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Welcome!

Microwave 101

Microwave 101 Webinar Series

PRESENTERS

Joe Marzin
Director, Technology Group

Peter Xu
Engineer, Product Support

REGISTER:
www.comsearch.com/microwave-101/

DAY 1: **Microwave Fundamentals Part I** (May 23)

- Microwave Components
- RF Propagation
- Field Survey
- 6 GHz Microwave Assurance

DAY 2: **Microwave Fundamentals Part II** (June 27)

- Path Reliability
- Path Design Considerations
- iQ·link — Microwave Design Software (Live Demo)

DAY 3: **Understanding the Frequency Coordination Process** (July 25)

- Interference Analysis
  - Microwave
  - Earth Station
- Frequency Planning & Protection
- FCC Licensing & Management
- Comsearch Connect - Customer Portal (Live Demo)
- FCC Regulatory Updates (6 GHz, 80 GHz, 13 GHz)

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Microwave Fundamentals Part II

1. Path Reliability

Joe Marzin
Director, Technology Group

PATH RELIABILITY

TRANSMITTING END

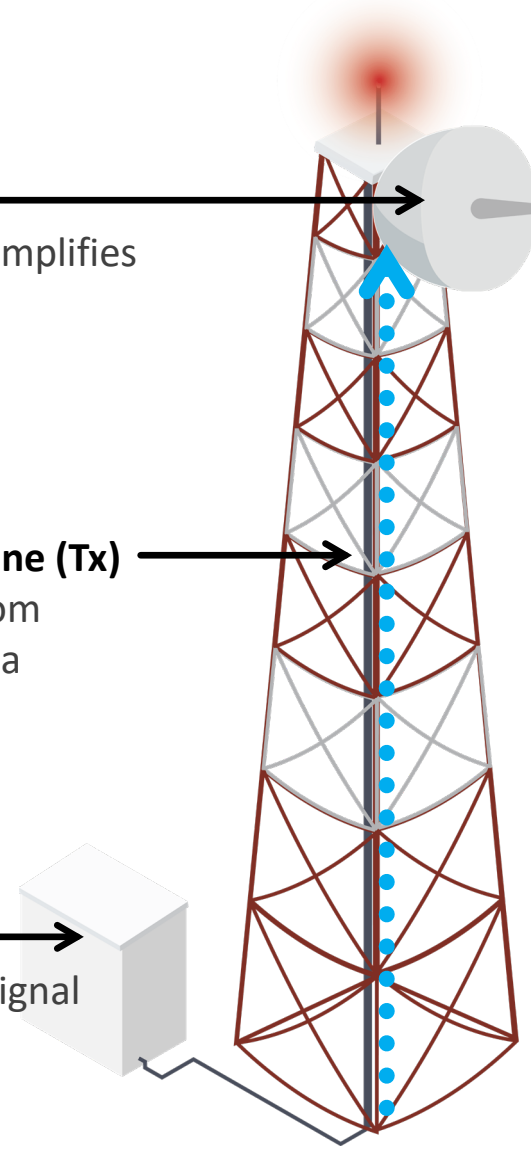
RECEIVING END

SIGNAL

Antenna (Tx)
transmits and amplifies the signal

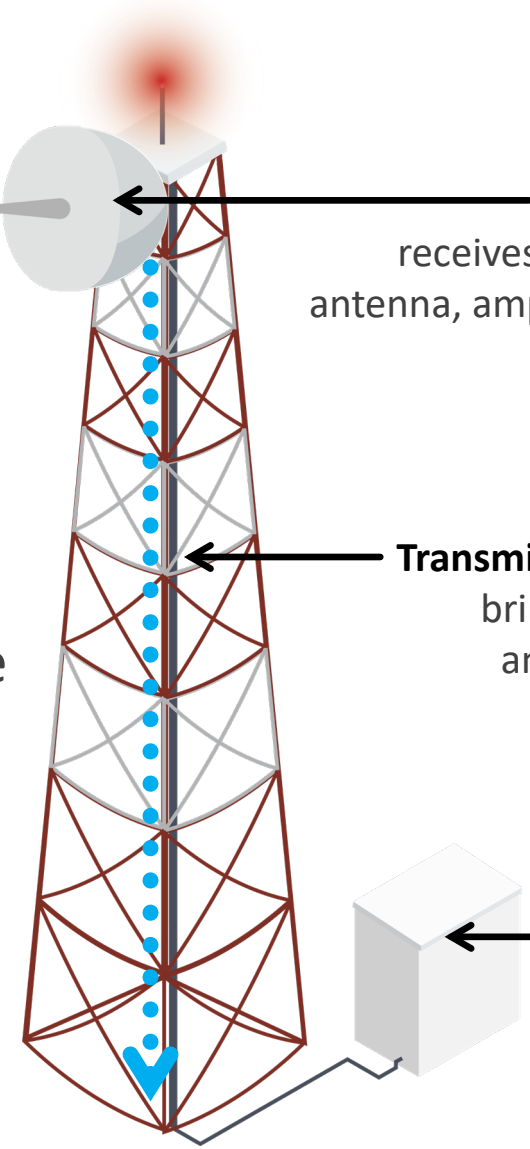
Transmission Line (Tx)
brings signal from radio to antenna

Radio (Tx)
generates the signal



What is path reliability?

Target reliability based on usage type + industry standard is 99.999% (“Five 9’s”)



Antenna (Rx)
receives signal from Tx antenna, amplifying it again

Transmission Line (Rx)
brings signal from antenna to radio

Radio (Rx)
receives signal

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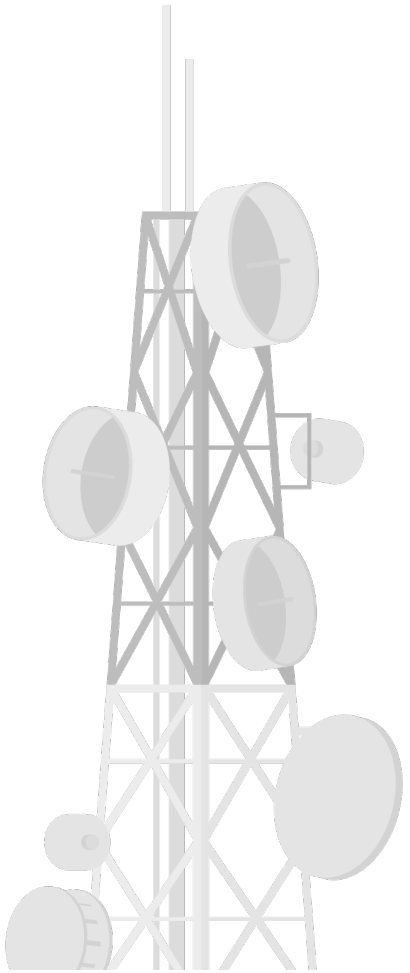
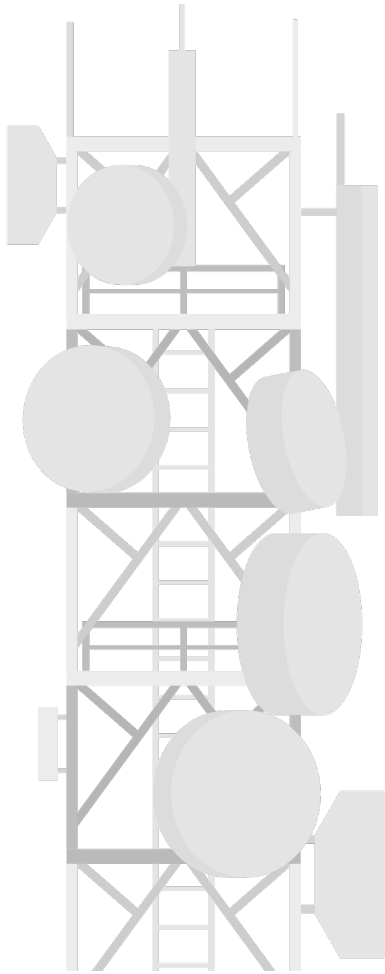
Factors that Affect Reliability



VARIABLE	RELATIONSHIP
Transmit Power Level	Higher Power → **More Reliable**
Antenna Size	Larger Antenna → **More Reliable**
Diversity	Diversity Usage → **More Reliable**
Terrain	Rough → **More Reliable**
Path Length	Longer Path Length → **Less Reliable**
Frequency Band	Higher Frequency Band → **Less Reliable**
Temperature	Higher Temperature → **Less Reliable**
Rain Rate	Higher Rain Rate → **Less Reliable**
Climate	Warm & Humid → **Less Reliable**



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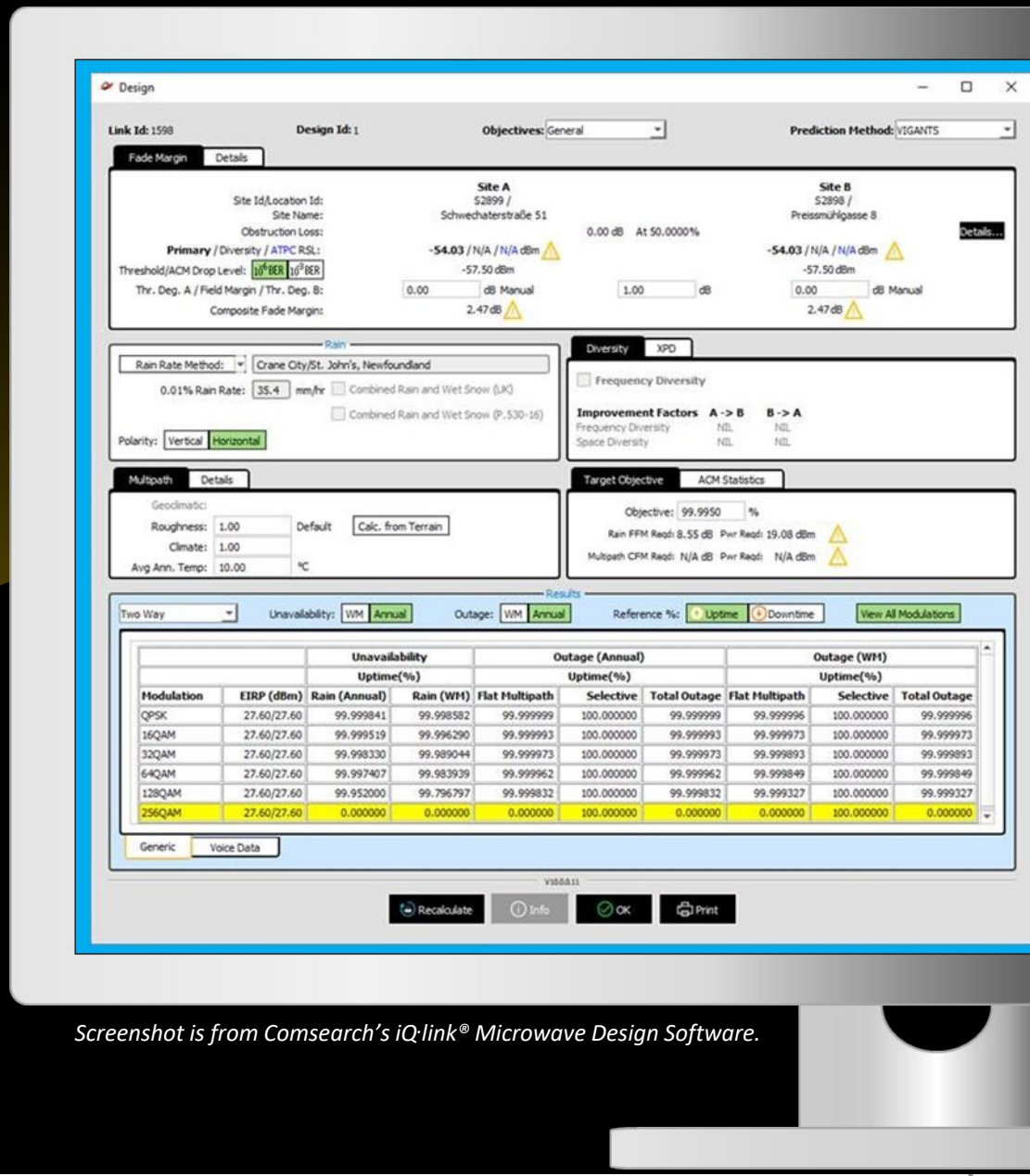
PATH RELIABILITY | OUTAGE

- The time that the Received Signal Level (RSL) is faded below the Receiver Threshold is known as ***Outage***
- Outage is calculated as time below 10^{-6} BER for most microwave applications



Screenshot is from Comsearch's iQ·link® Microwave Design Software.

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31,556,926

SECONDS IN A YEAR

An availability of **99.99% (four nines)** means an outage of 3155.7 seconds per year, or about **53 minutes**

An availability of **99.999% (five nines)** means an outage of 315.57 seconds per year, or about **5 minutes**

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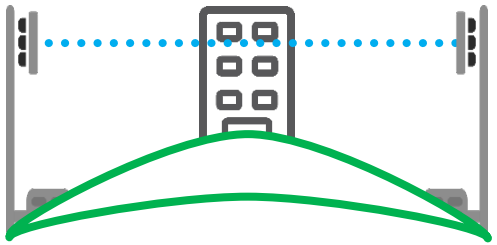
RF PROPAGATION | FADING TYPES

OBSTRUCTION

- Low K Factor -

- Path Blockage -



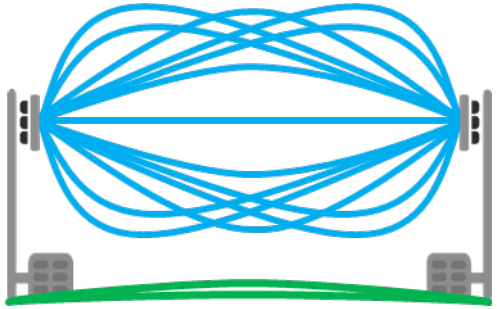
REMEDY

Increase antenna heights

MULTIPATH

- Phase Cancellation -

- Reflective or Atmospheric -



REMEDY

Space or frequency diversity

ABSORPTION

- Precipitation -

- Atmospheric Gases -

REMEDY

ACM or shorter paths

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Amount signal may fade before a path outage results

COMPOSITE FADE MARGIN

Thermal Fade Margin (TFM)

= normal RSL - receiver threshold

Dispersive Fade Margin (DFM)

= effect of frequency selective fading in the channel

External Interference Fade Margin (EIFM)

= effect of interference

$$CFM = -10\log_{10}(10^{-TFM/10} + 10^{-DFM/10} + 10^{-EIFM/10})$$

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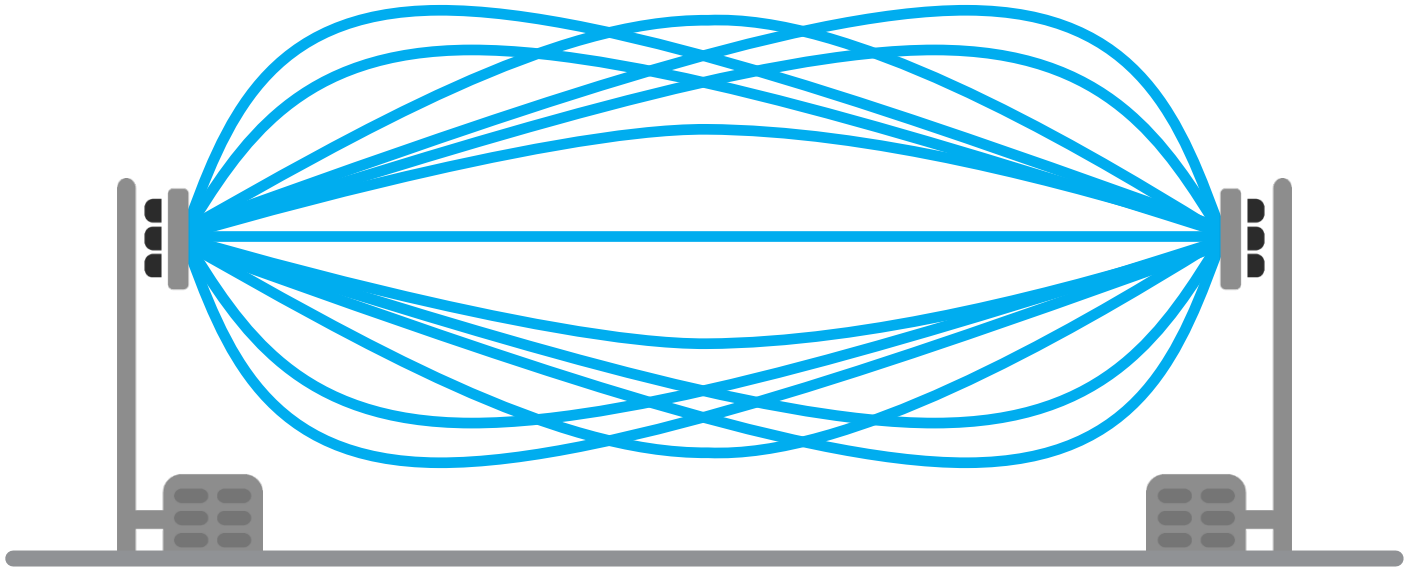
PATH RELIABILITY | MULTIPATH OUTAGE MODEL

- Fade margin must be high enough for the path to meet the *reliability objective*
- Multipath outage models (e.g. Vigants, ITU) predict link outage based on:
  1. Fade margin
  2. Climate
  3. Terrain
  4. Temperature
  5. Frequency
  6. Path length
- Outage time can be greatly reduced using frequency and/or space diversity



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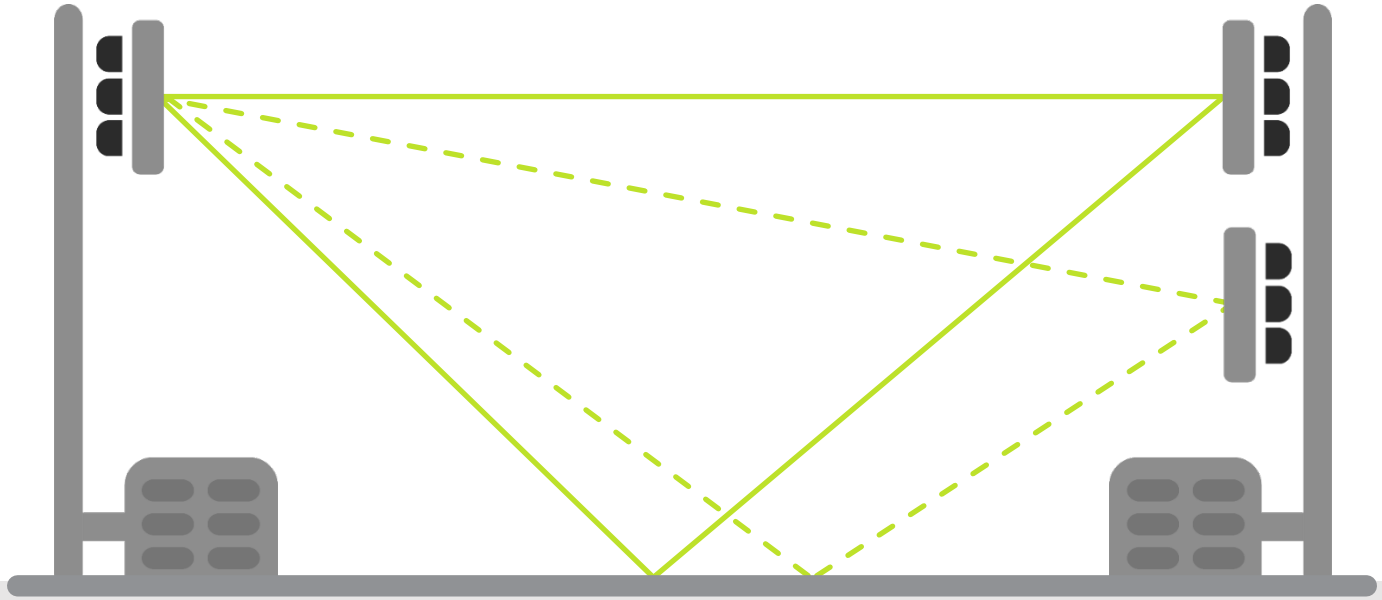
WHAT IS SPACE DIVERSITY?

Additional receive antenna to combat atmospheric or reflective multipath



WHAT IS THE OPTIMUM SPACING?

- Reflection analysis determines the optimum spacing between the antennas
- Typical spacing's range from 10 to 50 feet

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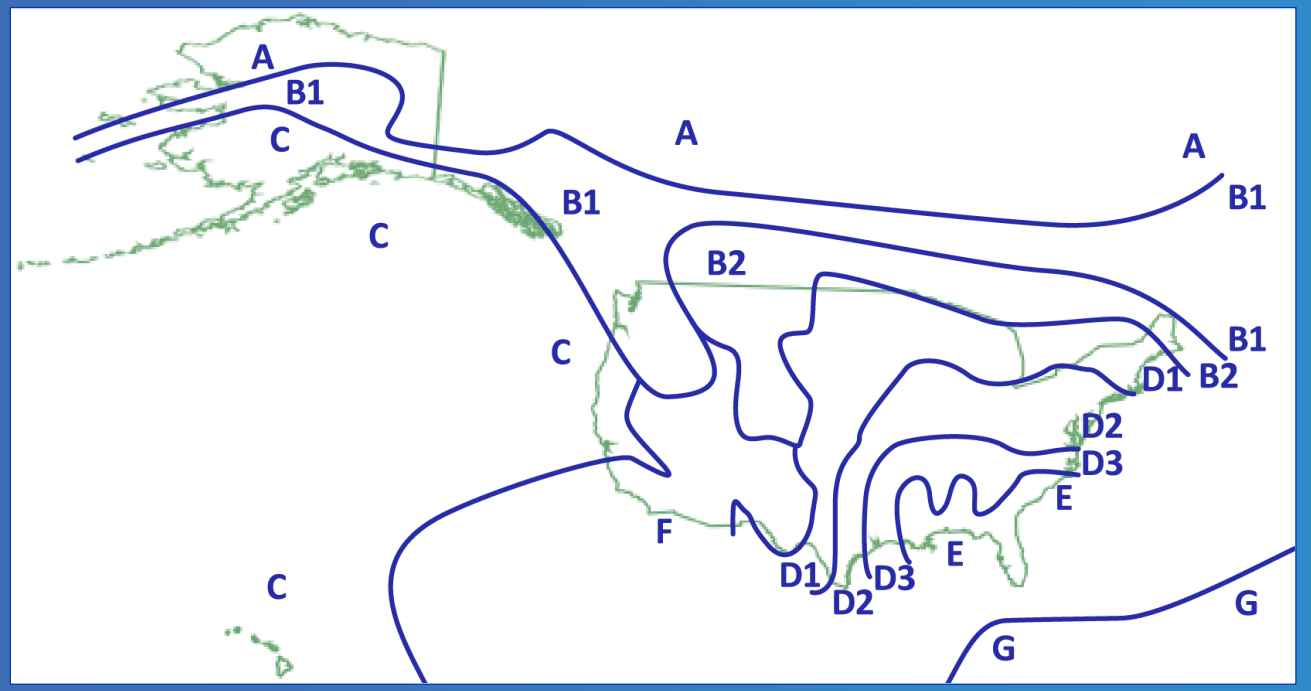
PATH RELIABILITY | RAIN OUTAGE

- **Rain fade** is significant above 10 GHz
- **Rain models** (e.g. Crane, ITU) predict rate of rain that would cause attenuation to exceed fade margin
- **Rain rate** statistics are available down to city level
- **Outage** probability proportional to rain severity—*not* total annual rainfall
- **Rain attenuation** for horizontal polarity is greater than for vertical



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EFFECT OF ENVIRONMENTAL FACTORS ON RELIABILITY

6 GHz			
Climate	Temperature	Terrain	Max. Path Length* (mi)
Good	Cool	Rough	28.1
Average	Average	Average	17.6
Poor	Warm	Smooth	11.5

23 GHz				
Rain City	Multipath Climate	Temperature	Terrain	Max. Path Length* (mi)
Seattle	Average	Average	Smooth	3.73
Chicago	Average	Average	Smooth	1.94
Miami	Poor	Warm	Smooth	1.38

< 10 GHz

rain fading insignificant

10 - 18 GHz

multipath *and* rain fading

> 18 GHz

rain fading significant, multipath fading insignificant

** Maximum path length to expect for a single antenna system that still meets 99.995% reliability using Vigant's method*

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Microwave Fundamentals Part II

2. Path Design Considerations

Joe Marzin
Director, Technology Group

COMMON BANDS

6.1 GHz
(5.925 – 6.425)

6.7 GHz
(6.525 – 6.875)

11 GHz
(10.7 – 11.7)

18 GHz
(17.7 – 19.7)

23 GHz
(21.2 – 23.6)

OTHER OPTIONS

70/80 GHz
“lightly licensed”

7 GHz
(only in some areas)

5.8 & 60 GHz
(unlicensed)

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LICENSED VS. UNLICENSED

	Licensed	Unlicensed
Typical Applications	Backhaul, critical infrastructure	Spur links, temporary links, rural areas
Time to Begin Operation	Varies (2-16 weeks)	Immediately
Equipment Costs	Higher, more features	Lower, less features
Antenna Size	Somewhat flexible	Very flexible
Licensing Cost	Ranges—few hundred to a few thousand	Zero
Interference	Protection	No Protection

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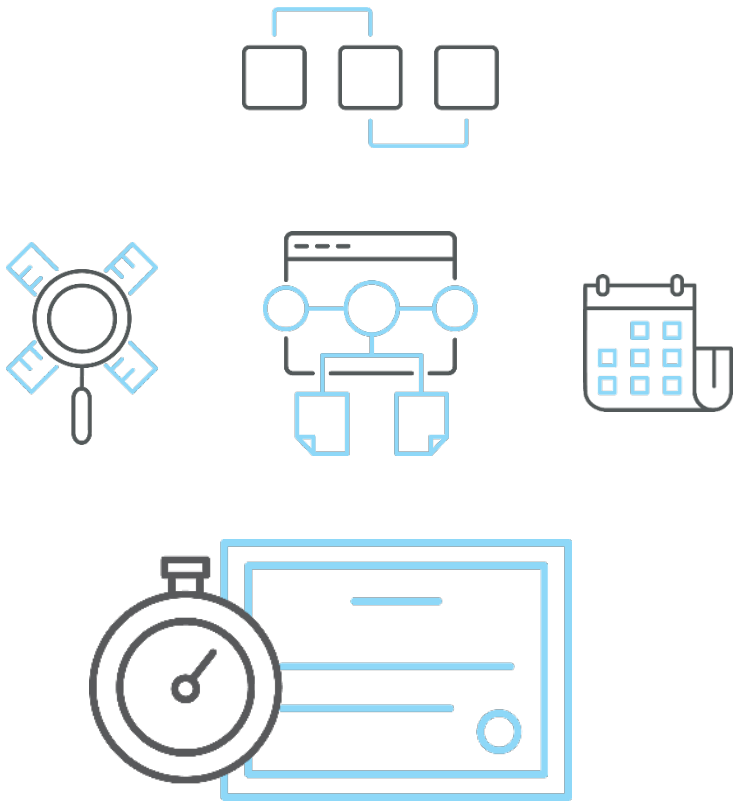
How long does the process take?

Total time … about **2-4 months**



WEEK(S)	PROCESS
2	Path Design / Survey
1	Interference Analysis
2 - 4	Prior Coordination (PCN)
1	FCC Licensing
4 - 8	FCC License Grant

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Licensed Microwave Maximum Bandwidths / Minimum Antenna Sizes

PART 101 MICROWAVE		
Band (GHz)	**Largest Channel** (MHz)	**Smallest Antenna** (ft)
6.1	60	3
6.7	30	3
7	25	3
11	80	2
18	80	1
23	50	0.75
70-90	5000	0.75

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Licensed Microwave EIRP Restrictions

Band (GHz)	**Minimum Path Length w/o Reducing Power** (km)
< 10 GHz	17
10 – 18 GHz	5
> 18 GHz	N/A

The maximum allowable **EIRP is 85 dBm** for most **Part 101** microwave bands

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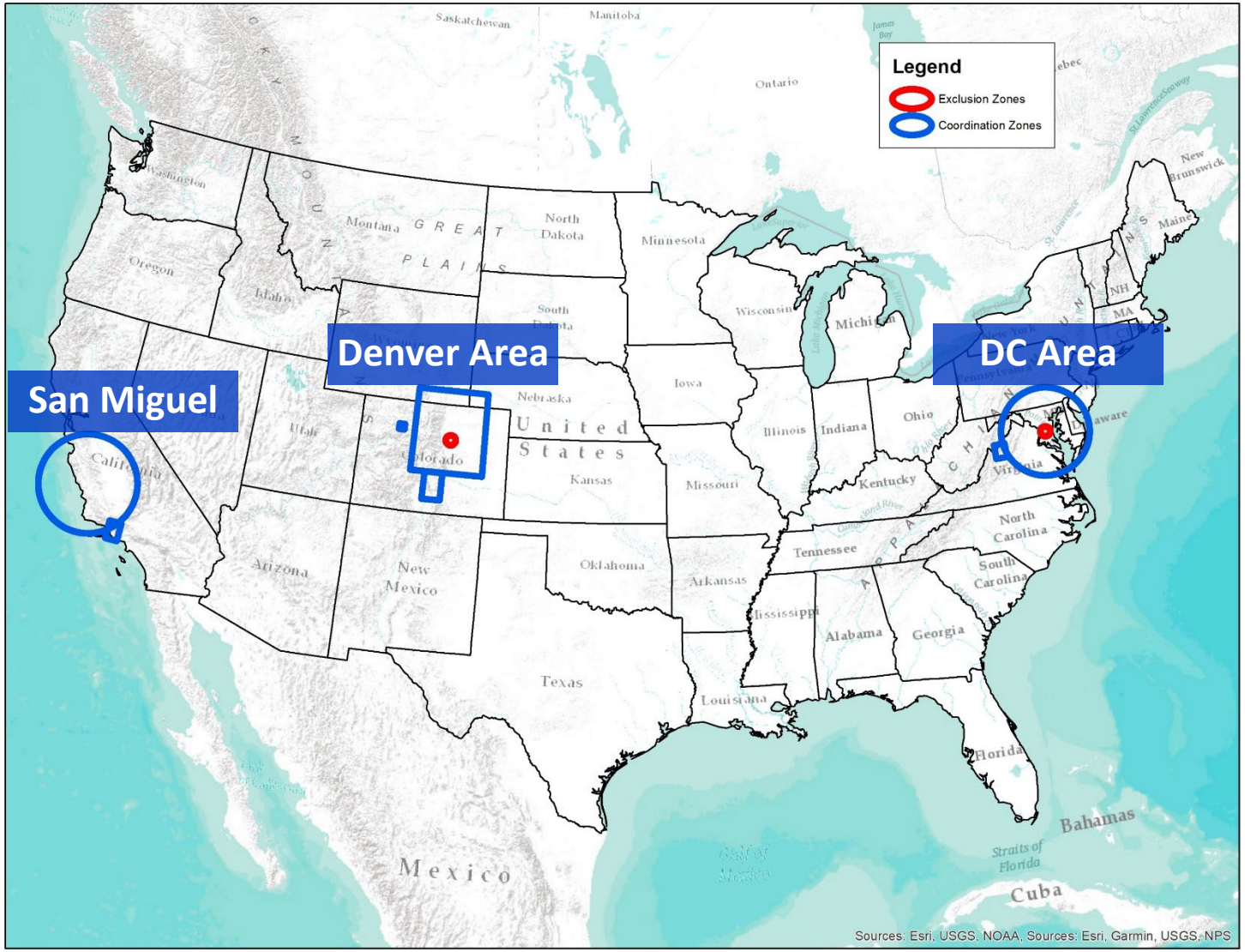
18 GHz DOD Quiet Zones (Parts 74, 78, and 101)



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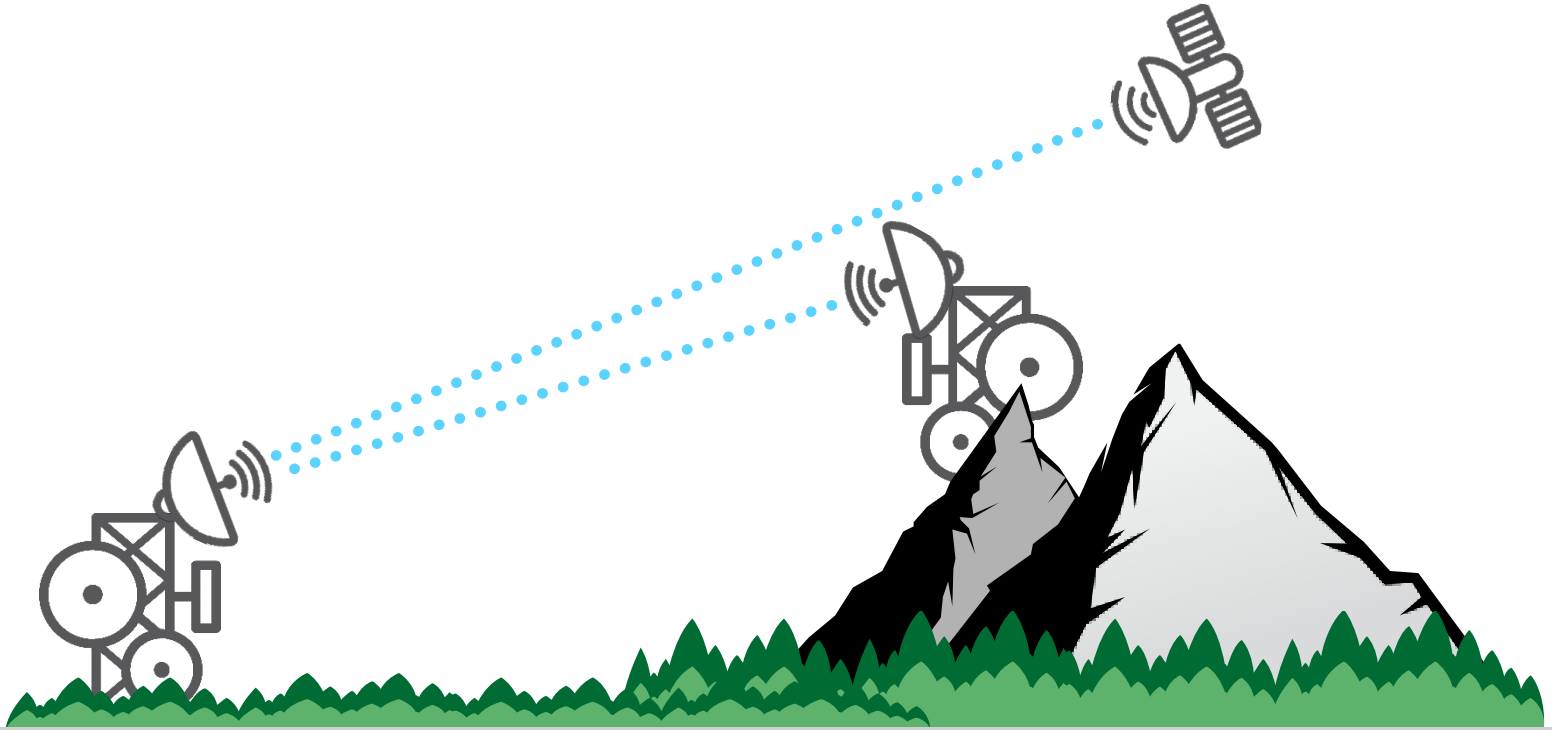
Microwave into Satellite Interference



6 GHz

EIRP ≤ 65 dBm = Conditional Authorization

EIRP > 65 dBm = Waiver Required and No Conditional Authorization

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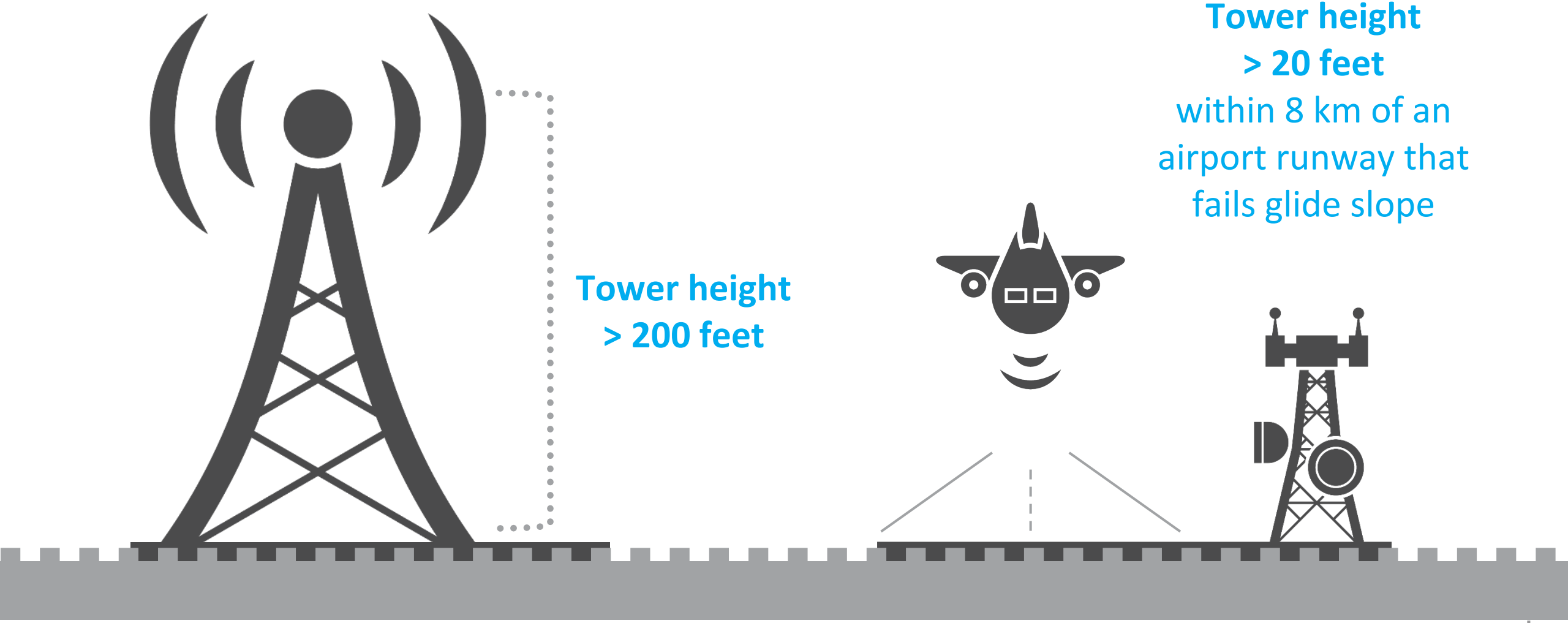
FCC / FAA Tower Registration Requirements



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When Can I Operate My Path?

A. **Conditional Authorization**—Can operate once FCC application is ***filed***

- ☑ No waivers
- ☑ No environmental impact
- ☑ Must be more than 56.3 km away from international borders
- ☑ Cannot lie within 10 GHz restricted zones
- ☑ Cannot lie within 18 GHz restricted zones (DC, Denver, San Miguel, and Guam)
- ☑ Must be >15 GHz if in Puerto Rico
- ☑ If 23 GHz, only operating on non-restricted channels

B. **No Conditional Authorization**—Can operate once FCC license is ***granted***

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iQ·link®

All the right tools to design and manage your microwave backhaul network for 5G and beyond

Microwave Fundamentals Part II

3. iQ·link Demo

Peter Xu
Engineer, Product Support

iQ·link®: A wireless microwave Point-to-Point and Point-to-Multipoint, fixed network design software tool

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World class technical support

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True multi-user environment

Efficient use of the spectrum

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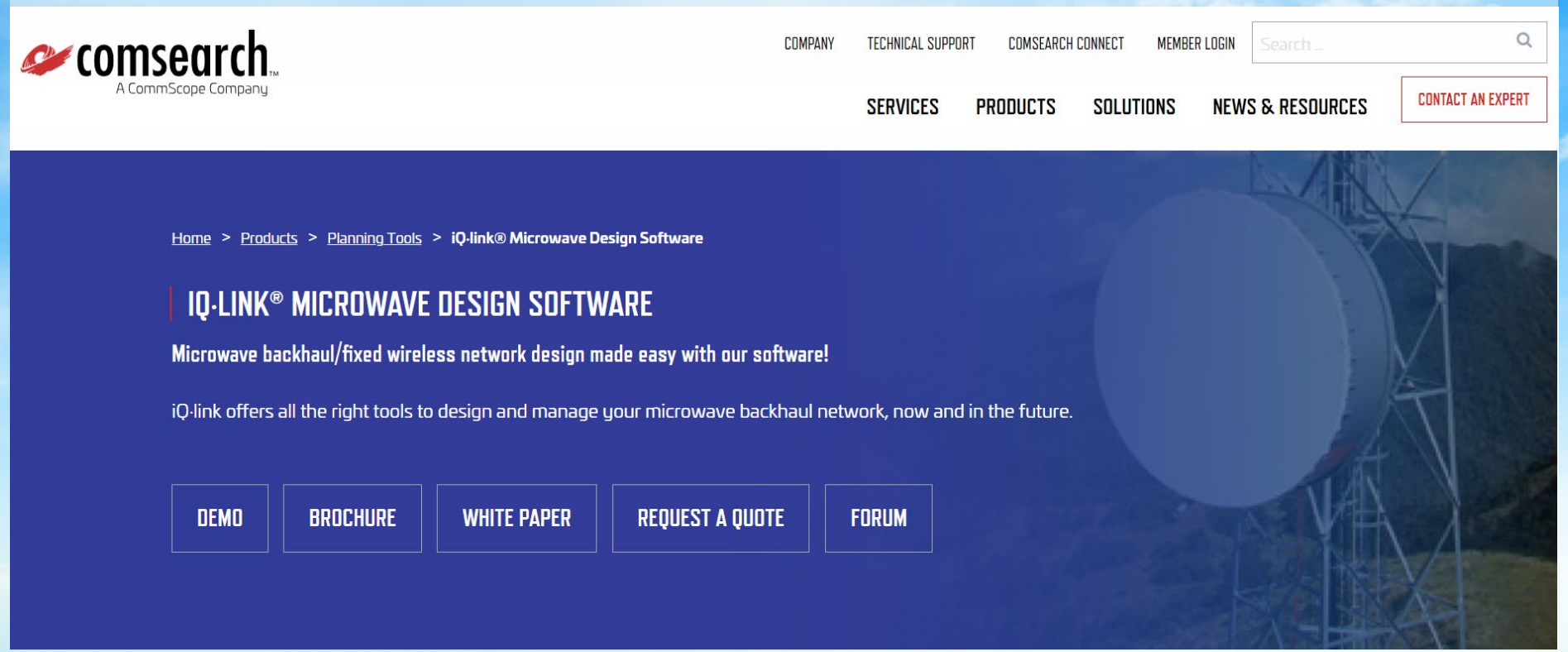
https://www.comsearch.com/products/planning-tools/iqlink/



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Thank You!

Joe Marzin
Director, Technology Group
jmarzin@comsearch.com

Peter Xu
Engineer, Product Support
peter.xu@commscope.com

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