Selecting the correct PTP product for your application

From microwave fundamentals to an engineering decision

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From link behaviour to product choice

The fundamentals still govern the answer. This session starts where the planning presentation finished.

The three questions that frame every PTP link

01

How far?

Path length, terrain, antenna locations and clearance determine which bands remain practical.

02

How fast?

Committed throughput, traffic direction and growth determine channel width and radio capacity.

03

How critical?

The SLA and operational consequence of an outage determine margin, spectrum and protection.

Product selection begins only after these answers are explicit.

PTP selection starts with the application

Propagation, availability and practical constraints define the viable product set.

01	**Availability target**	Required uptime and the capacity that must remain available
02	**Distance and path**	Terrain, obstruction, antenna locations and link length
03	**Spectrum**	Permitted bands, channel availability and interference environment
04	**Throughput**	Committed traffic by direction, interfaces and growth allowance
05	**Environment**	Multipath exposure, rain climate and clearance sensitivity

Propagation sets microwave link performance

Atmospheric conditions change the path even when the radio hardware remains healthy.

- Microwave energy travels through the troposphere
- Time of day, season and weather change refractivity
- Link design manages the probability and duration of outages

THE DESIGN QUESTION

How will the path behave during the conditions that matter to the service?

Microwave energy propagates as a wavefront

Common simplification

A narrow pencil beam following one straight ray

Physical behaviour

A spatially distributed wavefront whose components encounter different atmospheric conditions

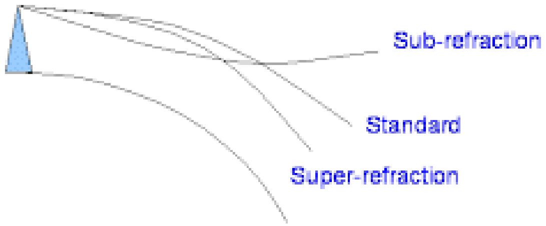
Refraction and multipath act across the wavefront. A single ray is only a planning abstraction.

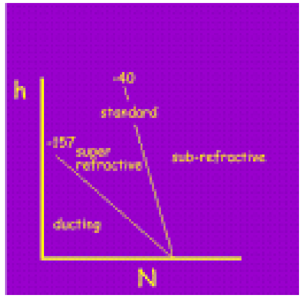
Refractivity controls path bending

Refractive index changes with pressure, temperature and humidity

The vertical change in refractivity bends the wavefront

Under standard conditions, the effective radio path curves slightly toward Earth





Refractivity describes the atmosphere. The gradient determines how strongly the path bends.

Refractivity gradient drives link stability

ARCIA

dN/dh

Change in refractivity with altitude

- Typical median reference: approximately −39 N-units/km
- The gradient varies with time and local atmospheric structure
- Large departures can produce sub-refraction, super-refraction or ducting
- These changes alter clearance and multipath risk

The design must tolerate a range of gradients, not only the median condition.

Propagation effects drive product choice

Atmospheric variability influences

- Fade margin required for the availability target
- Need for space or frequency diversity
- Practical frequency band and antenna size
- Reliance on high-order modulation during adverse conditions

Greater variability requires more margin or stronger mitigation.

Fade margin defines link survivability

Fade margin = **nominal receive level** − **receiver threshold**

The threshold must correspond to the modulation and capacity required by the SLA.

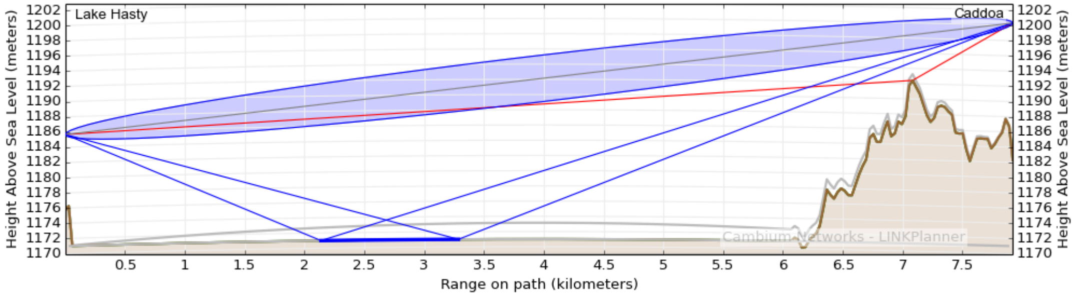
01	**Availability**	Margin determines how much fading the link can absorb
02	**Outage probability**	The fade model converts margin into expected unavailability
03	**Product choice**	Radio sensitivity, antenna gain and architecture create the margin

Multipath dominates many sub-11 GHz paths

Ground, water and atmospheric layers create additional propagation paths

Signals can combine destructively and produce deep fades

Wideband links may also experience frequency-selective fading

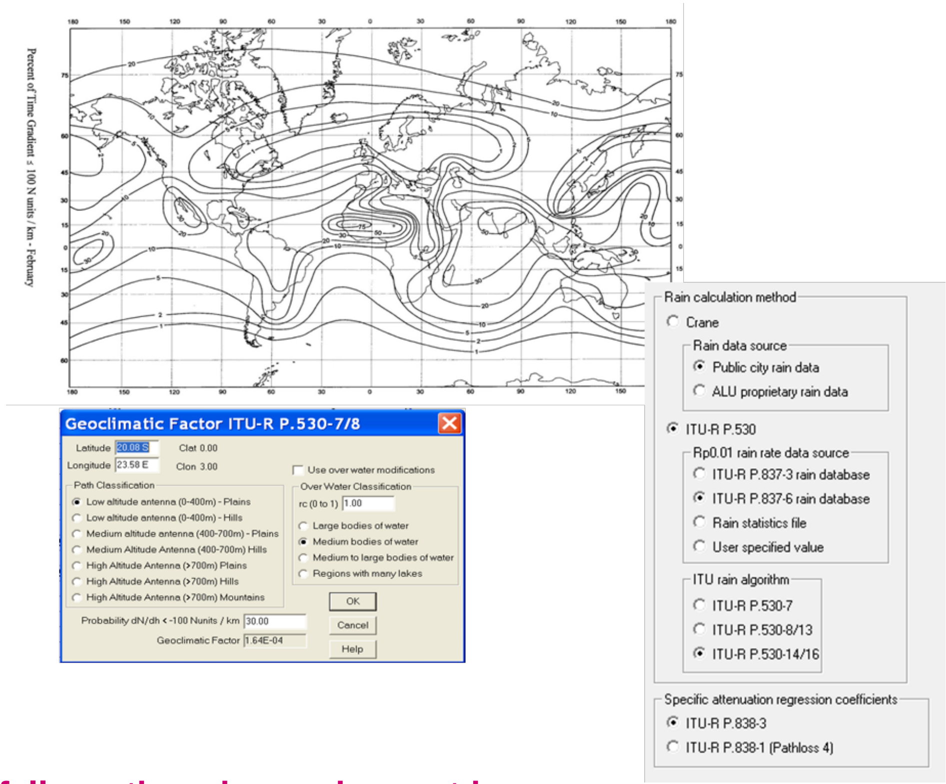


Product implication

Use adequate fade margin, robust equalisation and space diversity where the path model justifies it.

Rain attenuation increases with frequency

Below 5 GHz	Rain is usually a minor impairment
5–10 GHz	Rain may contribute, but often remains secondary
Above 10 GHz	Rain increasingly constrains distance and availability
Millimetre wave	Rain can become the design-limiting impairment

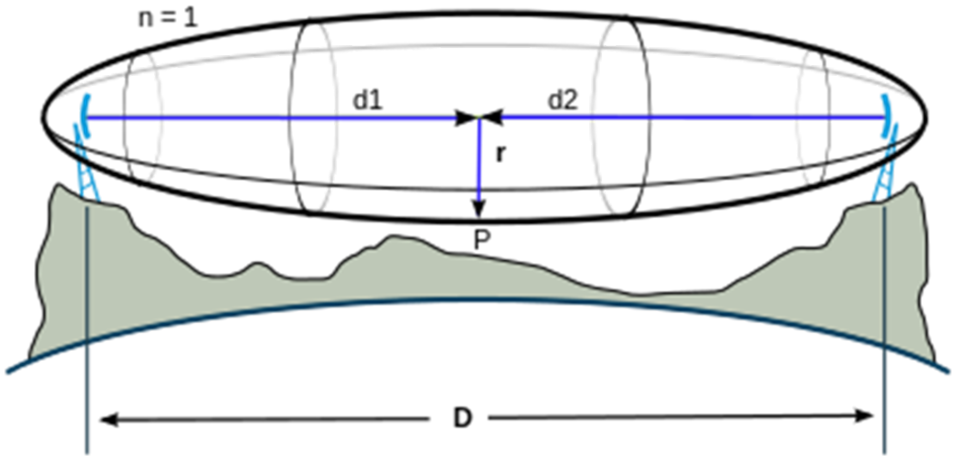


Higher frequencies support capacity, but the viable path length falls as the rain requirement becomes more severe.

Fresnel clearance: LOS alone is insufficient

Line of sight confirms visibility. Fresnel clearance controls diffraction loss.

- The first Fresnel zone is a geometric boundary around the direct path
- An obstruction inside the zone changes the net field at the receiver
- Clearance must be checked against Earth curvature, terrain, vegetation and structures



$$F_1 = \sqrt{\lambda \frac{d_1 . d_2}{d_1 + d_2}}$$

Diffraction fading and clearance criteria

Atmospheric refraction changes the effective Earth radius. A lower k-factor can move terrain into the Fresnel zone and create diffraction loss.

Design check	Atmospheric condition	Typical clearance objective	Purpose
Normal clearance	$k = 4/3$ reference	100% of first Fresnel zone	Avoid routine diffraction loss
Sub-refractive check	Selected minimum k	Partial first-zone clearance, often 60%	Test worst-earth sensitivity
Current ITU-R method	Path and obstacle specific	Apply the current P.530 procedure	Set defensible antenna heights

Confirm the current ITU-R P.530 revision and the organisation's design standard before fixing antenna heights.

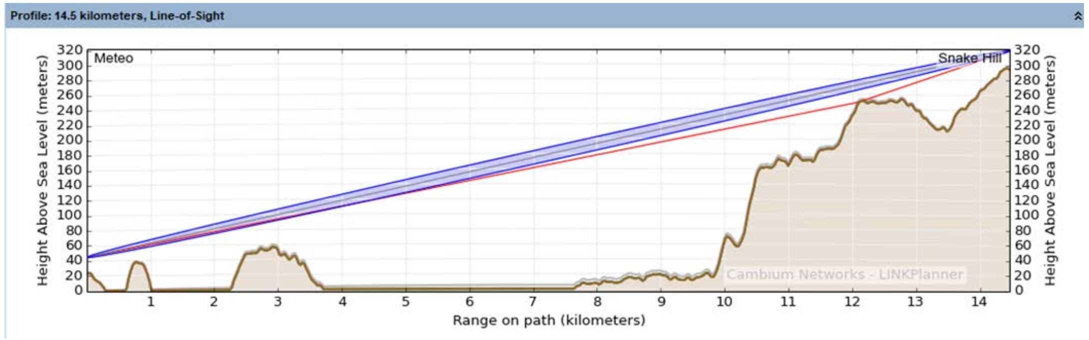
k-factor and clearance: practical design guidance

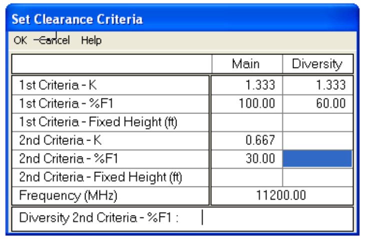
Short paths

Earth curvature has less influence, but local obstructions can still govern clearance.

Longer paths

Test normal and sub-refractive conditions. Small changes in k can materially change clearance.





Set Clearance Criteria

OK Cancel Help

	Main	Diversity
1st Criteria - K	1.333	1.333
1st Criteria - %F1	100.00	60.00
1st Criteria - Fixed Height (ft)		
2nd Criteria - K	0.667	
2nd Criteria - %F1	30.00	
2nd Criteria - Fixed Height (ft)		
Frequency (MHz)	11200.00	
Diversity 2nd Criteria - %F1 :		

A practical sequence **Check 100% F1 at k = 4/3, apply the selected worst-earth criterion, then set antenna heights from the controlling case.**

The planning tool applies the criteria. The engineer remains responsible for selecting them.

PTP product selection workflow

1	2	3	4	5	6
Application	**Spectrum**	**Path risk**	**Architecture**	**Product**	**Validation**
Traffic, SLA, interfaces	Available and permitted bands	Rain, multipath, clearance	1+0, protected, diversity, multiband	Radio, antenna and configuration	Model, optimise, document

The radio is the result of the process, not the starting point.

Application requirements

Service requirement

- Payload and committed throughput in each direction
- Latency, jitter and packet-loss limits
- Interfaces, VLANs, synchronisation and power
- Growth allowance over the design life

Operational requirement

- Annual and worst-month availability targets
- Maximum acceptable outage duration
- Restoration time and operational consequence
- Site access, wind loading and installation constraints

Write the requirement before selecting the band.

Spectrum is the first practical gate

Spectrum class	Main advantage	Primary risk	Best starting point
Licensed microwave	Coordinated and predictable	Licence and deployment lead time	Critical links and planned backhaul
Lightly licensed / area licensed	High capacity with controlled access	Band-specific coordination rules	Short high-capacity links
Unlicensed	Fast deployment and low spectrum cost	Interference can change after installation	Enterprise, temporary or redundant paths
Hybrid / multiband	High capacity with a more robust lower-band path	More equipment and design complexity	High-capacity links with strict availability

Technology class by range and service requirement

Technology class	Reach	Capacity	Availability control	Main concern
Sub-6 GHz PTP	Variable	Moderate to high	Margin and clean spectrum	Congestion
Licensed 6–11 GHz	Long	Moderate to high	System gain and diversity	Clearance and multipath
Licensed 13–38 GHz	Medium	High	Rain margin and protection	Rain
60 GHz V-band	Short	Very high	Fallback where required	Oxygen absorption and rain
80 GHz E-band	Short to medium	Very high	Rain margin or multiband	Rain and alignment

Every range boundary moves with antenna gain, channel width, climate and availability target.

Availability changes the product decision

Availability	Maximum outage / year	Design implication
99.9%	8 h 45 min 36 s	Tolerance for simpler architectures
99.99%	52 min 34 s	Greater fade margin and spectrum control
99.999%	5 min 15 s	Protection, diversity or multiband may be required

A working link

≠

A link that meets its SLA

Availability must be evaluated at the required capacity, not only at minimum modulation.

Dominant impairment determines the countermeasure

Dominant risk	What it does	Design response	Product implication
Clearance / diffraction	Consumes margin as k-factor falls	Change heights, path or frequency	Lower band, more gain or height change
Multipath	Creates deep or selective fades	Space diversity and robust equalisation	Diversity-capable licensed microwave
Rain	Attenuation rises with frequency and path length	More margin, lower band or multiband	Avoid relying on peak E-band / V-band capacity
Interference	Raises noise floor and reduces modulation	Coordination, narrower channels or alternate band	Licensed radio where predictability matters
Hardware / power	Removes the service independently of RF	Protected radio, power and route design	1+1, 2+2 or separate path

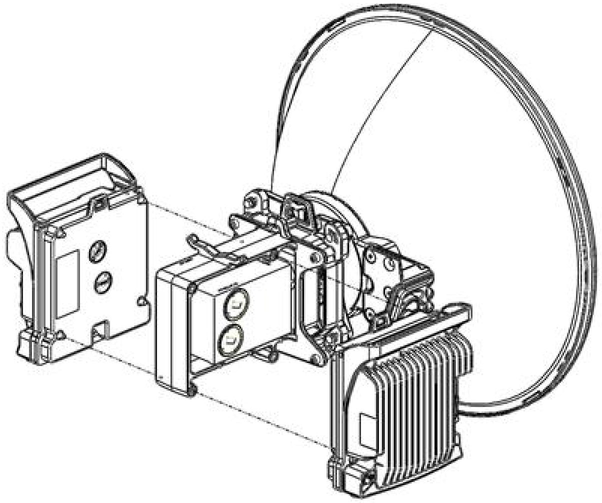
System gain and form factor

Antenna gain

+

Radio sensitivity

= usable margin



Integrated

Fast installation
Compact mounting
Fixed antenna gain

Connectorized

Antenna sized to the link
Higher gain options
Greater wind and rigging impact

Radio architecture by objective

Mode	Configuration	Choose it for	Do not assume
1+0	One active radio	Lowest cost and complexity	No radio protection
1+1	Protected pair	Equipment availability	Usually shares the same propagation path
2+0	Two active carriers	Higher capacity	Capacity may fall if one carrier fails
2+2	Two active plus protection	Capacity with equipment resilience	More equipment, spectrum and complexity
4+0	Four active carriers	Maximum channel aggregation	Capacity architecture, not inherent protection

Protection addresses a defined failure. Name that failure before adding hardware.

Space diversity and XPIC solve different problems

Space diversity

Improves availability when multipath fades decorrelate with antenna height.

- Requires a second antenna at calculated vertical spacing
- Targets propagation fading
- Most valuable on long, flat or over-water paths

XPIC

Uses both polarisations in the same channel to increase capacity.

- Requires adequate cross-polar discrimination
- Targets capacity and spectral efficiency
- Does not replace fade margin or protection

Diversity protects the path. XPIC increases the payload.

Scenario 1: regional emergency-services backbone

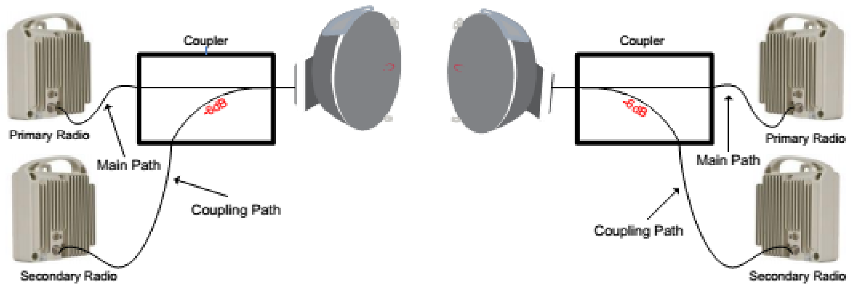
Requirement

45 km path

200 Mbps committed service

99.999% availability target

Flat terrain with multipath exposure



Selection

Licensed 6–11 GHz starting point

Connectorized high-gain antennas

Space diversity or protection if the model requires it

Why: long reach and availability dominate. The design must control clearance and multipath before chasing peak capacity.

Scenario 2: urban fibre extension

Requirement

1.5 km clear rooftop path

Multi-gigabit payload

Fast deployment

Service must continue during heavy rain

Selection

80 GHz E-band

Or 60 GHz where its spectrum model fits

Add a lower-band path for the required surviving capacity

Why: capacity drives the high-band choice. Availability determines whether a second band is part of the product solution.

Scenario 3: industrial site and temporary resilience

Requirement

0.5–5 km paths

CCTV, telemetry and operational traffic

Deployment needed quickly

Some sites have marginal clearance

Selection

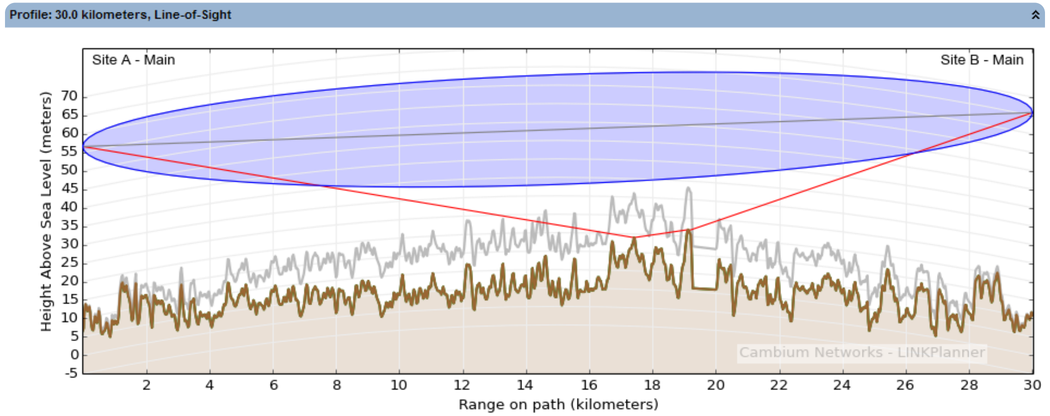
Sub-6 GHz PTP where clearance or flexibility matters

60 GHz for short, clean LOS and high capacity

Licensed microwave where interference predictability is essential

Why: one site can need more than one radio class. Segment links by requirement instead of forcing a single standard everywhere.

RF Planning Models turn the selection into a design



1 **Model the path**

Terrain, clutter, heights and obstructions

2 **Test alternatives**

Band, antenna, channel and architecture

3 **Validate service**

Capacity and availability against the requirement

4 **Document**

Configuration, BOM and deployment assumptions

Final product selection checklist

01

Application

- Committed throughput by direction
- Latency and interfaces
- Growth allowance

02

Availability

- Annual and worst-month objective
- Capacity that must survive
- Failure consequence

03

RF design

- Permitted spectrum
- Dominant impairment
- Antenna and channel plan

04

Architecture

- Protection or diversity
- Power and route resilience
- Management and support

When every box has an answer, the correct product family usually becomes clear.

Questions

How far?
How fast?
How critical?

Select the application requirements first. Then let spectrum, path behaviour and availability determine the product.

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