COMMSCOPE®

Maximizing E-band potential with dual band antennas

Wireless network managers face increasing pressure to expand their network capacity—not only to accommodate the growing volume of data being sent and received but also to support an increasing number of users. Yet increased capacity must not compromise availability; the network must continue to provide seamless service regardless of how much data or how many users must be supported. The need to ensure availability while increasing capacity creates major challenges for the network's mobile backhaul.

Within the network infrastructure, the backhaul network must not create a bottleneck when it comes to increasing capacity and availability. Traditional backhaul links use microwave transmission to connect cell sites to optical fiber infrastructure and the core network. Over time, fiber (where available) has increasingly been deployed for network backhaul as it requires no radio license, is immune to interference, and supports extremely high capacity—although it is vulnerable to accidental damage. Despite the uptake in fiber, microwave continues to provide unique benefits that wireline backhaul cannot match.

Deployment speed: Installing new fiber is time-consuming and labor-intensive, often taking several months or more to deploy. Fiber also requires obtaining access rights and way-leave permissions. With microwave, installation crews can typically install and commission a link within a matter of days after the completion of the path survey and co-ordination.

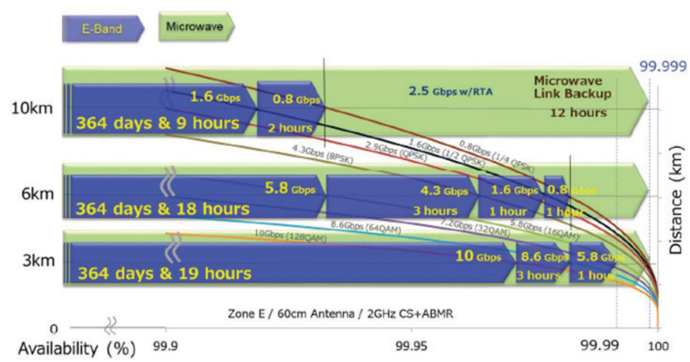
Cost: Based partly on its lower installation costs, microwave backhaul is typically less expensive to deploy than fiber. Operating costs are often lower as well. With relatively low licensing cost for E-band and other frequencies, the ROI for microwave backhaul might be years ahead of that for fiber.

Latency: Microwave signals travel point-to-point along the straightest path at about 299,700 km/s. Fiber may often take a more circuitous path to avoid physical obstacles. As the speed of fiber-optic signals is around 200,000 km/s, latency can be significantly increased due to path length and the refractive index.

Capacity: With almost unlimited bandwidth, the one area in which fiber has a clear advantage is capacity. A typical cell site currently requires a backhaul capacity of under 500 Mbps, with a limited number needing up to 1 Gbps. Whilst that's well within the capability of current radio systems, looking forward, some 5G applications may require over 10 times that amount at the cell site.

To meet future capacity needs, radio manufacturers are incorporating higher modulation schemes, considering sophisticated MIMO techniques, and utilizing higher frequencies where greater bandwidth is available. One of the most talked-about advances is the use of E-band, which operates within the 70-80 GHz spectrum and can carry up to 10 Gbps per channel. With a larger channel and lower licensing costs, E-band offers more capacity at a lower cost per megabyte.

E-band's traditional Achilles' heel, however, is its limited range. Depending on antenna diameter and local climate, E-band signals can travel only a couple of miles (about 3.2 km) before reliability falls below 99.999 percent.



Source: RCR Wireless, August 28, 2019

A potential solution to this is to combine E-band signals with traditional microwave signals (6–42 GHz). The idea is that using both would give network operators the cost and capacity advantages of E-band, plus the increased distance and "five 9s" reliability of microwave. Until now, the efforts to combine E-band and traditional microwave signals have focused primarily on radio design, with far less attention paid to the antennas' ability to support such a configuration.

Modeling antenna performance in single- and multi-band scenarios

Combining E-band and traditional microwave signals can be done but involves the use of two essentially separate links—one operating on a microwave frequency and the other operating at the higher E-band frequency. This design requires two antennas at both ends of the link, four in total, which increases CapEx costs and doubles the tower loading and rental costs. The alternative is to combine both frequencies into a single antenna with suitable outputs for both microwave and E-band. Ideally, such an antenna would also be field configurable to allow the future addition of dual-polarized (XPIC) systems, should they be required.

One of the more common and interesting applications of this design would be to use microwave channels in the 23 GHz band (21.2-23.6 GHz) linked with an 80 GHz link (71.0-86.0 GHz). The dual band paths would enable operators to leverage E-band's higher capacity while retaining the carrier-grade reliability of traditional microwave longer link spans.

CommScope engineers set out to measure the effects of combining an E-band link with a traditional microwave link; specifically, how it would impact reliability over distance, throughput capacity and total cost of ownership. By using iQ.Link network planning software from Comsearch®, the team created and modeled two network scenarios using publicly available data from an actual network located in Vienna, Austria. The modeled link spanned from a dense urban area to a suburban area.

Note: The statistics shown in the scenarios below indicate aggregated Layer 1 traffic. Layer 2 and Layer 3 traffic may show better availability due to retransmission from error detection or transmission correction.

Scenario 1: Single band radios with single band antennas

The first scenario was designed to establish a point of reference using a single band radio and two 60-cm CommScope VHLP2 single band antennas. The objective was to analyze the maximum signal range as a function of reliability in a traditional microwave link versus an E-band link.

The scenario was divided into two parts. The first part involved the transmission of a 23 GHz signal with a 28 MHz channel size. The second part modeled an 80 GHz E-band signal with a 500 MHz channel size.

In modeling the 23 GHz link, engineers designed the scenario to account for the effects of rain and multipath propagation. using the lowest possible modulation rate to maximise distance, the maximum path length, shown in Figure 1, was determined to be seven miles (11.31 km). Table 1 summarizes the results of the calculations.

Figure 1. Maximum path length = 11.31 km

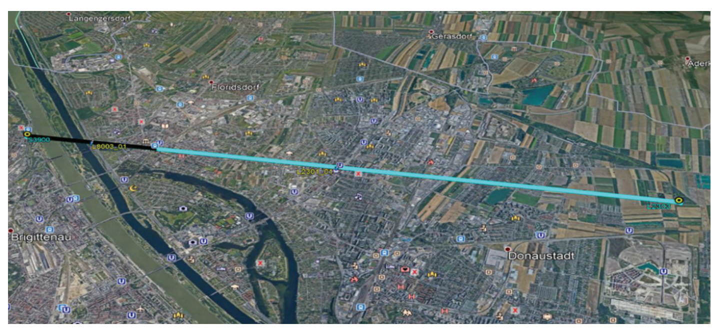


Figure 2. Maximum path length = 2.44 km

Link ID	Modulation	Band	Fade Margin	Throughput	Rain	Multipath	Rain	Multipath
		(GHz)	(dB)	(Mbps)	Uptime(%)		Downtime(s)	
L2301_01	4QAM	23.00	50.17	37.00	99.999005	99.999000	313.86	1.58

Table 1

Link ID	Modulation	Band	Fade Margin	Throughput	Rain	Multipath	Rain	Multipath
		(GHz)	(dB)	(Mbps)	Uptime(%)		Downtime(s)	
L8003_01	BPSK2	80.00	54.38	186.00	99.999011	100.000000	312.02	0.02

Table 2

To establish the longest E-band link path that would result in 99.999 percent availability, the team used a Binary Phase Shift Keying (BPSK) modulation scheme which resulted in a throughput of 186 Mbps. The maximum length, represented by the black line segment in Figure 2, was just over 1.5 miles (2.44 km).

Table 2 summarizes the results of the calculations.

Even with the lowest possible modulation, the E-band link (when transmitted by itself) is 79 percent shorter than the 23 GHz link by itself. The limited distance of the E-band link is a major challenge. Due to the large difference in throughput (37 Mbps versus 186 Mbps) the operator would need to balance the cost of multiple hops (e.g., multiple site locations, installations, radio and antenna costs, etc.) with the data rate requirements. There may be other scenarios where, by varying the modulation schemes and data rates versus distance, the higher data rate would justify this expense.

Scenario 2: Dual band antenna with link aggregation

Operators often use link aggregation to maximize both capacity and distance. In microwave backhaul applications, however, the technology has typically been expensive. The data is usually separated onto separate channels before hitting the transmit antennas, and then aggregated after being received by the receiving antennas. To serve two aggregated links with this design, the network operator must double the number of antennas. This increases tower loading, occupies precious space atop the tower, and can significantly increase OpEx.

Using dual band antennas makes it possible to support dual band aggregated links with a single antenna at each end. In the second scenario, the CommScope team sought to determine the effects of this solution on maximum hop distance with regards to availability.

For this scenario, the team established a couple of key parameters; the first was the clear sky margin, the fade margin of link during good propagation conditions (no decrease in fade margin due to precipitation or multipath propagation). While there is no strict rule or standard for establishing the clear sky margin, the accepted practice is to use 10 dB, which is the usual requirement for stable link operation.

Therefore, the goal in modeling this scenario was to determine the maximum throughput and hop length for the combined

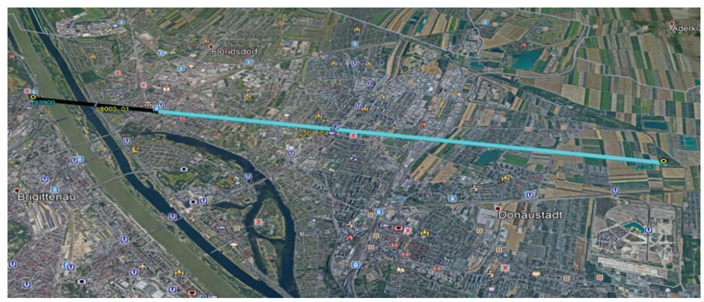


Figure 3

E-band and 23 GHz links where the 23 GHz link maintains 99.999 percent availability and the E-band link maintains a clear sky margin of > 10 dB.

The green overlay (Figure 3) shows the results for the aggregated 23 GHz and 80 GHz links using the same 60-cm dual band antenna. Table 3 summarizes the results of the calculations.

Link ID	Modulation	Band	Fade Margin	Throughput	Rain	Multipath	Rain	Multipath
		(GHz)	(dB)	(Mbps)	Uptime(%)		Downtime(s)	
L8002_01	256QAML	80.00	10.00	3124.00	99.669910	99.995642	104097.29	1374.39
L2302_01	128QAM	23.00	33.32	162.00	99.999082	99.999999	289.46	0.47
				3286.00	99.669910	99.995640	104097.31	1374.86
					99.665550		105472.17	

Table 3

LAG (Link Aggregation Group) statistics are based on aggregated traffic and are calculated using the method described in UC2017_D2_01_LAG_Outage_Unavailability_v1_2, available from Comsearch.

Even though aggregating the links, as opposed to transmitting them separately, reduces the overall maximum range to 3.8 miles (6.18 km), the results are impressive. The data shows that aggregating traffic using the 23 GHz and 80 GHz frequencies and employing a dual band antenna produces the following improvements.

- Maximum distance of the E-band signal more than doubles: from 1.5 to 3.8 miles (2.14 to 6.18 km)
- E-band throughput rises over 1,600 percent: from 186 Mbps to 3,124 Mbps
- Throughput of 23 GHz increases over 400 percent: from 37 Mbps to 162 Mbps
- Availability for the 23 GHz remains at or above 99.999 percent, giving a reliable carrier-grade backup link to which to offload data when fading conditions exist that would affect the E-band link

Microwave has a lot left in the tank

Applying a few simple calculations to an existing network shows that, by utilizing dual band antennas, it is possible to "stretch" the E-band link and maintain carrier-grade availability; moreover, doing so can significantly improve capacity while minimizing total cost of ownership. There are other possibilities to extend the value of microwave backhaul.

This exercise sought only to explore the current range limits of E-band links. Future opportunities include increasing the modulation and data rate for a shortened 23 GHz link. This would enable operators to offload more data at higher data rates from the 80 GHz link onto the 23 GHz link. In addition, adding two radios (XPIC) on the 23 GHz link and/or the 80 GHz link could double the capacity per frequency band. All these ideas are possible with fully configurable dual band antennas.

Needless to say, there is still a vast amount of untapped potential in microwave backhaul. As network operators prepare to handle the crush of new data from 5G, IoT and more, they will need to rely on every possible tool to keep up. Maximizing E-band's potential with dual band antennas and link aggregation is just one more tool in the kit.

Appendix

NOTE ON METRICS:

The availability percentage and unavailability seconds in the calculation tables below are based on the following performance parameters:

- **Annual rain:** Link unavailability caused only by precipitation and based on annual time statistics
- **Annual outage:** Outages caused only by multipath propagation and based on annual time statistics
- **Combined:** Total annual, two-way unavailability of the link due to precipitation and outage due to multipath propagation

REPORT TABLES

Table 4. 23 GHz reference link

Link ID: L2301_01
Link name: 23 GHz reference link
Link status: W-Working
Frequency band: 23 GHz

Site ID / Location ID	S3900 /	L2303 /
Site name	Heiligenstadter Strasse 178	L2303
Coordinates (Lat, Lon) WGS84	48-15-34.0 N, 16-22-5.0 E	48-14-30.1 N, 16-31-4.9 E
Ground elevation (m)	164.000000	157.000000
Radio model	**S3900 /**	**L2303 /**
Tx output power (dBm) / Reference modulation	24.00 / 4QAMsACM	24.00 / 4QAMsACM
Spectrum mask class—low reference high	2 / 2 / 5B	2 / 2 / 5B
Channel spacing (MHz)	28.000000	28.000000
Capacity (Mbps)	37	37
Frequency plan: Frequency (MHz)	High: 23310.000000	Low: 22302.000000
Polarization	V	V
Path calculations	**S3900 /**	**L2303 /**
EIRP (dBm)	64.70	64.70
Path length (km)	11.31	
Total propagation loss (dB)	142.88	
Obstruction loss (dB)	0.00	At 50.0000%
Threshold degradation (dB)	0.00 / Default	0.00 / Default
Field margin (dB)	0.00	
Receive level (dBm)	-37.33	-37.33
Threshold (dBm)—low reference high	-87.50 / -87.50 / -53.00	-87.50 / -87.50 / -53.00
Fade margin (dB)	50.17	50.17
Radio configuration	1+0	1+0
Rain zone	ITU-R / 33.33mm / hr	
Annual rain, two-way (100-% / s)	99.999005 / 313.86	
Annual outage, two-way (100-% / s)	99.999995 / 1.58	
Annual combined, two-way (100-% / s)	99.999000/ 315.44	

Table 5. E-band standalone reference

Link ID: L8003_01
Link name: 80 GHz reference link
Link status: W-Working
Frequency band: 80 GHz

Site ID / Location ID	S3900 /	L8001 /
Site name	Heiligenstadter Strasse 178	L8001
Coordinates (Lat, Lon) WGS84	48-15-34.0 N, 16-22-5.0 E	48-15-20.3 N, 16-24-1.5 E
Ground elevation (m)	164.000000	160.000000
Radio model	**S3900 /**	**L8001 /**
Output power (dBm) / reference modulation	18.00 / BPSK/2ACM	18.00 / BPSK/2ACM
Spectrum mask class—low reference high	2 / 2 / 6B	2 / 2 / 6B
Channel spacing (MHz)	500.000000	500.000000
Capacity (Mbps)	186	186
Frequency plan: frequency (MHz)	High: 80150.000000	Low: 79100.000000
Polarization	V	V
Path calculations	**S3900 /**	**L2303 /**
EIRP (dBm)	68.75	68.75
Path length (km)	2.44	
Total propagation loss (dB)	139.08	
Obstruction loss (dB)	0.00	At 50.0000%
Threshold degradation (dB)	0.00 / Default	0.00 / Default
Field margin (dB)	0.00	
Receive level (dBm)	-19.62	-19.62
Threshold (dBm)—low reference high	-74.00 / -74.00 / -47.00	-74.00 / -74.00 / -47.00
Fade margin (dB)	54.38	54.38
Radio configuration	1+0	1+0
Rain zone	ITU-R/33.33mm/hr	
Annual rain, two-way (100-% / s)	99.999011 / 312.02	
Annual outage, two-way (100-% / s)	100.000000 / 0.02	
Annual combined, two-way (100-% / s)	99.999011/ 312.04	

Table 6. E-band link at optimum distance (in link aggregation group with 23 GHz)

Link ID: L8002_01
Link name: 80 GHz combined link (23 GHz offload)
Status: W-Working
Frequency band: 80.00 GHz

Site ID / Location ID	S3900 /	L2302 /
Site name	Heiligenstadter Strasse 178	L2302
Coordinates (Lat, Lon) WGS84	48-15-34.0 N, 16-22-5.0 E	48-14-59.1 N, 16-27-0.0 E
Ground elevation (m)	164.000000	160.000000
Radio model	**S3900 /**	**L2302 /**
Output power (dBm) / reference modulation	15.00 / 256QAMLACM	15.00 / 256QAMLACM
Spectrum mask class—low reference high	2 / 6B / 6B	2 / 6B / 6B
Channel spacing (MHz)	500.000000	500.000000
Capacity (Mbps)	3124	3124
Frequency plan: frequency (MHz)	High: 80150.000000	Low: 79100.000000
Polarization	V	V
Path calculations	**S3900 /**	**L2302 /**
EIRP (dBm)	65.75	65.75
Path length (km)	6.18	
Total propagation loss (dB)	148.42	
Obstruction loss (dB)	0.00	At 50.0000%
Threshold degradation (dB)	0.00 / Default	0.00 / Default
Field margin (dB)	0.00	
Receive level (dBm)	-32.00	-32.00
Threshold (dBm)—low reference high	-74.00 / -47.00 / -47.00	-74.00 / -47.00 / -47.00
Fade margin (dB)	10.00	10.00
Radio configuration	1+0	1+0
Rain zone	ITU-R/33.33mm/hr	
Annual rain, two-way (100-% / s)	99.669910 / 104097.29	
Annual outage, two-way (100-% / s)	99.995642 / 1374.39	
Annual combined, two-way (100-% / s)	99.665551 / 105471.68	

CommScope pushes the boundaries of communications technology with game-changing ideas and ground-breaking discoveries that spark profound human achievement. We collaborate with our customers and partners to design, create and build the world's most advanced networks. It is our passion and commitment to identify the next opportunity and realize a better tomorrow. Discover more at commscope.com

commscope.com

Visit our website or contact your local CommScope representative for more information.

© 2021 CommScope, Inc. All rights reserved. COMMSCOPE, the COMMSCOPE logo and VALULINE are registered trademarks of CommScope, Inc. and/or its affiliates in the U.S. and may be registered in other countries. All other trademarks are the property of their respective owners.

Unless otherwise noted, all trademarks identified by ® or ™ are registered trademarks or trademarks, respectively, of CommScope, Inc. This document is for planning purposes only and is not intended to modify or supplement any specifications or warranties relating to CommScope products or services. CommScope is committed to the highest standards of business integrity and environmental sustainability, with a number of CommScope's facilities across the globe certified in accordance with international standards, including ISO 9001, TL 9000, and ISO 14001. Further information regarding CommScope's commitment can be found at https://www.commscope.com/corporate-responsibility-and-sustainability.

WP-114222.4-EN (12/21)