PLANNING ADVISORY NOTICE

Microwave Backhaul Site Selection

When most people think of telecommunications wireless infrastructure, they envision groups of panel antennas mounted at the tops of towers and to the sides of water tanks or other structures. These types of antennas are considered a point-to-multi-point technology and require a multitude of other equipment to operate properly. However, none of these systems would work without a connection to the rest of the network. This connection is typically referred to as the 'backhaul,' with the most common type being fiber optic cable. It provides speed and bandwidth and is very cost effective in densely populated urban areas. But what about rural areas? According to the US Census Bureau, "Urban areas make up only three percent of the entire land area of the country but are home to more than 80 percent of the population."

Conversely, 97 percent of the country's land mass is rural; so how do wireless carriers, government agencies, and broadcasters (aka, end users) provide economically feasible backhaul in these areas?

The most common solution to this problem is through the use of a point-to-point microwave radio system.

When connecting a site to the network, it must be determined if there is a need for backhaul. An evaluation must be made if fiber optic is a reasonable solution, whether short or long term. If fiber optic is not a reasonable solution, then consideration moves to the design of a microwave backhaul path and the availability of the backhaul must be defined. Once these considerations are defined, then the focus moves to path design and identifying the "hub." The hub, which goes by many names, is where the microwave path needs to transport the backhaul to. Often this can be done with a single microwave path. A microwave path consists of two points with a microwave antenna (aka microwave dish) at each end, with at least one microwave antenna connected to the backhaul network. However, there

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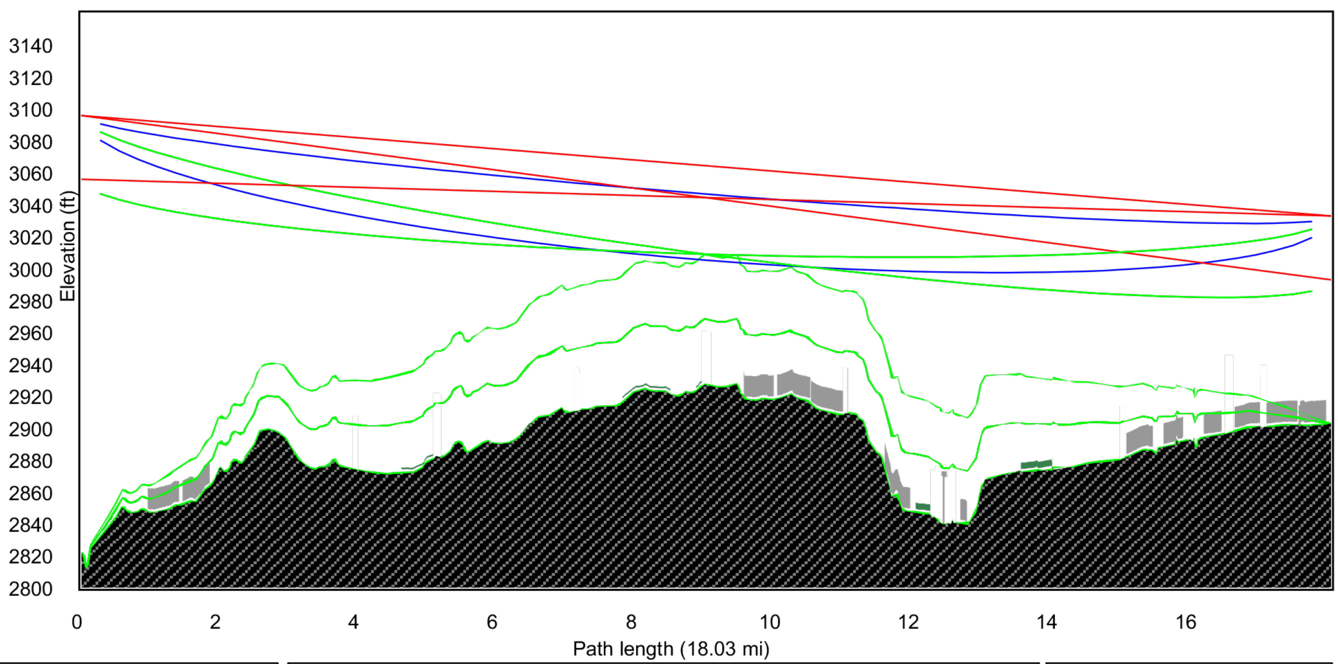
are times where a microwave path will require multiple "hops" to connect the backhaul network at one microwave site to the termination hub.

Microwave antennas come in a variety of sizes and operate at various frequencies depending on their application. Compared to other wireless technology, microwave technology is a lot less forgiving, requiring much tighter tolerances to operate properly. Due to the size of the antenna, the polarity required, Fresnel zone requirements, and longer operating distances, the effects of twist and sway now become inherently more critical. So, the question becomes, how are sites selected for a microwave backhaul? The best answer, being the simplest answer; where does the end user need to connect one part of their network to another. As previously mentioned, there is a starting point and an end point. Sometimes this connection can be achieved with a single point-to-point installation, and other times it requires multiple microwave hops. When selecting microwave antenna sites, there are many factors that can complicate the selection process. A few of the most common are line of sight, interferences, availability of existing infrastructure, and the frequencies available along a given path.

When designing a microwave system, the engineer typically begins with a desktop study to identify potential obstructions along the intended path. As previously mentioned, microwave antennas work on the principle of point-to-point line of sight transmission, meaning that interferences, natural or manmade, can have a material impact to the performance of the system. Topography is an obstruction that is typically encountered along a microwave path and can be overcome by going around or over the obstruction. This sometimes requires placing a tower and microwave dish on a hill, cliff, or mountain which can lead to a myriad of serviceability issues such as wind speed effects. Large reflective surfaces (i.e., lakes or other bodies of water) are another topographical effect that can interfere with the transmission along the microwave path. One solution to minimize reflection is to locate the microwave antenna at the lowest possible elevation to reduce reflection off of these surfaces. This brings us to another obstruction along a microwave path: vegetation, or more specifically, trees. When considering a microwave path, it is common to consider a minimum of 10 years of tree growth when assessing a viable path. In addition to natural obstructions, manmade

Path Profile Sample



Site A	
Latitude	38 03 27.48 N
Longitude	100 37 44.42 W
Azimuth	262.22°
Elevation	2821 ft ASL
Antenna CL	275.0, 235.0 ft AGL

Frequency (MHz) = 6700.0
K = 0.67, 1.33, 1.33, 1.33
%F1 = 30.00, 100.00, 60.00, 60.00

Site B	
Latitude	38 01 18.50 N
Longitude	100 57 23.12 W
Azimuth	82.02°
Elevation	2903 ft ASL
Antenna CL	130.0, 90.0 ft AGL

obstructions can be just as troublesome. In an urban area the construction of a new high-rise building can block the path of an existing microwave system, but this is not typically considered in rural areas. However, with the increase in alternative energy initiatives, windmill farms are more commonly a reason for reworking proposed or established microwave paths.

Identifying support structures along a proposed microwave path can be a factor which complicates the design of a microwave system. Many times, new structures must be built to complete the design. This can require new land leases, getting access to power from the local electric utility, and creating access to the new site. Although a new site may seem like it would require more time and be more costly, this process can often be more efficient than finding an existing structure in the right location with the proper capacity to add a microwave antenna. When all goes well with co-locating on an existing structure, time and cost can be significantly reduced, however many times this is not the case. When support structures require modification, the expense and delays to the schedule can increase exponentially. Fortunately, with the rural setting of most microwave paths, adding new structures is not as rigorous a process as it is in urban areas where space on towers and other support structures is at a premium.

The last and arguably the most complex consideration when designing a microwave path is identifying and getting approval for the frequencies needed to complete the system. The first step required is completing a Prior Coordination Notice, which is typically referred to as a “PCN.” This is necessary to identify the frequencies, polarities, and microwave antenna types available along the proposed path. If the required frequencies are unavailable, then all your efforts to design and implement a microwave path will ultimately become wasted. As part of a PCN, the microwave engineer will take the path design and use a frequency coordinator such as Comsearch, Micronet, or other companies that provide a similar service. Frequency coordinators research the FCC database and reference current licenses, applications, active coordination efforts, and vet the available frequencies to identify the minimum type of microwave antenna that could be used for a microwave path. The final PCN is submitted when the project is finalized. At this time the clock starts on the application lease, locations should be locked down and final engineering design should be completed. Issuing a final PCN will lock in your frequencies, and no one will be able to interfere or utilize them. A PCN is active for six-months from the date of issuance,

Path Design Sample

	Site A	Site B
Call sign	WABC123	WABC321
Latitude	38 03 27.48 N	38 01 18.50 N
Longitude	100 37 44.42 W	100 57 23.12 W
True azimuth (°)	262.22	82.02
Vertical angle (°)	-0.14	-0.06
Elevation (ft)	2821.00	2903.00
ASR	1321734	
Tower height (ft)	330.00	
Tower type	self supporting	self supporting
Antenna model	PADX6-59W (TR)	PADX6-59W (TR)
Antenna gain (dBi)	38.90	38.90
Antenna height (ft)	275.00	130.00
TX line model	EW63	EW63
TX line unit loss (dB/100 ft)	1.36	1.36
TX line length (ft)	315.00	192.00
TX line loss (dB)	4.29	2.61
TX switch loss (dB)	0.40	0.40
Antenna model	SBX 4 - W60C (DR)	SBX 4 - W60C (DR)
Antenna gain (dBi)	35.70	35.70
Antenna height (ft)	235.00	90.00
TX line model	E65J	E65J
TX line unit loss (dB/100 ft)	1.36	1.36
TX line length (ft)	275.00	162.00
TX line loss (dB)	3.74	2.21
Frequency (MHz)	6700.00	
Polarization	Horizontal	
Path length (mi)	18.04	
Free space loss (dB)	138.24	
Atmospheric absorption loss (dB)	0.27	
Main net path loss (dB)	68.01	68.01
Diversity net path loss (dB)	70.67	70.80
Configuration	MHSB/SD	MHSB/SD
Radio model	I6V4HU6_30M_ACM_R70	I6V4HU6_30M_ACM_R70
Radio file name	i4hu630macm_r70_accp	i4hu630macm_r70_accp
Emission designator	30M0D7W	30M0D7W
Maximum receive signal (dBm)	-22.00	-22.00
Climatic factor	1.00	
Terrain roughness (ft)	22.63	
C factor	2.80	
Average annual temperature (°F)	53.89	
Fade occurrence factor (Po)	2.755E-001	
SD improvement factor	23.08	22.37
Effective frequency spacing (MHz)	60.00	60.00
FD improvement factor	3.75	3.75
Quad diversity improvement factor	26.84	26.13

	TX power (dBm)		RX threshold level (dBm)		EIRP (dBm)		Receive signal (dBm)		Thermal fade margin (dB)		Flat fade margin - multipath (dB)	
4096QAM 267 Mbps	27.50	27.50	-53.85	-53.85	61.71	63.39	-40.51	-40.51	13.34	13.34	13.34	13.34
2048QAM 245 Mbps	28.00	28.00	-57.85	-57.85	62.21	63.89	-40.01	-40.01	17.84	17.84	17.84	17.84
1024QAM 227 Mbps	29.50	29.50	-60.60	-60.60	63.71	65.39	-38.51	-38.51	22.09	22.09	22.09	22.09
512QAM 200 Mbps	30.50	30.50	-64.60	-64.60	64.71	66.39	-37.51	-37.51	27.09	27.09	27.09	27.09
256QAM 180 Mbps	**31.00**	**31.00**	**-67.10**	**-67.10**	**65.21**	**66.89**	**-37.01**	**-37.01**	**30.09**	**30.09**	**30.09**	**30.09**
128QAM 155 Mbps	31.50	31.50	-70.35	-70.35	65.71	67.39	-36.51	-36.51	33.84	33.84	33.84	33.84
64QAM 132 Mbps	31.50	31.50	-73.10	-73.10	65.71	67.39	-36.51	-36.51	36.59	36.59	36.59	36.59
32QAM 109 Mbps	31.50	31.50	-75.60	-75.60	65.71	67.39	-36.51	-36.51	39.09	39.09	39.09	39.09
16QAM 90 Mbps	31.50	31.50	-78.35	-78.35	65.71	67.39	-36.51	-36.51	41.84	41.84	41.84	41.84
QPSK 39 Mbps	32.00	32.00	-89.10	-89.10	66.21	67.89	-36.01	-36.01	53.09	53.09	53.09	53.09

	Worst month multipath		Annual multipath		Annual rain		Total annual (2 way)	Time in mode (2 way)
4096QAM 267 Mbps	99.3615	99.3615	99.8280	99.8280			99.6559	99.6559
2048QAM 245 Mbps	99.8090	99.8055	99.9485	99.9476			99.8961	0.2402
1024QAM 227 Mbps	99.9634	99.9625	99.9901	99.9899			99.9800	0.0839
512QAM 200 Mbps	99.9960	99.9959	99.9989	99.9989			99.9978	0.0178
256QAM 180 Mbps	**99.9990**	**99.9990**	**99.9997**	**99.9997**			**99.9994**	**0.0016**
128QAM 155 Mbps	99.9998	99.9998	99.9999	99.9999			99.9999	0.0005
64QAM 132 Mbps	99.9999	99.9999	99.9999	99.9999			99.9999	0.0001
32QAM 109 Mbps	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
16QAM 90 Mbps	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000
QPSK 39 Mbps	99.9999	99.9999	99.9999	99.9999			99.9999	0.0000

Multipath fading method - Vigants - Barnett

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then 6-month renewals are available. As a rule of thumb, if you exceed two renewals there is the potential to lose one or more of the frequencies you are using to another end user. Once the microwave path is ready for construction, a Construction Grant is submitted to the FCC. The resulting construction permit is valid for 18 months. Once the microwave path is constructed, the final FCC document is a Certification of Construction (COC). If the microwave path construction is not completed within the 18-month period you will have to start the entire process over, beginning with the PCN as the FCC will rarely grant an extension.

As networks continue to expand across rural areas, microwave antenna site selection will continue to be an important link in creating the telecommunications infrastructure that we become more reliant on every day. Whether you are providing a small community with a vital link to emergency services or creating secure connections between private or government facilities, microwave systems provide a cost competitive way to send and receive information over long distances and through the myriad of terrain encountered across the vast areas of rural America.

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