White Paper

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Microwave Backhaul - Design to Deployment

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In recent years, the Fixed Wireless Access craze that ran so rampant and reckless in the late '90s and into 2000 has really started to heat up again. Big players have stepped in, WISPs have cropped up everywhere, WiMAX is happening, and the capital pipeline is again free-flowing. The vision of ubiquitous untethered (affordable) high-speed connectivity is proving to be a here-and-now reality. Network designers are aggressively working to build and expand their systems. The challenges are great, and wireless connectivity to the customer premises is only half the battle. At the heart of any well-designed wireless deployment is a reliable, diverse, and robust backhaul network.

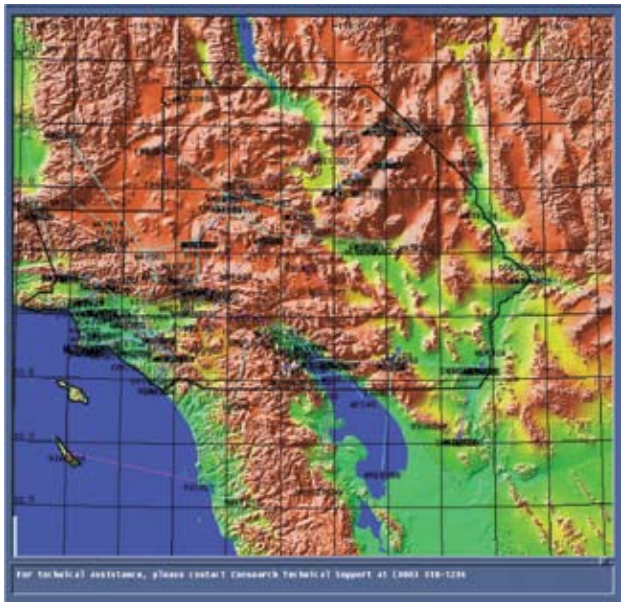
Last-mile connectivity is of no use if you can't get that traffic back to the point of presence (POP) and ultimately onto the internet. Designing a solid backhaul network can be a daunting task. There are many tools that can help, and just being aware of the various options at each step of the process will bring you closer to being a full-fledged backhaul designer. In the following sections I examine just a few of the challenges you may face.

Microwave?

Although the focus of this article is on microwave backhaul, a full microwave or even partial microwave backhaul network is by no means a requirement. In fact, most backhaul networks will be a hybrid of microwave, leased line, or even fiber. Factors such as available capital, capacity requirements, reliability, customer base, type of terrain, and local vegetation will all affect your decision to use microwave. Having said that, it if fair to state that microwave is an extremely reliable medium for backhaul traffic and its long-term economic viability often exceeds all other options.

Terrain Data

The first step in any design project is assembling the necessary tools to get the job done. Digitized terrain data is a must to perform path designs accurately and efficiently. Thirty-meter (30m) resolution terrain data is readily available from many vendors, and if just a small area is required, free downloads can be found. At this time, 10m national elevation data (NED) datasets are available for large portions of the United States and 3m datasets are available for select areas.



Comprehensive terrain data with a comprehensive design tool.

Being able to quickly profile many different paths is critical to getting a design done in a timely manner. A backhaul network consisting of 50 or even 100 sites can result in many hundreds of potential paths that need to be assessed. Ruling out those links which are blocked by terrain first, and then prioritizing the remainder, will allow you to focus your efforts on those links with the highest probability for success. Incorporating comprehensive terrain data with a network design tool, such as Comsearch's iQ·link® tool, will allow you to automate parts of this process, dramatically decreasing the time required to develop a solid preliminary design.

Map Datum

A map datum is a mathematical model of the surface of the Earth. All positioning information on a map, such as latitude and longitude, must be based on a reference datum. Digitized terrain data will also refer to a given map datum. The most common datum in the United States is North American Datum 1983 (NAD83). The reference datum for the global positioning system (GPS) is the World Geodetic System 1984 (WGS84) datum. For all practical purposes WGS84 and NAD83 datums are interchangeable. In addition to these, there are numerous other local and regional datums covering all parts of the world. In fact, many US Geological Survey (USGS) topographic maps are still based on North American Datum 1927 (NAD27) datum. In many parts of the country, the difference between NAD83 and NAD27 coordinates can be many tens of meters.

The key point to stress here is that a consistent map datum must be utilized throughout the design process. All design tools, terrain data, GPS units, and reference maps must all refer to or convert to a single consistent datum. Field engineers should never just blindly turn on a GPS and take a reading without knowing the associated map datum.

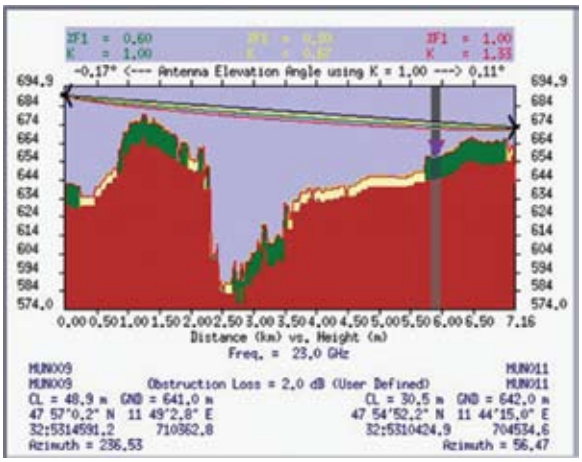
Site Selection

There are many factors controlling the site selection process in a network deployment. Often, the overriding factors will have little to do with backhaul requirements. Customer locations, last mile RF concerns, lease costs, zoning, and even existing relationships can all affect site selection. However, since site selection can so dramatically affect the microwave design process, backhaul engineers should be engaged early in the process. Maintaining an open dialogue between the backhaul and site acquisition specialists is the best way to insure the selection of backhaul friendly sites.

So what makes a site "backhaul friendly"? In a word, height; high centerlines are the number one factor in getting microwave connectivity. Higher elevation sites, large towers with little or low vegetation surrounding them, rooftops that slightly exceed the average height in the area, these are all good candidates. Other backhaul concerns may include available tower space, structural loading, ambient RF environment (especially if using unlicensed radios). In addition, proximity to customers, core network facilities, or other sites must also be considered.

Field Surveys

Often, designers may forego field surveys in order to save time and expense. This is a very dangerous proposition, however. Full path surveys or at least visual line-of-sight (LOS) verifications are always recommended. Through the preliminary design process you can make some fairly reliable judgments, but nothing can take the place of real world surveys. A building database can aid in the design process and is definitely useful for ruling out paths, but generally not reliable enough for ensuring clear LOS. In urban and suburban areas, there are just too many potential obstructions. In rural areas most of your antennas will be mounted on towers. Guessing at average tree heights and leaving sufficient margin to ensure a clear path can lead to unnecessarily high antenna centerlines. This is turn



A properly performed path survey can ensure unobstructed line of sight.

can lead to increased lease costs, structural loading concerns, additional transmission line, excessive line losses, and even path fading. With a properly performed field survey, antenna centerlines can be optimized, clear line of sight can be insured, and the potentially disastrous consequences of a blocked path can be avoided.

Equipment Selection

Many of the key factors in choosing microwave radio equipment are completely dependent on the network architecture. Thus, many of these choices go hand-in-hand with the type of service being provided. But there are some on-going choices the designer will be constantly evaluating. Band selection and antenna size will be adjusted accordingly based on path length while maintaining overall link quality and reliability. Capacity requirements are also a huge factor the designer will be considering. Higher capacity links will be required closer to the POP as traffic from all other sites will have been aggregated. All other things being equal, higher capacity generally means higher modulation rates, and thus higher receiver thresholds. This results in a reduced fade margin with a greater percentage of path outage. The reduced fade margin can usually be overcome with larger, higher gain antennas or by limiting path lengths, but those options are not always viable. The designer must be well aware of this delicate balance of the various factors. All factors must be considered and the unique aspects of each link must be addressed individually.

Licensed vs. Unlicensed

Unlicensed manufacturers have begun implementing some rather ingenious modulation schemes into their unlicensed radios. With so many unlicensed radios deployed and clearly so many more being planned, interference rejection is a top priority. Dynamic frequency selection (DFS) is just one example of this type of thinking. DFS radios continuously scan the available band looking for clear spectrum and then assign the active channel accordingly. Adaptive modulation is also used to allow for operation in complex environments. By constantly optimizing the modulation scheme, throughput can be maximized while maintaining link quality. But probably most important of all has been the use of orthogonal frequency division multiplexing (OFDM). OFDM is inherently resistant to interference and especially multipath. The use of OFDM is the basis for many of the non-line of sight (NLOS) radios now being advertised. OFDM schemes divide the carrier channel into numerous sub-carriers while intelligently distributing traffic. They do well to combat frequency selective fading, allow for increased delay spreads, and provide increased resistance to cochannel interference.

With all these advances in unlicensed radio technology, one might wonder why bother with licensed radios. Well, the interference rejection schemes were developed for a reason: crowded spectrum. Deployments in the unlicensed bands are so prevalent that finding clear spectrum is increasingly difficult. Although these rejection schemes

are resistant to interference, they are not immune. With adaptive modulation, link quality can often be maintained even in noisy environments, but throughput is always the first to suffer. Consistent throughput limitations can wreak havoc on a backhaul network.

The most disconcerting aspect of utilizing unlicensed spectrum is the lack control. An operator can perform every possible test of the RF environment at the time of deployment, but what happens after that is completely beyond his control. Licensed links are the safe choice for long-term reliability of the network. Many WISPs will often opt to use a combination of licensed and unlicensed radios, where all critical backbone and transport links utilize protected licensed frequencies and less critical spurs may utilize unlicensed spectrum.

FCC Filing

When planning your network rollout and scheduling a launch date, enough time must be set aside for frequency coordination and FCC filing. In most cases, your links can be coordinated and launched under "conditional authorization" meaning transmissions can begin immediately upon filing applications with the FCC. This eliminates the typical 60 to 120 day period while waiting for applications to be granted, but you still must allow time for the coordination process. Typical time frames would include 5 to 7 days for a frequency search, 30 days waiting period for the Prior Coordination Notice (PCN), and 3 to 5 days to file all applications. In total 40 to 45 days from initiation of the frequency search to available launch date is typical. An estimate of 55 to 60 days is probably safer to avoid any possible delays. Lack of available frequencies, geographical/band restrictions, or even objections from other incumbents could all hamper the process and lead to extended coordination time frames.

Frequency Protection

So all your designs are complete, line of sight has been verified, you've got clear frequencies and they've been filed with the FCC. Now don't forget about protecting those licenses. Although many licensees feel that just having their license on file with the FCC will provide adequate protection, the burden actually lies with the licensees. Licensees are actually required to review all prior-coordination notices and applications that come out on public notice. Frequency Protection services from a qualified vendor can relieve this burden and provide for years of worry free interference-free operation.

Comsearch is here to help. With design tools such as iQ·link, services including Fixed Network Design, Path Surveys, Microwave Coordination, FCC License Preparation and Submittal, Frequency Protection, and a complete array of data solutions including worldwide terrain and morphology data, we can provide any level of assistance. We provide services that can help throughout all phases of your design, implementation, and on-going network management. For more information on Comsearch's Backhaul services, go to www.comsearch.com.

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