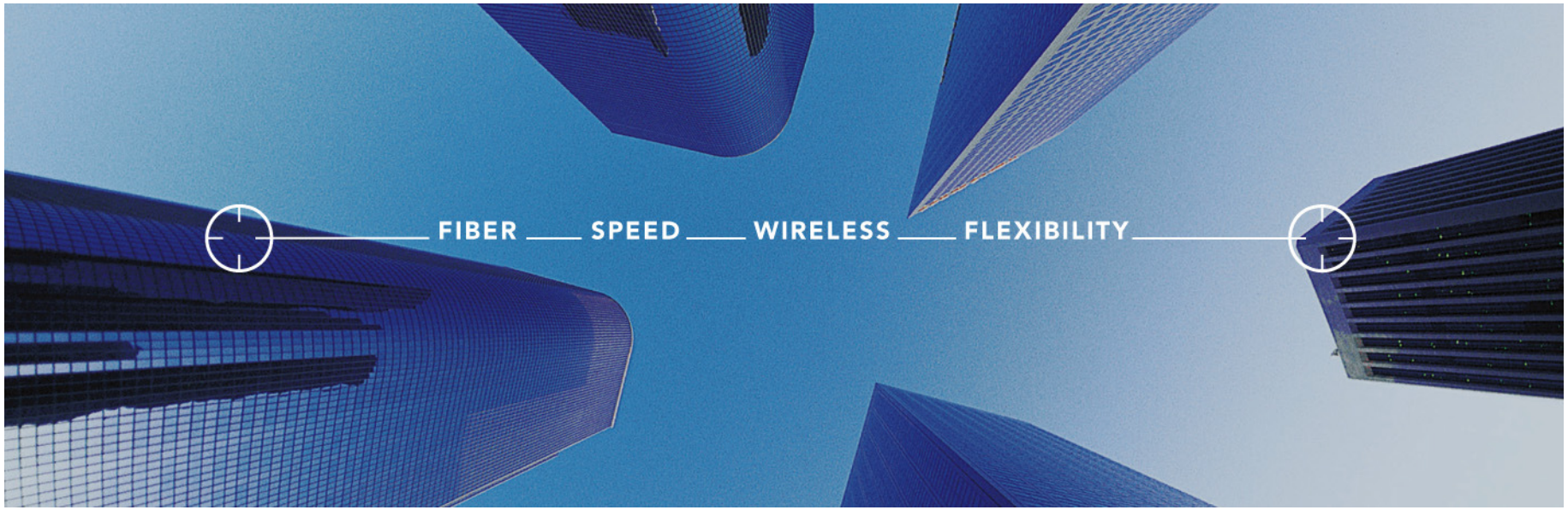


Alternative Wireless Access Technologies

Heinz Willebrand, CEO & President

The Mobile Wireless Backhaul Dilemma

❑ Backhaul Capacity Requirements Increasing

Single 4G/LTE base station capacity requirement is 50 Mbps+

Traffic requirement goes up further for co-shared locations

❑ The "T1 Line Age" Is coming To An End

The classical "T1" or "nxT1" leased copper line approach can't keep up anymore with capacity requirements of 3G/4G Mobile Wireless Networks

❑ T1 Line Pricing Model - No Economy of Scale

Leasing "T1 line model" economically not feasible anymore

Example:

- Even a simple 10 Mbps connection requires already seven T1 lines
- Average T1 leasing cost in US is about *US$300/month*
- Leasing cost for a 10 Mbps connection *US$2,100/month* or *US$25,200/year*
- Already too expensive now, not scalable, and price prohibitive in the future even if T1 line pricing comes down by 50%….

The Mobile Wireless Backhaul Dilemma (cont.)

❑ Cable Operators - Increasing Market Share

In the US Cable Operators try to fill the void by offering network access through the broadband coax cable network. Unfortunately, base station locations and coax cable availability are often not a good match. More challenges with coax cable availability outside the US.

❑ Fiber Optic Cable – The Ultimate Solution?

Using an already existing optical fiber connection is a great fit from the capacity point of view. However, monthly leasing costs can be very high.

Trenching new fiber is typically not very cost effective and can be rather time consuming.

❑ Base Station Density – Increasing

In particular in metro areas, base station densities are rapidly increasing to accommodate higher end user traffic demand in particular for new data/multimedia services. As a results, there are constantly more base station backhaul connections needed.

The Mobile Wireless Backhaul Dilemma (cont.)

❑ Licensed Microwave Backhaul – Spectrum Needed

With already existing and/or anticipated base station service radius of 1000 meters and below, frequency spectrum shortage becomes a real challenge with lower frequency pt-t-pt microwaves.

However, even if lower frequency spectrum is available interference planning becomes a real challenge with lower frequency pt-t-pt microwaves due to the relatively large antenna transmission angles.

The Mobile Wireless Backhaul Dilemma (cont.)

… and last not least one of the largest challenges:

Operators are under a lot of pricing pressure. The Mobile Wireless end user market is extremely competitive and ARPU can only be maintained by offering more advanced services at the same price or better for less.

Huge implications for the Mobile Wireless backhaul market!

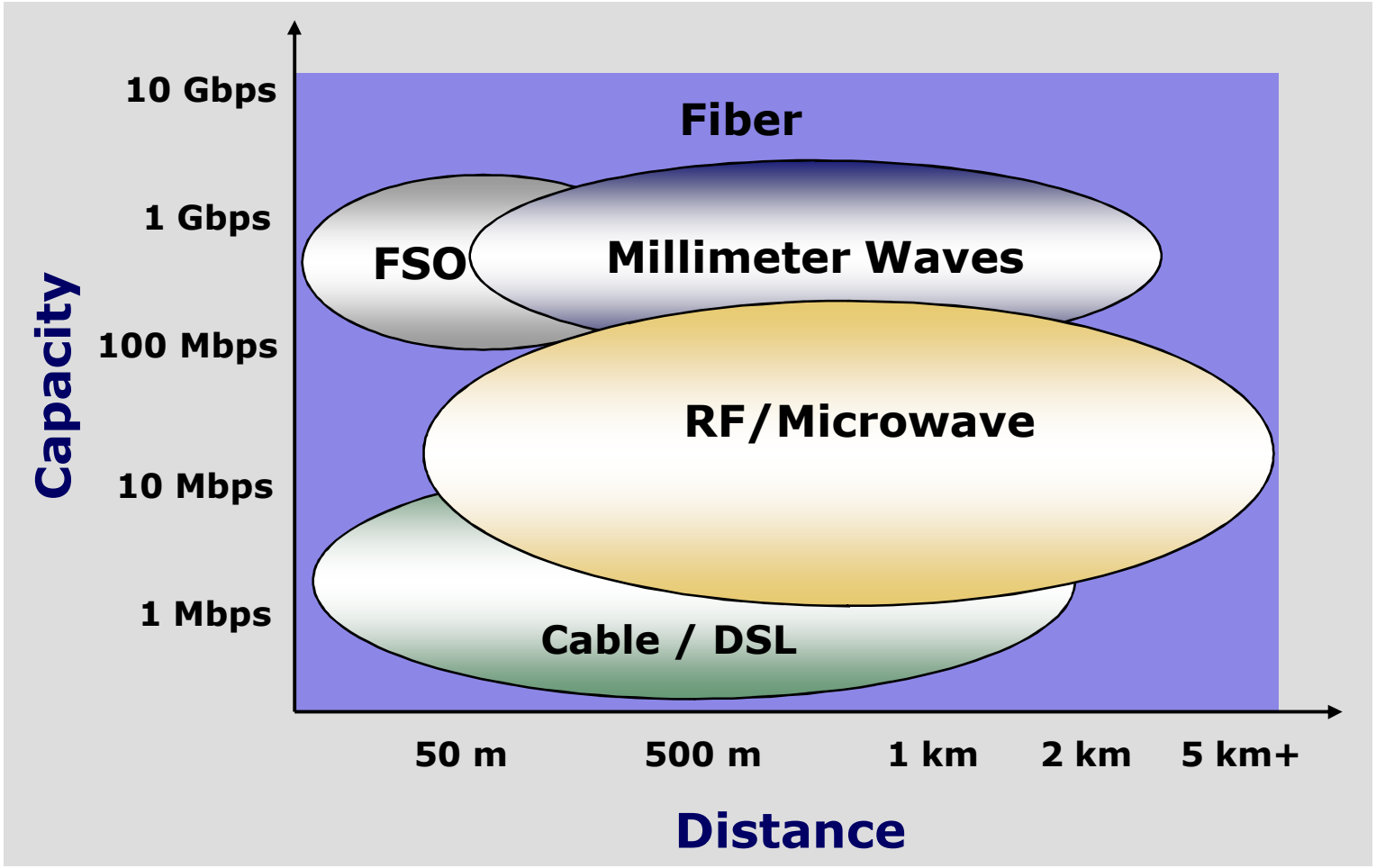
The Mobile Wireless Backhaul Dilemma (cont.)

To solve/ease the "Mobile Wireless Backhaul Dilemma" two alternative ultra-high capacity Access Technologies should be considered:

- **Millimeter Wave (MMW) Technology**

- **Free Space Optics (FSO) Technology (aka. Optical Wireless Technology)**

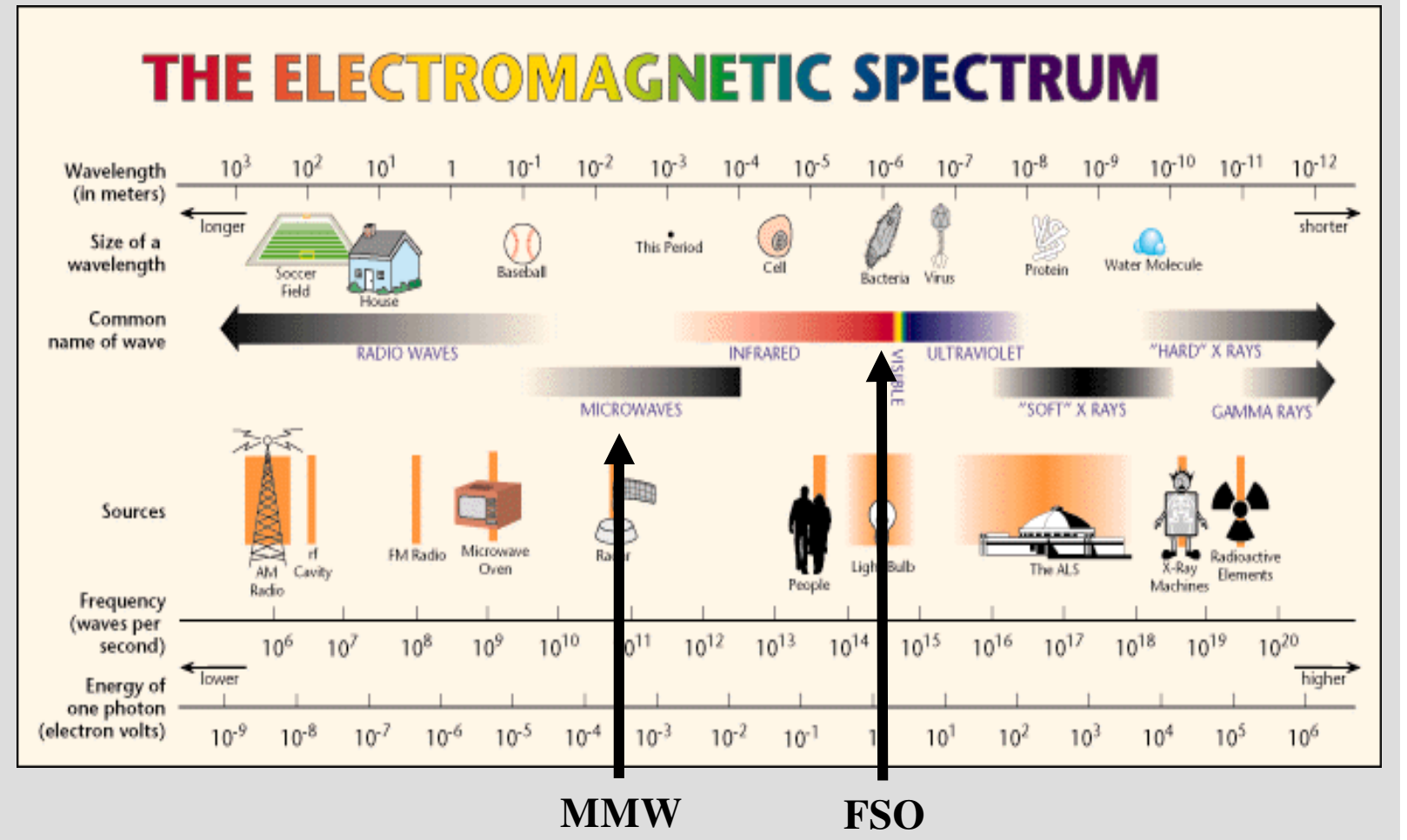
Point to Point Connectivity Technology Landscape



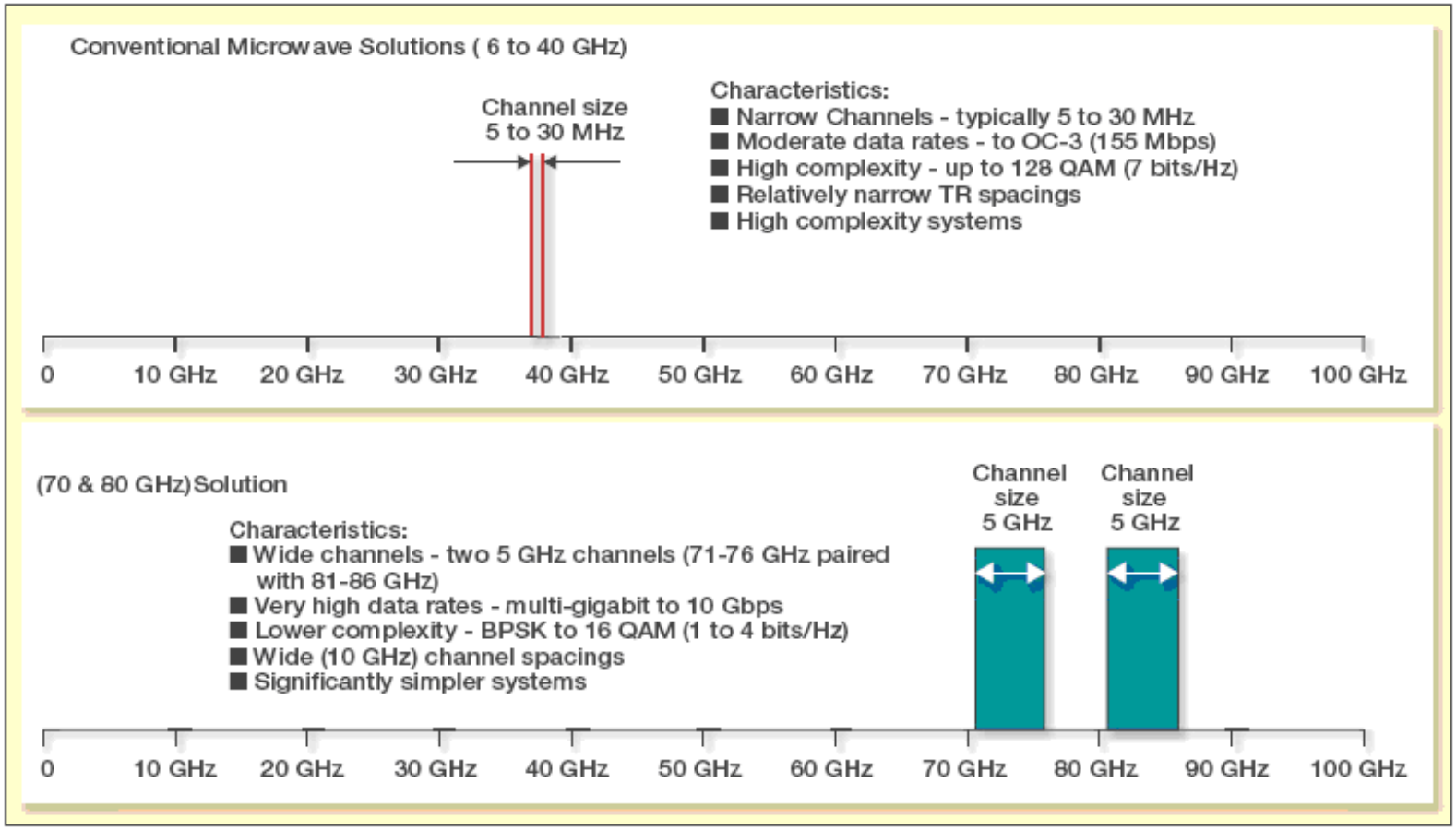
Higher Capacity Point to Point Connectivity Options

	60/70/80 GHz MMW	Leased Fiber	Buried Fiber	RF /Microwave	FSO
Commercial Availability	High	Poor (Access to ~ 14% of commercial buildings in US)	Poor	High	High
Throughput	High (> 1000 Mbps)	High (> 1000 Mbps)	High (> 1000 Mbps)	Medium (1 – 300 Mbps)	High (> 1000 Mbps)
Distance	Short/Medium	Long	Long	Medium/Long	Very short
Availability factors	Rain	Service Interruptions/ Fiber cuts	Fiber cuts	Spectrum Saturation, Interference, Rain	Fog, Snow, Dust or Sand
Right of way or spectrum permits required	60 GHz (No) 70/80 GHz (Yes) Check with local spectrum regulator for country rules	Yes	Yes	No (unlicensed) Yes, if licensed, cumbersome licensing process	No
Cost	Capital Investment, Spectrum costs vary by country	High (US$2,000 – US$10,000 per month)	High, varies (US$40k – US$250k/kilometer)	Mainly Capital Investment, Spectrum cost varies by country	Capital Investment Only
Deployment Time	Fast, a few days, Internet based “Light Licensing “ process in US. About US$300 for 10 year license.	Can take several months	Can take several months	Fast (unlicensed) Medium (licensed)	Fast, a few days

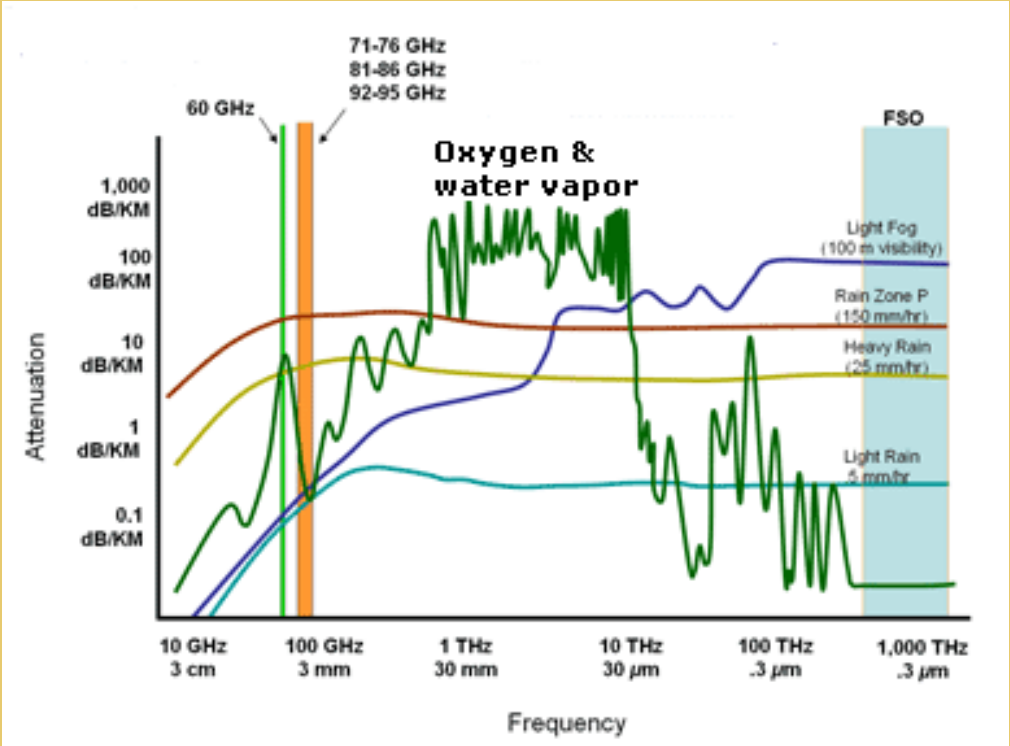
Where is the MMW and FSO spectrum located?



Difference between Microwaves and MMW



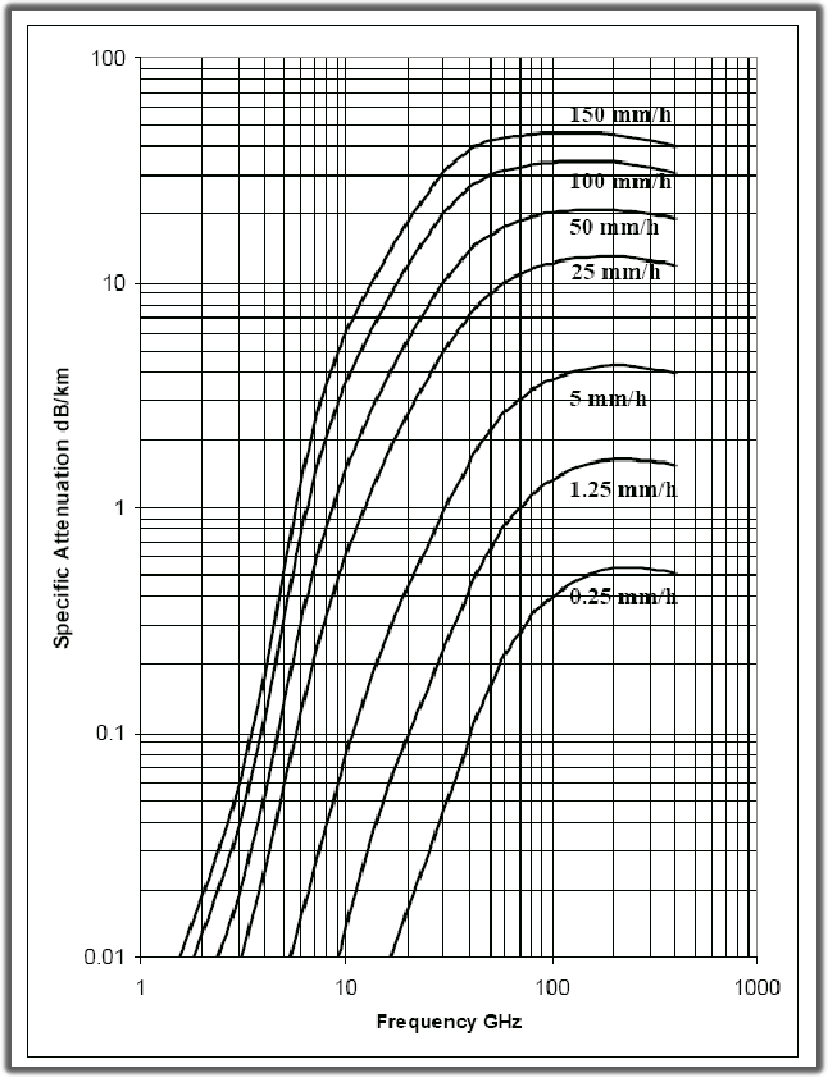
What Attenuates a MMW or FSO Signal?



Comparison of rain attenuation as well as oxygen and water vapor absorption at different frequencies. Oxygen absorption peaks around 60 GHz. Fog attenuation is very low when compared e.g. to FSO technology operating in the infrared frequency range.

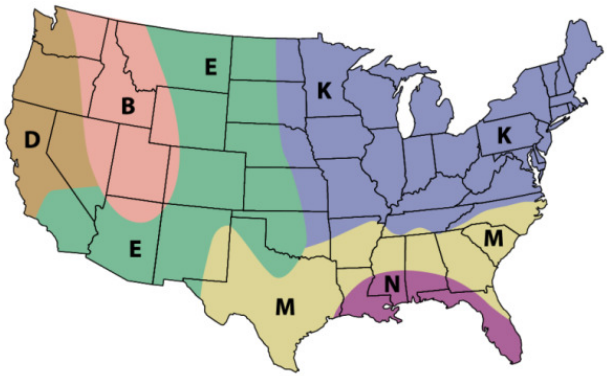
From: FEDERAL COMMUNICATIONS COMMISSIONOFFICE OF ENGINEERING AND TECHNOLOGY (Bulletin Number 70 July, 1997)

How much does rain attenuate a MMW signal?

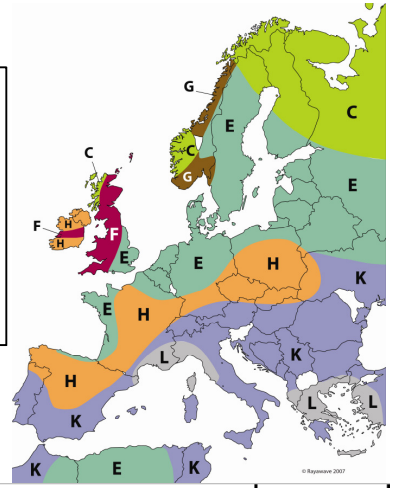


Rainfall attenuation vs frequency (ITU-R Recommendation P.838-2)

MMW System Availability



Like with all other RF/microwave radios, system distance/availability relationship depends largely on the rain zone category of the deployment location!



Outage/Year		Rain Climate Zone (rain rates in mm/hour)														Availability
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	
Percent	Time															
0.0010	(5 Min.)	22.0	32.0	42.0	42.0	70.0	78.0	65.0	83.0	55.0	100.0	150.0	120.0	180.0	250.0	99.999%
0.003	(11 Min.)	14.0	21.0	26.0	29.0	41.0	54.0	45.0	55.0	45.0	70.0	105.0	95.0	140.0	200.0	
0.01	(1 Hrs.)	8.0	12.0	15.0	19.0	22.0	28.0	30.0	32.0	35.0	42.0	60.0	63.0	95.0	145.0	99.990%
0.03	(1.8 Hrs.)	5.0	6.0	9.0	13.0	12.0	15.0	20.0	18.0	28.0	23.0	33.0	40.0	65.0	105.0	
0.1000	(9 Hrs.)	2.0	3.0	5.0	8.0	6.0	8.0	12.0	10.0	20.0	12.0	15.0	22.0	35.0	65.0	99.900%
0.3000	(18 Hrs.)	1.0	2.0	3.0	5.0	3.0	4.0	3.0	4.0	13.0	6.0	7.0	11.0	15.0	34.0	
1.0000	(88 Hrs.)	-	1.0	-	3.0	1.0	2.0	-	-	-	2.0	-	4.0	5.0	12.0	99.000%

70/80 GHz: In rain zone K or below (covers 90% of the US. and nearly 100% of Europe) typical 99.99% availability is at least one mile.

60 GHz: Transmission distance @99.99% in rain zone K is about 0.5 miles

FSO: Shorter distances in heavy fog environments. Typically not more than a few hundred meters @99.99% availability.

Summary - MMW Radio Technology

- ✓ Perfect technology to create ultrahigh capacity short/medium distance Mobile Wireless backbone links.
- ✓ Full duplex and low latency GbE radios commercially available; higher speed solution under development.
- ✓ MMW radios provide an extremely secure transmission path due to narrow transmission beam antenna pattern (~1.2 degrees (1 foot antenna), 0.6 degrees (2 foot antenna)
- ✓ In the US, 70/80 GHz MMW radio solutions can be rapidly deployed due to online Internet based licensing process.

Summary - MMW Radio Technology

- ✓ 10 year license is less than US$300 in the US.
- ✓ No license required for systems operating in the 60 GHz frequency range.
- ✓ Narrow beam pattern minimizes potential interference and jamming resistance (of particular importance for unlicensed 60 GHz solutions).
- ✓ Radios can easily be re-deployed (no sunken costs).
- ✓ Inexpensive when compared to alternative high capacity leased fiber line connections.

ROI typically 6…12 months.

Summary - FSO Technology

- ✓ **Highest capacity and lowest cost Last Mile wireless access technology in the market. Perfect for very short distance backhaul links.**
- ✓ **Full duplex and low latency GbE and higher capacity system commercially available. More than one Tbps demonstrated in outdoor lab environments!**
- ✓ **No license required (worldwide); no cost to license spectrum.**
- ✓ **Rapid deployment (hours or days v. months or year).**
- ✓ **Re-deployable (no sunken costs).**

Summary - FSO Technology

- ✓ Extremely secure transmission due to narrow optical transmission beam. No electromagnetic interference and jamming resistant.
- ✓ Inexpensive when compared to deploying fiber.
- ✓ No health risks (Eye-safe Class1/1M laser systems).
- ✓ Environmentally friendly (No need to dig, no electromagnetic pollution).
- ✓ BUT, very short distances (a few hundred meters) to ensure highest system availability in foggy environments due to fog attenuation of transmission path.

Conclusion

- **MMW and FSO transmission systems offer a viable alternate backhaul solution for short/medium distance Mobile Wireless backhaul links.**
- **The vast amount of free or "Light licensed" spectrum available in the FSO and the MMW frequency spectrum allows system operation and GbE speeds and beyond without the use of complex and expensive modulation schemes.**
- **Distance/Availability (just as a rule of thumb):**

70/80 GHz:	In rain zone K or below (covers 90% of the US. and nearly 100% of Europe) typical 99.99% availability is at least one mile.
60 GHz:	Distance @99.99% in rain zone K or below is about 0.5 miles.
FSO:	Shorter distances in heavy fog environments. Typically not more than a few hundred meters @99.99% availability.

Conclusion (cont.)

With

- **Rapidly increasing density of Mobile Wireless Base Stations,**
- **Shorter distances between Base Stations,**
- **Constantly increasing demand for backhaul capacity,**

FSO and MMW radio solutions are well positioned to become part of a next generation 3G/4G Mobile Wireless backhaul strategy.

FOR MORE INFORMATION

For more information and to download white papers please go to:

http://www.lightpointe.com/solutions/whitepapers.cfm