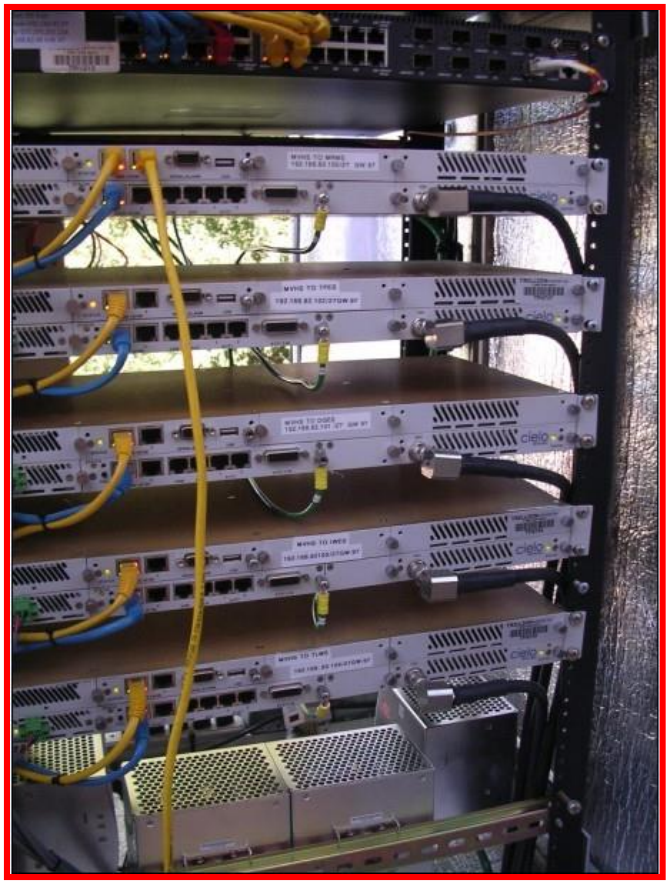
cielo®
NETWORKS

Licensed Microwave Options for the Broadcast Industry



Presentation Overview

- Part 74 and Part 101 Overview
- Part 101 New Rules for Broadcasters
- Using microwave to meet increasing data throughput needs
- Part 101 Microwave Technology
- Planning for a new link
- Licensed vs Unlicensed
- FCC Licensing Process
- Costs
- Reliability
- Networking
- Remote Management
- Cielo Networks Overview
- Questions

Part 74 Summary

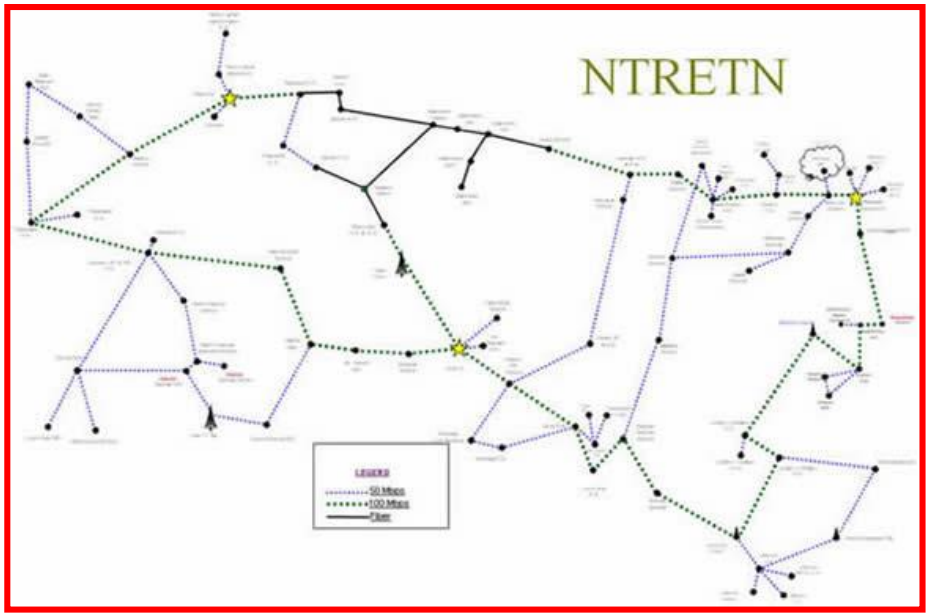
- Part 74 summary:
  - Used by broadcasters
  - For relaying broadcast aural and television signals.
  - Stations can be used to relay signals from the studio to the transmitter, or between two points, such as a main studio and an auxiliary studio.
  - Services also include mobile TV pickups and remote pickup stations which relay signals from a remote location, back to the studios
  - Frequency Bands
    - 944 to 952 MHz
    - 2 GHz
    - 2.5 GHz
    - 7 GHz
    - 13 GHz

Part 101 Summary

- Part 101 summary:
  - Fixed point-to-point microwave service used by everyone else.
  - Applications
    - Early days T1 and OC3
    - Now almost all Ethernet
  - Capacity
    - Full Duplex hops
    - Greater than 490 Mbps (upgrade to 2+0 and nearly 1 Gbps
    - Dependent on channel size and modulation
  - Frequency Bands Used:
    - 6 GHz
    - 11 GHz
    - 18 GHz
    - 23 GHz
    - 38 GHz (not anymore – going 5G)
  - Licensed Solution
    - Simple process to license and get 10 year license
    - Federal Protection against interference

Microwave Network Applications and Architectures

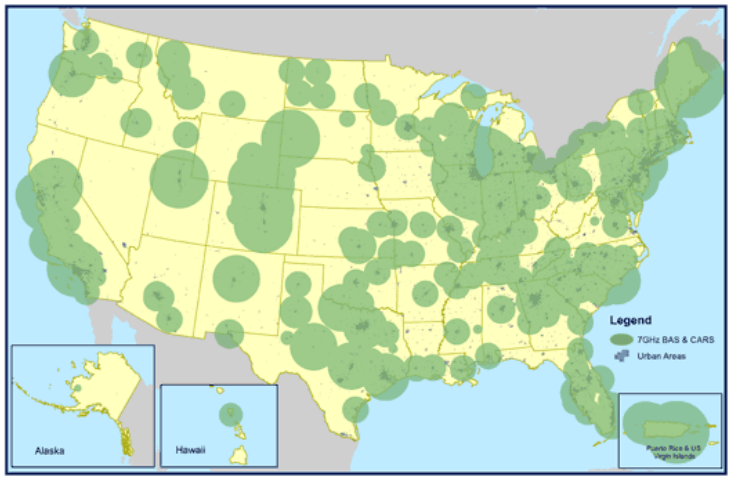
- Common applications for point to point wireless:
  - Fixed wireless access & fiber network extension
  - Cellular & WISP backhaul
  - Enterprise & private networks
  - Local/state Government, education, public safety networks (state, county, local government agencies are exempt from the FCC license fees).
  - US Government has 7, 8, and 15 GHz to their own. Also 23 GHz but is shared with Part 101. Primarily they stick to these bands.
  - Critical communications redundancy
  - Low latency optimized networks
- Architectures: Single Hop, Star, cascade ("daisy chain"), and ring network topologies



FCC Rules Change for Common Carriers

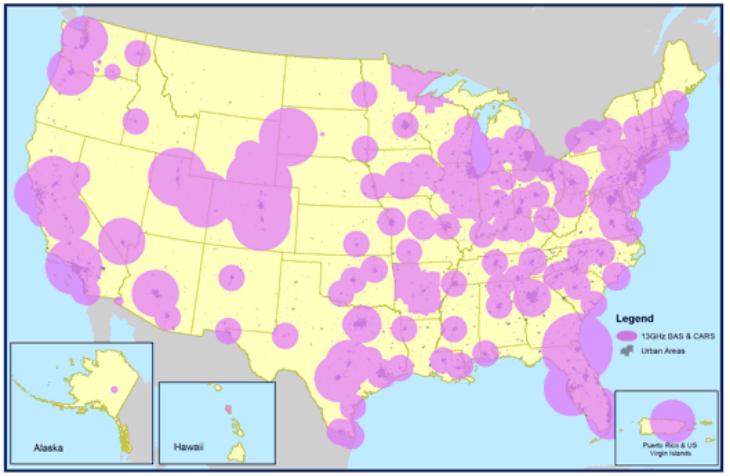
- August 2011 – FCC defines new rules
  - Common Carriers have access to 7 and 13 GHz Broadcast Auxiliary Service and Cable Antenna Relay Services channels
    - Rules very stringent for common carriers.
    - Exclusion Zone map knocks out most metro areas
    - Not a popular option for common carriers

Exclusion Zones



COMSEARCH

7GHz BAS and CARS



COMSEARCH

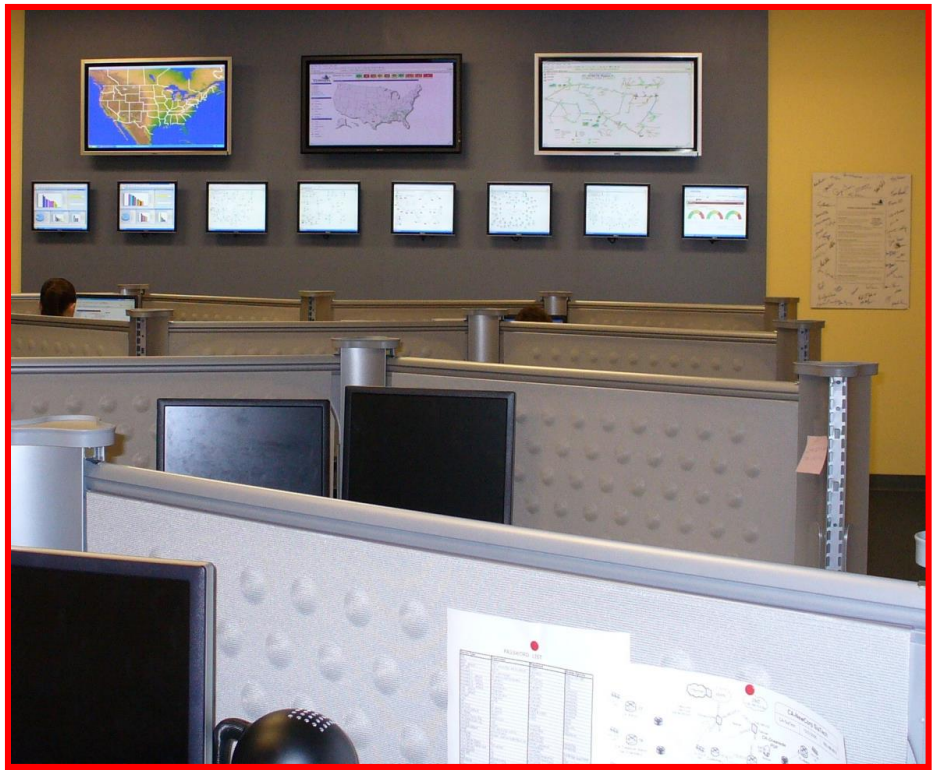
13GHz BAS and CARS

FCC Rules Change For Broadcasters

- Broadcasters have access to Part 101 frequencies – eliminating the “Final mile” rule
  - Opens up options for “final mile” needs for studio to transmitter.
  - Primary or backup broadcast links at 6, 11, 18, and 23 GHz
  - These channels are full duplex.
- Not only the Final Mile to the transmitter site:
  - Use for out-of-band capacity from broadcast to have a high speed connection to the transmitter site for management, surveillance, etc.
  - Consider new applications. Connect remote offices together with your own private network.

Monitoring Your Sites

- Microwave equipment supports remote management via Web GUI or management tools such as SNMP
  - Always know the status of your gear and have alarms sent immediately to NOC
  - Remote control and telemetry
- Monitor remote / unattended transmitter sites with IP cameras

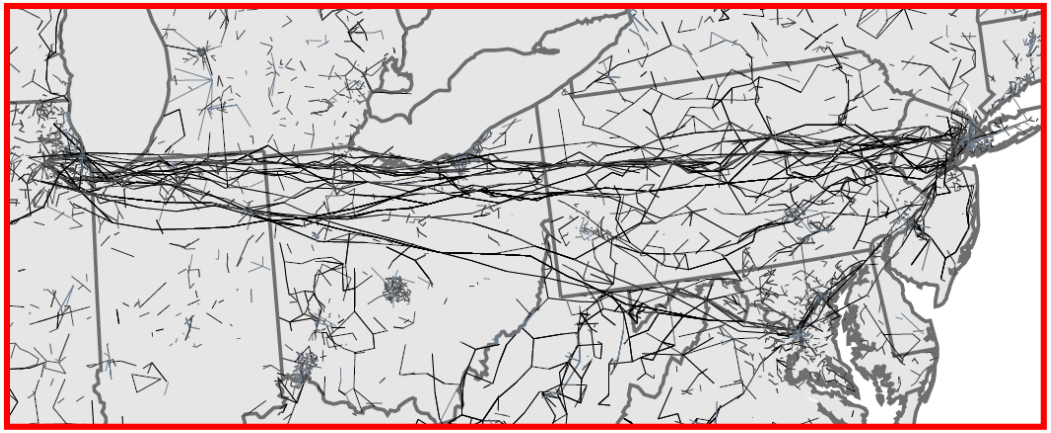


Why Use Microwave?

- Connectivity may be satisfied by dark/leased fiber or the public Internet, but there are clear benefits to point-to-point microwave.
  - Most alternative commercial solutions are vulnerable to “backhoe fade.” →
  - The public Internet is a shared resource. Sudden spikes in user demand can result in increased packet loss and jitter.
  - Microwave is your own private network. No sharing of bandwidth. Can extend your LAN to the remote site.
  - Although there is an initial equipment cost, the minimal ongoing operational cost of private microwave makes it very attractive.

Point-to-Point Microwave Advantages

- Microwave and other technologies can be combined for even higher system reliability.
  - Use it as a backup to your primary connection (alternative path protection)
- Time to market for microwave – be connected in days.
- If latency is critical, microwave is the best solution
  - Path Distance
    - Microwave path distance is direct as the crow flies
    - You may never know what fiber path your data takes unless you put it in yourself
  - Microwave is faster than fiber
    - Microwave – speed of light (5.3 microseconds / mile)
    - Fiber - .67 speed of light (7.9 microseconds / mile)



Low Latency Microwave Radio Links
NY to CHI, DC to CHI, DC to NY

Point-to-Point Microwave
How Far Can I Go

- All Microwave Hops require Line of Sight
- General Path Distances
  - 23 GHz: Less than 5 miles (limited by rain fade)
  - 18 GHz: 5 to 10 miles (limited to rain fade)
  - 11 GHz: 10 to 15 miles (rain fade and multipath)
  - 6 GHz: Greater than 15 miles (multipath)
- For lower frequency bands use space diversity to increase path distances
- In all cases use path engineering tools to design the best solution for your application

Microwave Technology

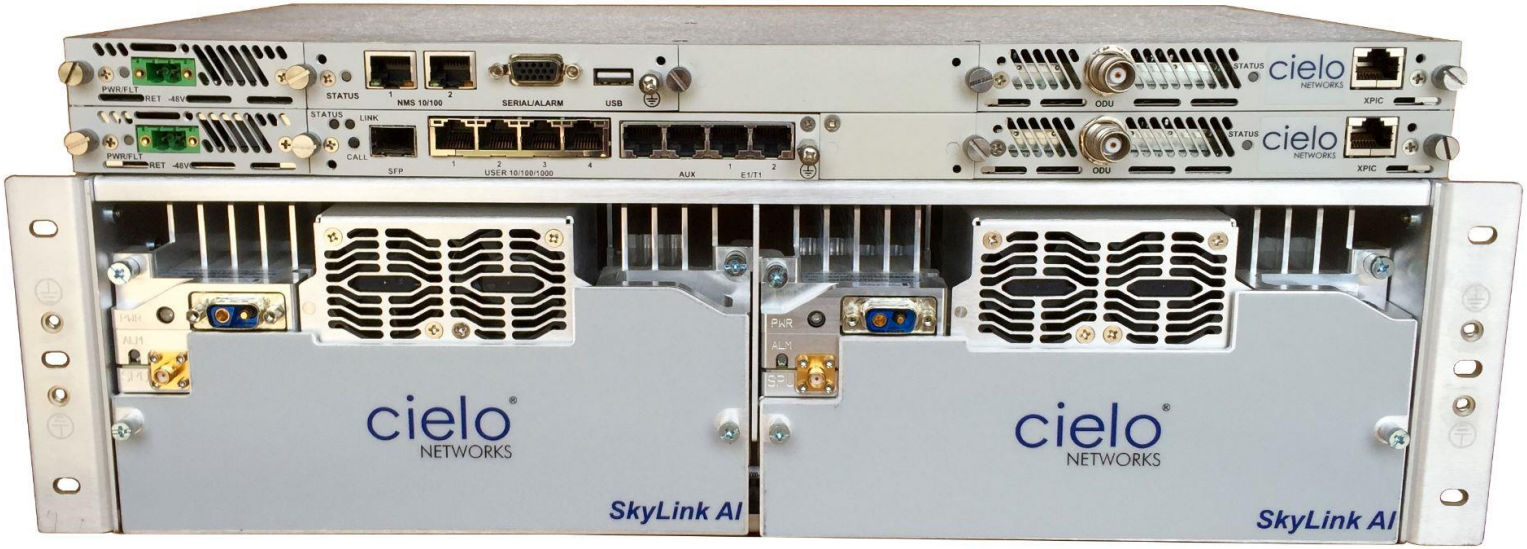
- Common Product Architectures
  - Split Mount:
    - Low install cost
    - Lower product costs
    - Indoor unit for your network connections
    - Outdoor unit for radio with direct or remote mount connection to antenna. 6 to 38 GHz
    - 50 Ohm Coaxial Cable connection between IDU and ODU
    - Indoor Unit is used with any ODU transmit frequency. Indoor Unit to ODU connection operates at 140 MHz / 350 MHz on coaxial cable
    - Tower climb / Roof Access required for issues involving radio

Indoor Unit

Outdoor Unit
Directly Mounted to Antenna

Microwave Technology

- Common Product Architectures
  - Indoor Radio:
    - Higher product cost – Indoor radio costs more than Outdoor unit
    - Higher install cost – elliptical waveguide, dehydrator
    - More rack space required for radio
    - All electronics indoors – should not be a need to climb the tower unless the antenna moves.
    - 6 to 11 GHz



Microwave Technology

- Common Product Architectures
  - All Outdoor:
    - No rack space required
    - Ethernet only (POE)
    - Lowest product cost
    - All gear is up on the tower.
    - Generally highest capacity solutions (wideband channels)
    - 6 to 38 GHz
    - E-Band (60 to 80 GHz) – Not under Part 101 rules

Microwave Radio Link Capacity

- Capacity of Microwave Links
  - Based on channel size and modulation
  - Scalable Ethernet solutions – increase link bandwidth over time. Purchase gear up front at lower cost and add capacity later

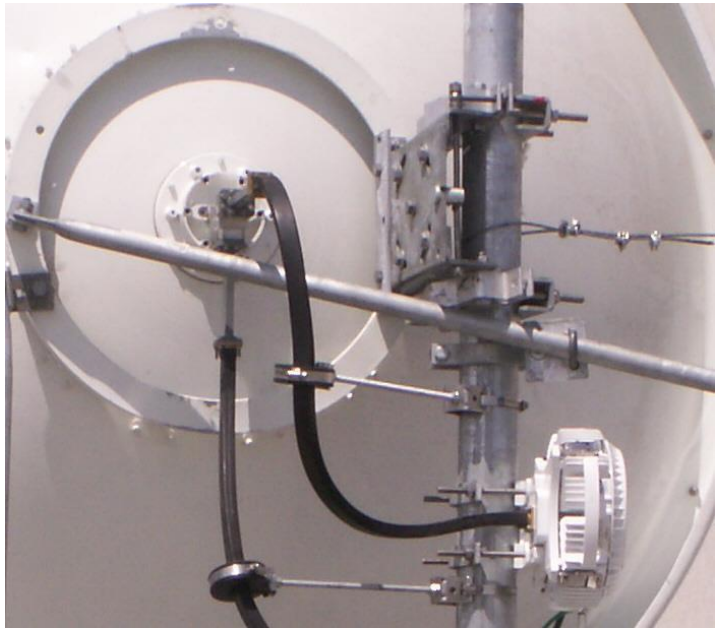
Higher Modulation = More Bandwidth

	Typical Bandwidth Capacities							
	Modulation	**QPSK**	**16QAM**	**32QAM**	**64QAM**	**128QAM**	**256 QAM**	**512 QAM**	**1024 QAM**
RF Channel Size	**10 MHz**	17 Mbps	34 Mbps	43 Mbps	52 Mbps				
	20 MHz	34 Mbps	69 Mbps	86 Mbps	104 Mbps	121 Mbps	138 Mbps	156 Mbps	173 Mbps
	30 MHz	52 Mbps	104 Mbps	130 Mbps	156 Mbps	182 Mbps	208 Mbps	234 Mbps	260 Mbps
	40 MHz	69 Mbps	138 Mbps	173 Mbps	208 Mbps	243 Mbps	277 Mbps	312 Mbps	347 Mbps
	50 MHz	86 Mbps	172 Mbps	215 Mbps	258 Mbps	301 Mbps	344 Mbps	387 Mbps	430 Mbps
	56 MHz	98 Mbps	197 Mbps	247 Mbps	296 Mbps	346 Mbps	395 Mbps	445 Mbps	494 Mbps

Larger Channel = More Bandwidth

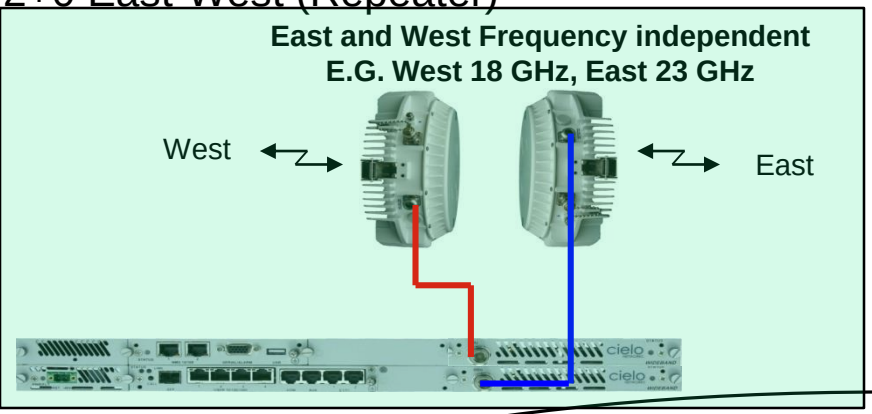
Antennas

- There are all types of antennas for different applications.
  - Direct Mount up to 6 foot
  - Large antennas for long hops
  - High wind antenna
  - Extreme environment
- Existing antenna – if in good shape can often be used
  - Use remote mount kits to connect ODU to antenna using waveguide

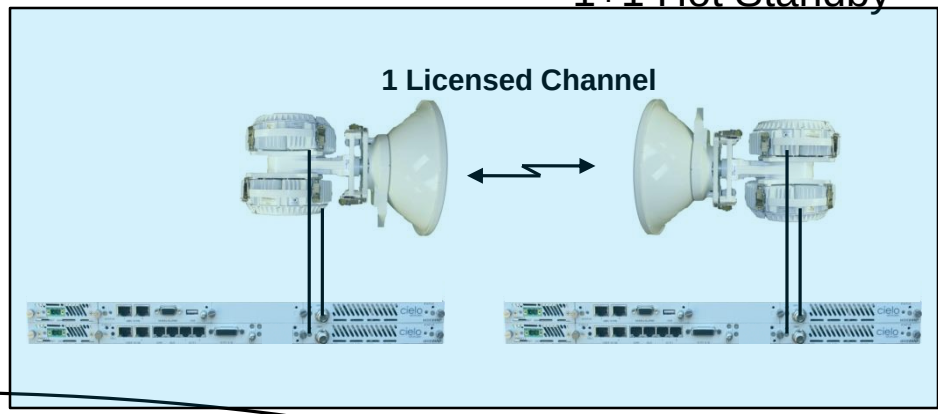


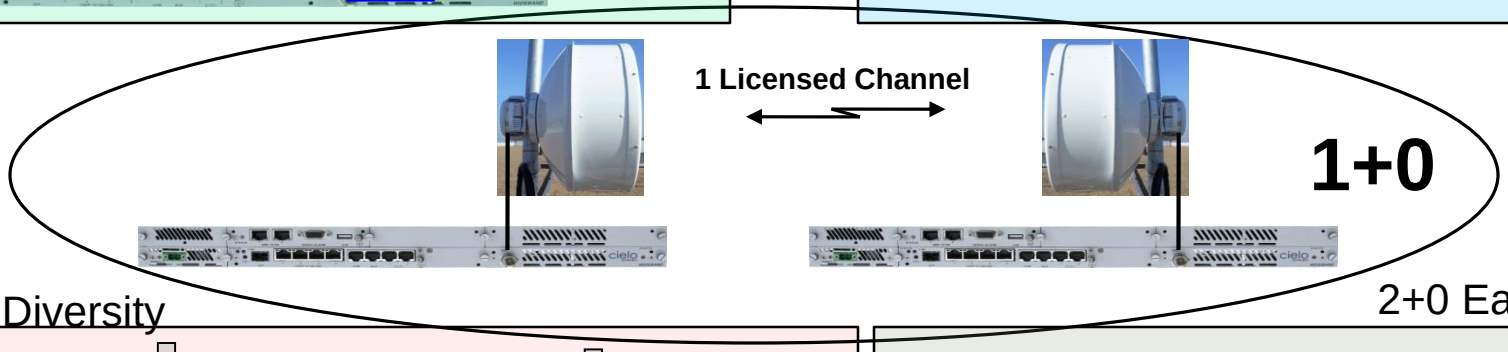
Network Architecture Examples

2+0 East-West (Repeater)

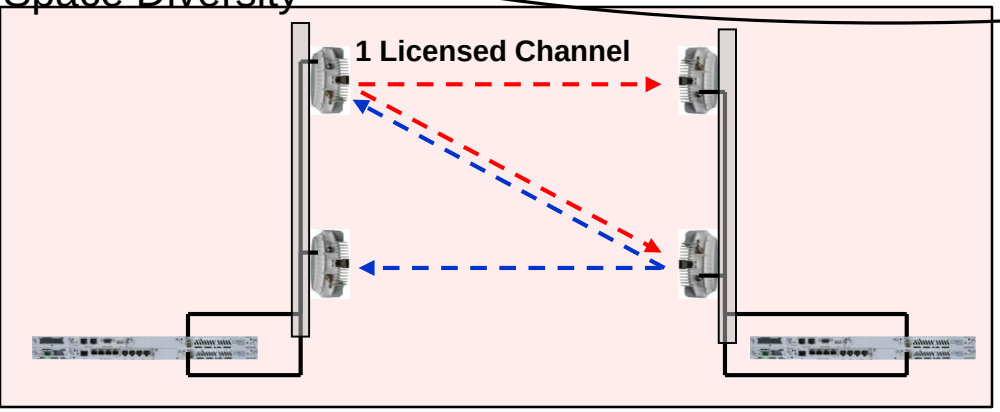


1+1 Hot Standby

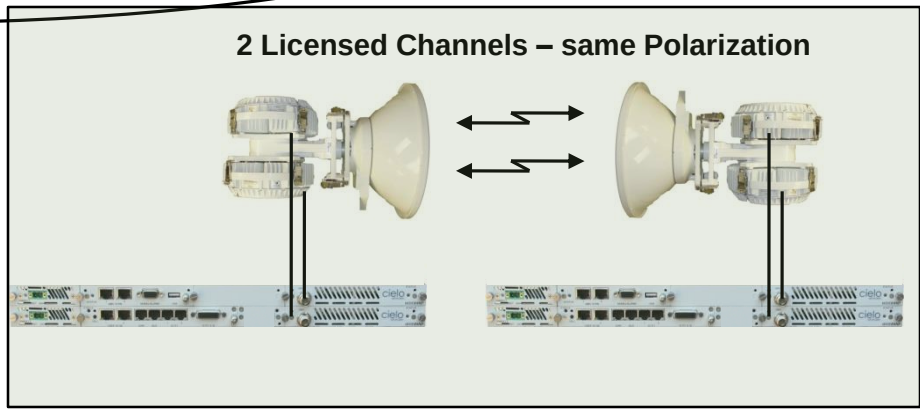




Space Diversity



2+0 East/East Link



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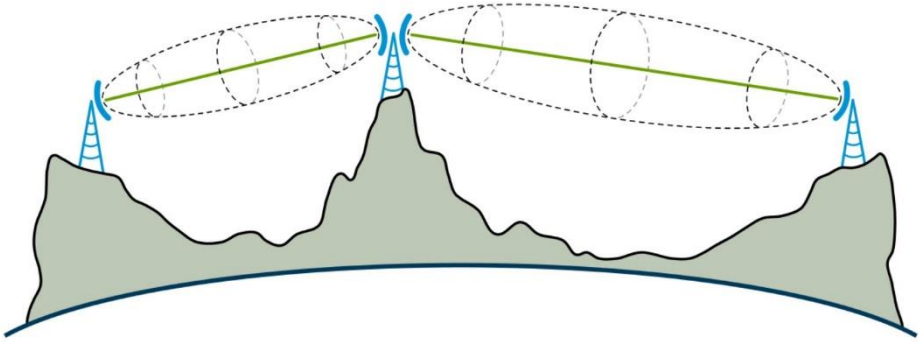
Path Planning

Path Planning

- Line of Sight is required. Does it exist?
  - Use Path planning tools such as Pathloss to identify if LOS exists between the two sites. Includes terrain data.
  - Google Earth
  - Check for building obstructions.
  - Future building plans
  - Include Fresnel Zone Clearance



- Requirements and Limitations
  - Capacity Planning
    - How much capacity is needed now?
    - How much capacity is needed in the future.
    - Design your link for future growth
  - Antenna
    - Maximum size that can be used? Longer the hop the larger the antenna required.
    - If rooftop, how big of an antenna can you get up the maintenance elevator?
    - Weight limitations (which dictates maximum size)
    - Rooftop
      - Will the building owner require it to be moved out of view?
      - Change the color (standard is white radome)

Path Planning Terms

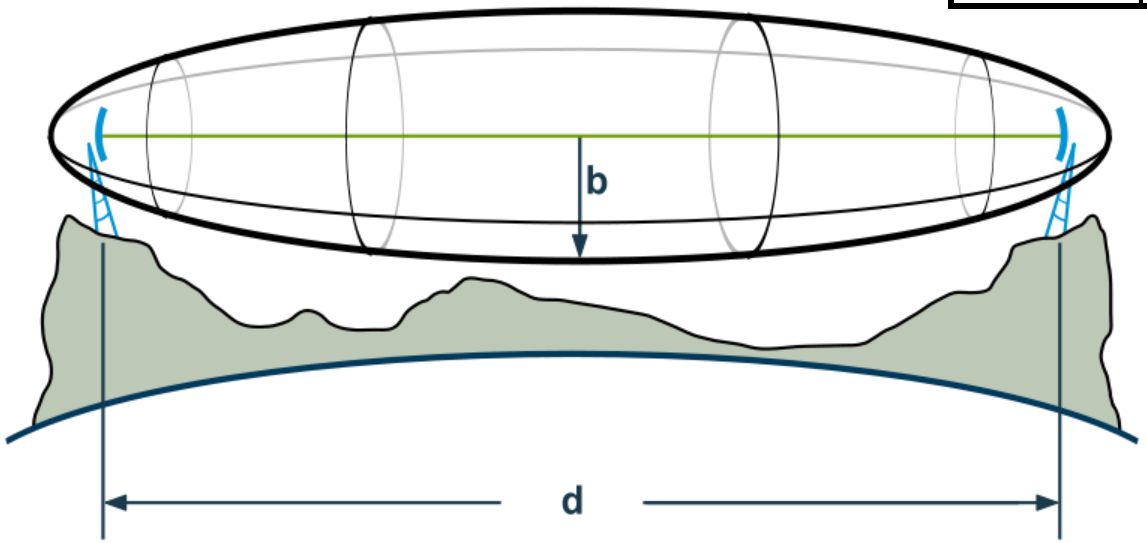
- Rain Fade
  - Frequencies 10 GHz and above are affected by rain fade
  - The higher the frequency the greater the affect the rain has on the signal
- Fade Margin
  - Fade margin is the difference between the received signal level on a clear day (referred to as unfaded RSL) and the receiver threshold specification
  - Receiver Threshold specification for Cielo SkyLink is defined where the BER is measured at 10e-6.
  - A minimum of 30 dB of fade margin is typically recommended
- Link Budget
  - Results in the unfaded RSL
  - Adds the transmit power and the gains of the two antennas in a path and subtracts the free space loss
- RSL Calculation
  - RSL (dBm) = $P_{TX} + G_{TX\ ANT} - L_{Path} + G_{RX\ ANT}$

    Where: P_{TX} is the transmitter output power (in dBm)
    $G_{TX\ ANT}$ is the gain of the transmit antenna (in dB)
    $G_{RX\ ANT}$ is the gain of the receive antenna (in dB)
    L_{Path} is the Pathloss (Free Space Loss) defined by:
    L_P (dB) = $96.6 + 20\text{Log}_{10} F + 20\text{Log}_{10} D$
    Where: F is the frequency in Hz; D is the distance in miles

Fresnel Zone Clearance

- 100% clearance of first Fresnel Zone required to eliminate interference of the signal
- The lower the frequency, the larger the Fresnel Zone radius.
- Trees, road traffic, buildings can infringe on the Fresnel Zone.

Fresnel Zone Radius at Mid-Point of 5 Mile Hop				
	Frequency (GHz)			
	6	11	18	23
Radius (ft)	32.9	24.3	19.0	16.8



$b = 72.05 \sqrt{(d/4f)}$

Where:
b = radius in feet of Fresnel zone at the mid-point
d = total distance in miles
f = frequency in gigahertz

Link Availability

- Link Availability drives the design for any path
- Key factors for Link Availability
  - Bandwidth – now and for future growth
    - Always design for the future
    - Remotely upgrade capacity with upgrade key
  - Path Distance
    - Longer path distances drive frequency required and antenna size to meet the path availability requirements
  - Frequency
    - Any limitations due to availability?
    - Baltimore and Denver areas have 18 GHz quiet zones
  - Antenna Size – any site limitations?
  - Rain Region
  - Customer path availability requirements?
    - 99.990%
    - 99.995%
    - 99.999%

Link Availability Bandwidth

- Higher bandwidth requires
  - Higher modulation
  - Lower Link Budget - because
    - Lower transmit power
    - Lower Receive Sensitivity

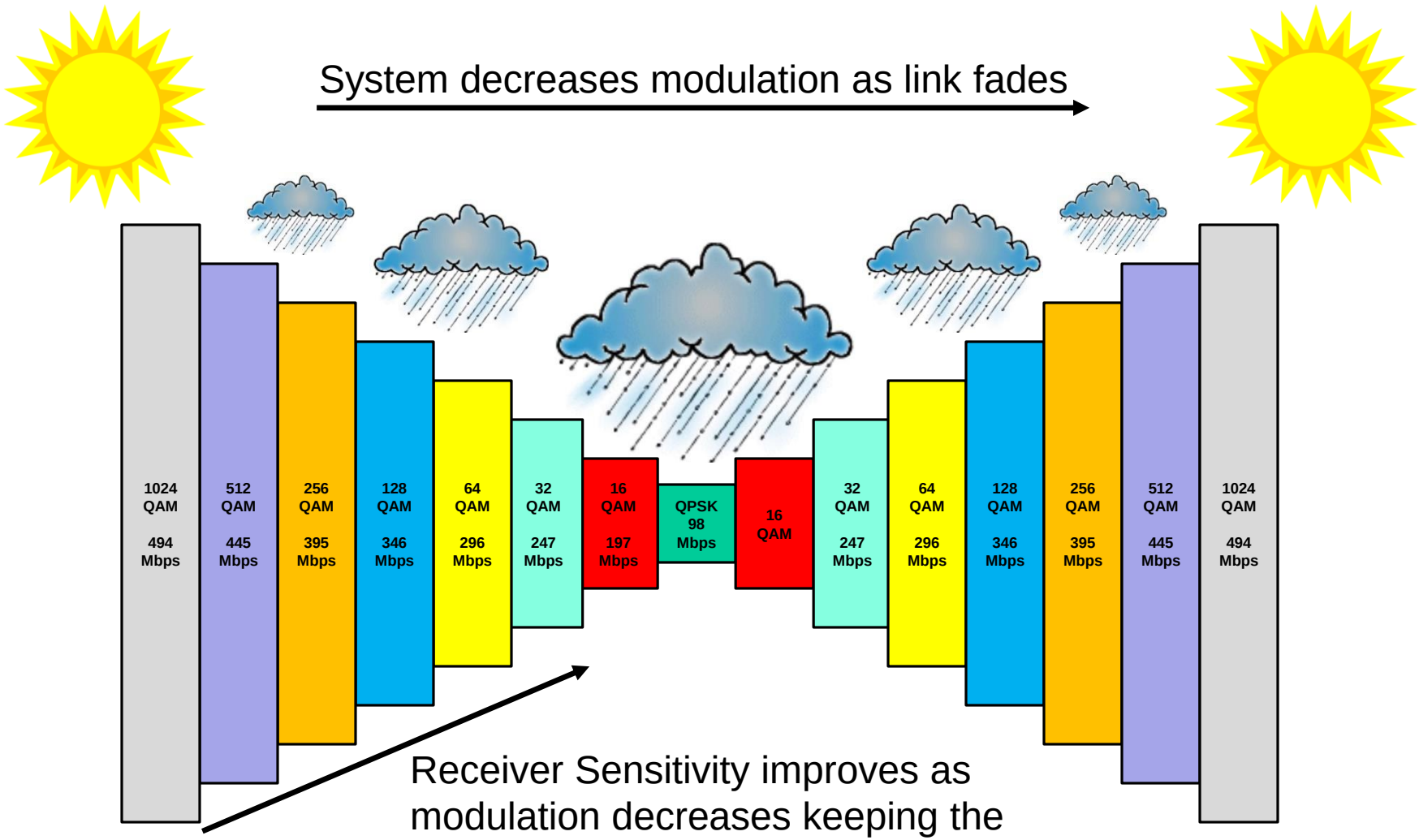
	Capacity Bandwidth																			
	Ethernet	20 Mbps			50 Mbps			100 Mbps			150 Mbps			200 Mbps		250 Mbps		300 Mbps	
	T1	0	2	16	0	2	16	0	2	16	0	2	16	0	2	0	2	0	2
RF Channel Size	10 MHz	16QAM		128QAM															
	20 MHz	QPSK		16QAM	32QAM														
	30 MHz	QPSK		16QAM				32QAM		64QAM	128QAM								
	40 MHz	QPSK					16QAM				64QAM		128QAM						
	50 MHz	QPSK					16QAM				32QAM		64QAM			128QAM			
	56 MHz	QPSK					16QAM				32QAM		64QAM			128QAM			

Radio Information	*18 GHz*					*23 GHz*				
Modulation	QPSK	16QAM	32QAM	64QAM	128QAM	QPSK	16QAM	32QAM	64QAM	128QAM
Transmit Power	25 dBm	25 dBm	25 dBm	23 dBm	20 dBm	24 dBm	23 dBm	22 dBm	21 dBm	21 dBm
Automatic Power Control (APC)	+2 to +25	+2 to +25	+2 to +25	+2 to +23	+2 to +20	+2 to +24	+2 to +23	+2 to +22	+2 to +21	+2 to +21
Receiver Sensitivity (BER 10e-6)	-89 dBm	-82 dBm	-77 dBm	-73 dBm	-68 dBm	-88 dBm	-81 dBm	-77 dBm	-71 dBm	-67 dBm
Receiver Overload (BER 10e-6)	-20 dBm	-20 dBm	-20 dBm	-28 dBm	-28 dBm	-20 dBm	-20 dBm	-20 dBm	-28 dBm	-28 dBm

- System Gain differences at 18 GHz, 50 MHz Channel
  - 50 Mbps (QPSK) System Gain = 114 dBm
  - 150 Mbps (32QAM) System Gain = 102 dBm
  - 12 dB delta
- Best Solution – Use Adaptive Modulation to transition from higher modulation to lower modulation under fading conditions

Hitless Adaptive Modulation

Pass traffic as link conditions change

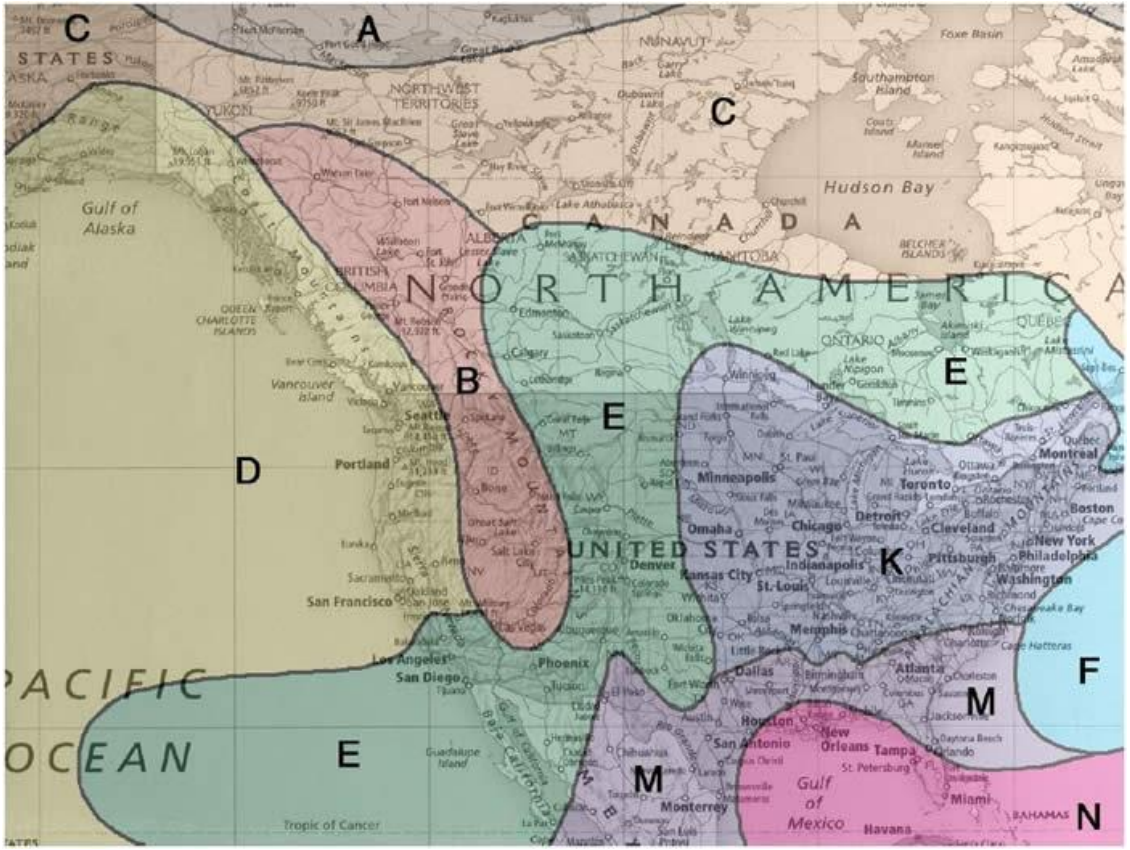


Path Availability
ITU-R Rain Regions

The higher the letter the more intense the rain – specified as mm/hr

- Seattle is a much better rain region than Dallas

ITU-R Rain Region	Rain Rate mm/hr
B	12
D	19
E	22
K	42
M	63
N	95



General Path Availability Tables

- Link Availability tables for Rain Regions K, M, and N for 18 and 23 GHz (low power channels).
- Lower frequency and larger antenna results in improved path availability

Avail	Annual Outage		
	Seconds	Minutes	Hours
99.000%	315360	5256	87.6
99.900%	31536	525.6	8.76
99.950%	15768	262.8	4.38
99.990%	3153.6	52.56	0.876
99.995%	1576.8	26.28	0.438
99.999%	315.36	5.256	0.0876

18 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region K

	2 Foot Antenna			3 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	20.0	15.5	7.5	22.7	17.0	8.5	QPSK
100 Mbps	16.4	12.6	6.6	20.0	14.7	7.0	16 QAM
150 Mbps	13.5	10.0	5.6	15.6	12.2	6.4	32 QAM

23 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region K

	1 Foot Antenna			2 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	8.1	6.2	3.6	11.0	8.2	4.5	QPSK
100 Mbps	6.2	5.0	3.0	8.7	6.8	3.9	16 QAM
150 Mbps	4.8	4.0	2.5	6.8	5.5	3.3	32 QAM

18 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region M

	2 Foot Antenna			3 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	14.5	10.2	5.0	17.2	11.9	5.6	QPSK
100 Mbps	11.0	8.4	4.4	13.5	9.7	4.9	16 QAM
150 Mbps	9.3	7.0	3.8	11.2	8.2	4.5	32 QAM

23 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region M

	1 Foot Antenna			2 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	5.7	4.4	2.4	7.7	5.7	3.1	QPSK
100 Mbps	4.6	3.6	2.1	6.3	4.8	2.7	16 QAM
150 Mbps	3.9	3.0	1.9	5.4	4.1	2.4	32 QAM

18 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region N

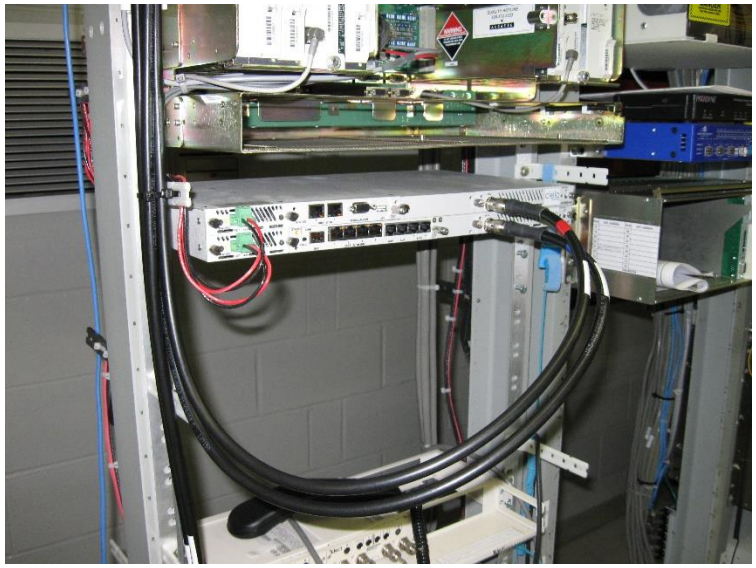
	2 Foot Antenna			3 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	12.6	8.2	3.7	15.5	9.6	4.1	QPSK
100 Mbps	10.0	6.6	3.2	12.1	7.8	3.6	16 QAM
150 Mbps	8.0	5.6	2.8	9.8	6.5	3.2	32 QAM

23 GHz - 50 MHz Channel Plan - Vertical Polarization - Miles
ITU-R Rain Region N

	1 Foot Antenna			2 Foot Antenna			
Mode	**99.99%**	**99.995%**	**99.999%**	**99.99%**	**99.995%**	**99.999%**	**MOD**
20/50 Mbps	4.5	3.3	1.8	6.0	4.3	2.2	QPSK
100 Mbps	3.5	2.7	1.5	4.9	3.5	1.9	16 QAM
150 Mbps	2.9	2.3	1.3	4.0	3.0	1.7	32 QAM

Radio Link Planning

- Site Survey
  - Generally done after the Path analysis that confirms line of sight, what antenna size is required in order to meet your requirements.
  - Can you get access necessary to put up the link?
  - Where is the IDU going to be installed?
  - Cable run from the IDU to the ODU / antenna?
  - Space available on tower or rooftop
  - Tower analysis required with the new antenna load?



Unlicensed vs. Licensed Bands

- Unlicensed band users have:
  - no vested rights or “first use” preference
  - no formal recourse against interferers
- Unlicensed bands increasingly congested
  - Permanent or random interference common
  - Link QOS suffers, link revenues always at risk
  - Any functional link often impossible
- Costs of interference investigation & resolution, if even possible, are substantial - truck rolls, spectrum analysis, finding interferers, tower climbs, etc.
- FCC licensed links insure carrier grade QOS
  - Area frequency exclusivity insures interference free channel
  - License initial validity of 10 years insures interference immunity at reasonable cost:
    - Commercial user typically < $1/day
    - Government or non-profit user typically < 50 cents/day

FCC Licensing

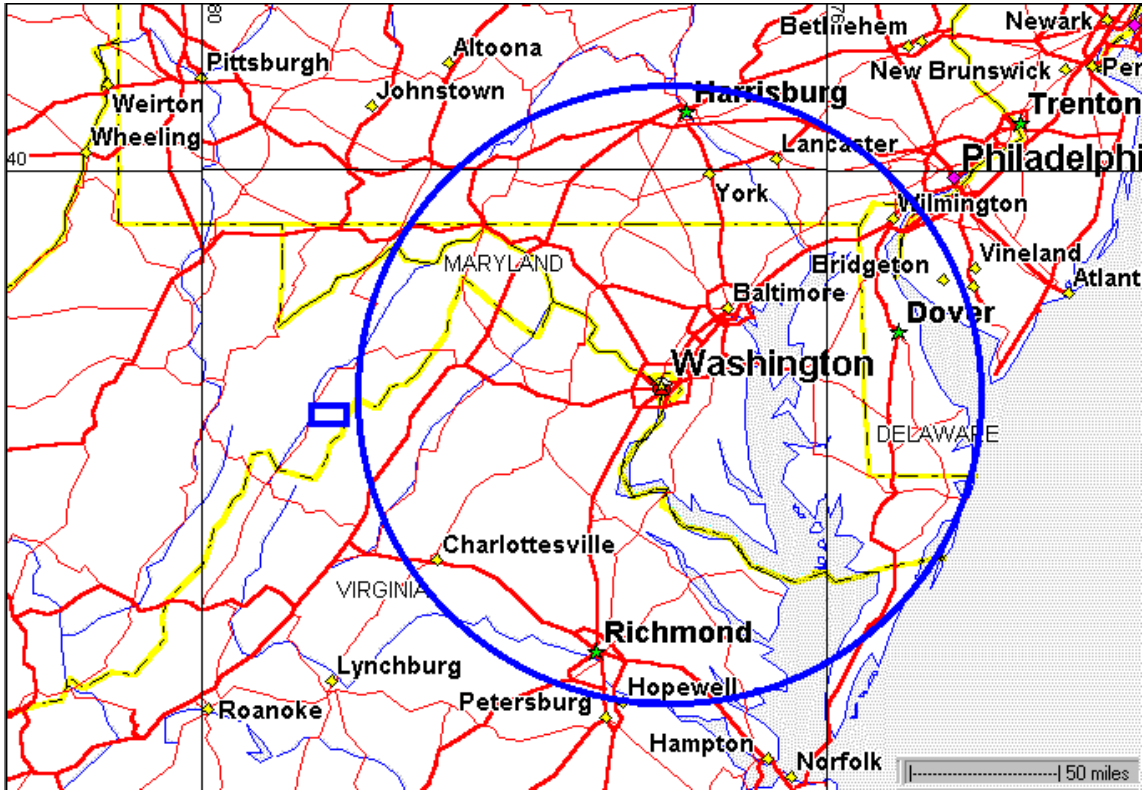
- Simple – straight forward process
- Use license coordinators to perform the coordination, PCN, and application submittal
  - Comsearch – Ashburn, VA
  - Radyn – Bethesda, MD
  - Micronet – Plano, TX
- Cost: Less than $2500 per hop turnkey

FCC Licensing

- New links can only be licensed if they do not interfere with existing links
- FCC license is valid for 10 years – can be renewed
- Typical period from initiation of licensing process until link can be turned up is 35 – 40 days:
  - 5 days for engineering
  - 30 days PCN letter distribution
  - 1 to 2 days for filing FCC application
- Once the FCC application is filed a link can be turned up and operated "conditionally"
  - Exception is 23 GHz High Power Channels – can take 2 to 3 months for issuance of license and the ability to start transmitting
- Expedited licensing is available – 2 weeks
- FCC has 18 GHz quiet zones – Baltimore and Denver area
- Once link is turned-up, file Notice of Completion. 18 months from application date to get link turned-up.

FCC Licensing
DC Exclusion Zone

For Washington, D.C., the exclusion zones are defined by 178 Km radius around 384800 N 0765200 W), which is the southeast corner of the air fields at Andrews AFB, and a box defined by the corners NE = 384000 N 0785000 W and SW = 381000 N 0792000 W), which is bounded on its west side by the NSA Sugar Grove facility



Antenna Sizes
FCC Requirements

- FCC defines the minimum antenna size requirements at each frequency band based on minimum antenna gain and maximum beamwidth
  - Defined in CFR47 Part 101
- Antennas meeting the FCC requirements are typically referred to as “Category A” antennas

Frequency	6 GHz	11 GHz	18 GHz	23 GHz
Minimum Antenna Size	6 foot	2 foot	2 foot	1 foot

- New Category B rules allow even smaller antennas
  - 6 GHz – 3 foot and 4 foot
  - 18 GHz – 1 foot
  - 23 GHz – 9 inches

Maximum Channel Size FCC Requirements

- The FCC defines the channel size for each frequency band
  - Defined in CFR47 Part 101
- The maximum channel size will define the maximum throughput
  - 6 GHz
    - 30 MHz channels (8 channels available) – Up to 260 Mbps throughput
    - 60 MHz channels (4 channels available) – Up to 494 Mbps throughput
  - 11 GHz
    - 30 MHz channels (13 channels available) – Up to 260 Mbps throughput
    - 40 MHz channels (12 channels available) – Up to 347 Mbps throughput
    - 80 MHz channels (6 channels available) – Up to 494 Mbps throughput
  - 18 GHz
    - 50 MHz channels (8 channels available) – Up to 430 Mbps throughput
    - 80 MHz channels (5 channels available) – Up to 494 Mbps throughput
  - 23 GHz
    - 50 MHz channels (24 channels available but only 6 commonly used) – Up to 430 Mbps throughput

	Capacity Bandwidth - Maximum								
	Modulation	**QPSK**	**16QAM**	**32QAM**	**64QAM**	**128QAM**	**256 QAM**	**512 QAM**	**1024 QAM**
RF Channel Size	**10 MHz**	17 Mbps	34 Mbps	43 Mbps	52 Mbps				
	20 MHz	34 Mbps	69 Mbps	86 Mbps	104 Mbps	121 Mbps	138 Mbps	156 Mbps	173 Mbps
	30 MHz	52 Mbps	104 Mbps	130 Mbps	156 Mbps	182 Mbps	208 Mbps	234 Mbps	260 Mbps
	40 MHz	69 Mbps	138 Mbps	173 Mbps	208 Mbps	243 Mbps	277 Mbps	312 Mbps	347 Mbps
	50 MHz	86 Mbps	172 Mbps	215 Mbps	258 Mbps	301 Mbps	344 Mbps	387 Mbps	430 Mbps
	56 MHz	98 Mbps	197 Mbps	247 Mbps	296 Mbps	346 Mbps	395 Mbps	445 Mbps	494 Mbps

General Cost of Part 101 Gear

- Split Mount
  - Typical Link is $8K to $13K
  - Installation cost similar to All outdoor
    - Running coaxial cable up to ODU
    - Surge arrestors to protect the gear from surges
    - Mounting IDU indoors in rack
- All Indoor
  - Typical Link cost is over $20K
  - Installation cost is highest among all options
    - Elliptical Waveguide
    - Dehydrators
    - Rack space
- All Outdoor
  - Typical Link Cost is less than $8K
  - Installation cost similar to Split Mount
    - Running Ethernet cable up to ODU
    - Surge arrestors to protect the gear from surges
    - Find mounting location for POE (pole or wall)

Reliability of Microwave Gear

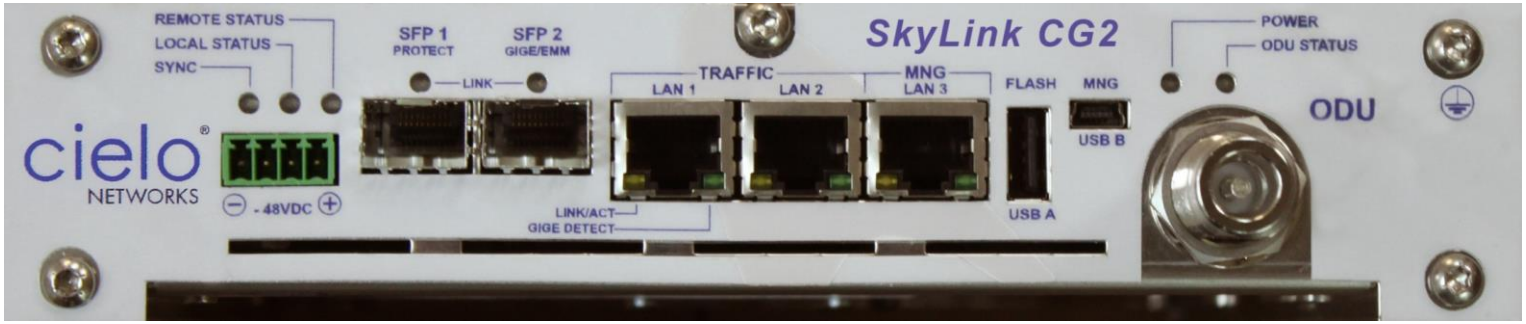
- New microwave gear are fully integrated with digital board designs resulting in higher MTBF numbers
- No components to adjust
- Troubleshooting - Swap out assembly and return for repair
- Protection against equipment failures
  - Configure link for Hot Standby mode of operation. Operate with active and standby radio.
  - Purchase Spares to have on hand when trouble-shooting

Maintenance

- Simple to install and maintain
  - Electronics do not require annual maintenance
  - For repair, the assembly is returned (IDU, ODU)
  - For failures, replace unit. (Spares)
  - Inspect connections as water ingress is commonly a problem due to worn weatherproofing
  - Surge arrestors are used on coaxial cable to protect gear. Consider replacing yearly.

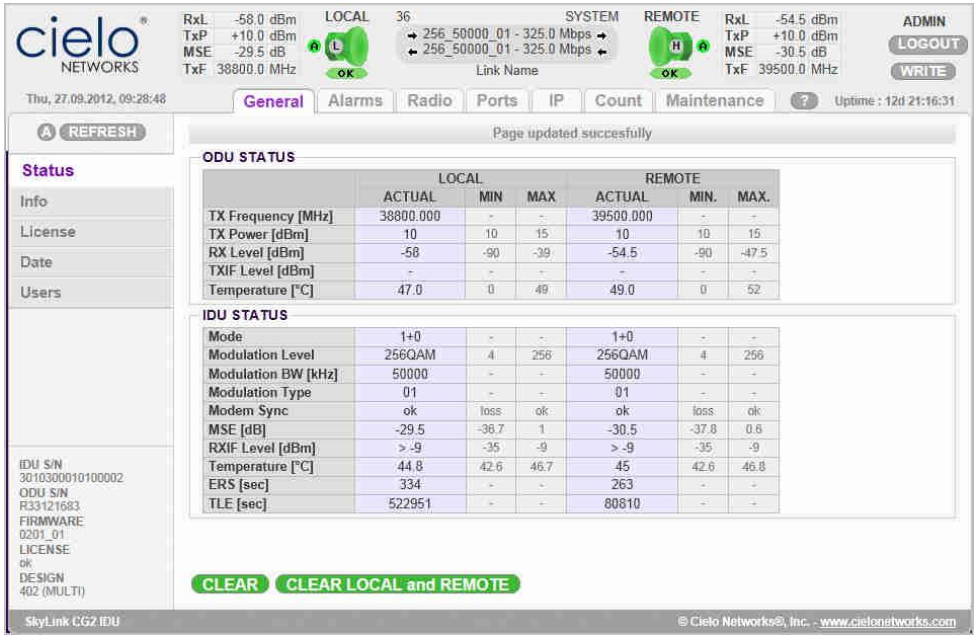
Network Interface and Capabilities

- Most Microwave gear supports Ethernet Layer 2 functionality enabling ring protection type architectures
- Layer 2 capability can give the user an option not to install a layer 2 device (switch) at the end site location – especially for just removing VLAN tags
- Most IDUs Include options for VLAN functionality, packet prioritization
- Separate Ethernet tunnels across the radio link with specific capacities defined for each one.
- Traditional TDM Interfaces: T1, OC3
- Video Interfaces: DVB-ASI



Remote Management

- Management of microwave systems is done with Web GUI and SNMP
- How the management systems are setup in appearance and presentation is the primary difference between radio vendors
  - GUI
    - Units allow users to manage with their standard Web Browser
    - Type in the IP address and access with username/password
  - SNMP
    - Integrated the MIB into your SNMP management system
    - Constant monitoring of system
    - Collect readings of critical performance indicators
    - Traps alert of alarm being set



About Cielo Networks

- Founded May 2006 by PTP industry veterans
- Based in Dallas – Fort Worth area
- Veteran owned small business designation
- Strategy:
  - Bootstrap – Maintain financial independence
  - Address US market first, build scale & reputation
  - Leverage long term relationships with best in class, volume producing component technology suppliers
  - High performance yet proven reliable systems
  - Full licensed band digital microwave portfolio
  - Superior total value: High performance, competitive prices, less bureaucracy, better support – a committed partnership

SkyLink IDU Family

SkyLink

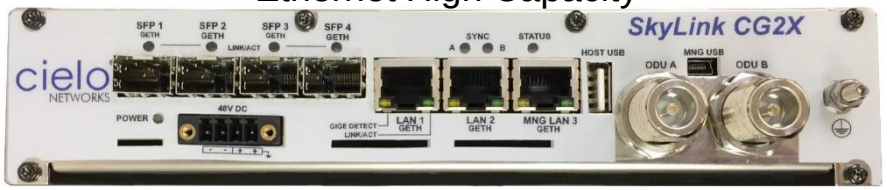
Ethernet+ TDM

SkyLink CG2

Low Cost Ethernet

SkyLink CG2X

Ethernet High Capacity



SkyLink Radio Family

Licensed Microwave Only
All SkyLink IDUs work with ODU or Indoor Radio

SkyLink Outdoor Unit (ODU)
6 to 39 GHz

SkyLink AI (All Indoor)
6 to 11 GHz

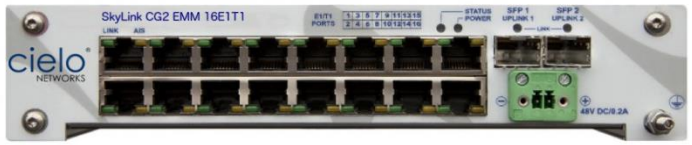
Other SkyLink Products

SkyLink All Outdoor Unit (AO)
6 to 39 GHz

External Modules for other Network Interfaces

SkyLink EMM ASI

- Works with SkyLink CG2 and CG2X
- 4xDVB ASI
- Can cascade 4 together for 16 DVB ASI ports



SkyLink EMM 16E1T1

- Works with SkyLink CG2 and CG2X
- 16 x T1 / E1 ports
- Can cascade 4 together for 64 T1/E1 ports

Contact Information

- Sale Lilly – sales
  - slilly@cielonetworks.com
  - 662-316-0212
- Brian Wright – technical
  - bwright@cielonetworks.com
  - 972-273-0680
- Web: www.cielonetworks.com
- Office: 817-488-9473
- HQ: Southlake, TX (DFW Area)

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Questions?

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Thank You