focus more resources on managing their business rather than the network. We make connectivity that just works.

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