



## *Q&A With the CIC Experts!*



### **Commonly asked Questions regarding Point-to-Point Microwave Links: Part 2**

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**1. I would like to design my microwave network for 99.999% availability per hop. What if some of those links cannot achieve better than 99.998% availability?**

Most likely nothing will happen. The calculations are based on empirical models and the probability of experiencing impairments, as noted from long-term observations of similar links. That means that some installed links may experience better results and some may experience worse results than calculated. To reject a link design because of the 1/1000th of a percent difference in the yearly availability is simply poor engineering and indicates a lack of understanding of microwave radio propagation.

**2. In microwave link design, is *protection* and *diversity* the same thing?**

No, and the terms are often incorrectly interchanged when applied to microwave links. Protection (hot-standby configuration) commonly improves long-term traffic interruptions ( $\geq 10$  CSES), while diversity arrangements (space, frequency, or any other type) greatly reduce the number and duration of short-term outages ( $< 10$  CSES). CSES stands for Consecutive Severely Errored Seconds.

**3. What are the different phases in a microwave network build-out process?**

Planning, design, and deployment are the three main phases. Planning usually includes a high-level decision-making process, defining the budget and schedule, and identifying the required team members to carry out the project. It also includes defining frequency band, system capacity, and network configuration and performance objectives. Designing the network includes an actual detailed link engineering process, creation of the detailed Bill of Material (BOM), ordering equipment (MW radios, shelters, towers, other transmission hardware and software), in addition to the ordering of engineering, installation, and other services. Deployment (also called implementation) includes all the field activities, like surveying the site and path, erecting towers, installing equipment, creating an as-built documentation, and acceptance testing and commissioning. Refer to CIC's technical paper, *Building a Microwave Network for Wireless Communications* (<http://www.cicusa.com/pages/newsroomPage2.asp?nid=56&l=2>), for more details on managing a microwave network build-out project.

**4. I'm designing a microwave link in a country other than the United States and that does not have strict control or records of the installed microwave systems. What should I do to make sure that there is no interference?**

In this case the most reliable information on potential interference cannot be achieved by calculations, since there is little—if any—information on the existing terrestrial or satellite systems in the area of concern (often a case in places outside of North America and Europe). The best way to check for interference is to sweep the entire spectrum using test equipment at the future microwave-system antenna location (specifically at the antenna centerline height) and



determine interference potential at that location. The result is a spectrum analyzer plot showing all potential interference in the applicable band. Unfortunately, this method can ensure only interference-free operation at the time of link installation but cannot ensure that an interference problem won't appear at some later time due to someone else's negligent new link installation.

### **5. Should I be concerned about a microwave link shooting through high-voltage transmission lines?**

Typically, transmission lines are not an issue for microwave links as long as the transmission towers are not in a near-field (or in the first Fresnel zone) of the antenna. To be on the safe side, however, when doing the path calculations, add an additional 1 dB in losses on both sides of the link to take into consideration any losses due to the obstacles (electrical wires) within the Fresnel zone.

### **6. What are the consequences of referencing geodetic coordinates to the wrong geodetic datum?**

Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters. Here's why: Geodetic datum defines the reference systems that describe the Earth's size and shape. Ever since Aristotle made the first estimates of Earth's size, hundreds of different datums have been used to frame position descriptions, having evolved from those that describe a spherical Earth to ellipsoidal models derived from years of satellite measurements. Modern geodetic datums range from flat-Earth models used for plane surveying to complex models used for international applications that completely describe Earth's size, shape, orientation, gravity field, and angular velocity.

### **7. Do excessive fog or pollution, or their combined result as smog, have any effect on microwave links?**

Smog, pollution, and fog are important in designing optical links but do not need to be considered in designing microwave links.

### **8. What is an XPIC and when do I need it?**

The Cross-Polarization Interference Canceller (XPIC) is an adaptive coupling circuit between two orthogonal co-frequency channels, or two alternated adjacent channels, on the same link. It is used to reduce cross-polar interference during adverse propagation conditions. With dual polarity transmission, two signals are transmitted—one with horizontal polarity and one with vertical polarity. The technology was developed to double the wireless capacity over the same channel. The main challenge with this kind of configuration, however, is cross-polarization interference, where energy from one polarization is received in the other.



### **9. What is *residual BER* and what is its importance for the microwave link?**

In essence, the residual BER is a measure of a radio's quality. Weak signals create many bit errors, and as received signal strength increases, the error rate will fall to a very low level, or "error floor." This error floor is called the "residual bit error rate," or residual BER. It measures the combined effect of the digital radio's modulator, transmitter, receiver, and demodulator. On the other side, as received power increases, the receiver will ultimately reach an overload point where the error rate again increases quickly. If the residual BER of the radio itself is not low enough, the link will show dribbling errors even under perfect propagation conditions.

### **10. Could you recommend the best microwave design tool on the market?**

Most microwave network design software tools are developed by radio manufacturers and, by their nature, are biased toward their own equipment. In addition, sometimes a tool is proprietary and not for sale on the open market. These tools sometimes come with the engineering personnel assigned to work on a customer's site and perform the network design. Many operators and consultants prefer tools available on the open market, such as Pathloss 4.0™, a vendor-independent tool. Pathloss 4.0 is probably one of the best—and moderately priced—tools for the complex microwave design of terrestrial point-to-point systems. It includes North American and ITU standards, different diversity schemes, diffraction and reflection (multipath) analysis, rain effects, and interference analysis, among many other features.

### **11. What is a difference between NAD-27 and NAD-83?**

The North American Datum (NAD) is the official datum used for the primary geodetic network in North America. Its coordinates are based on either NAD-27 or NAD-83. The NAD-27 datum is based on the Clarke ellipsoid of 1866 and uses a stone in Meades Ranch, Kansas, as a reference point. The more modern NAD-83 referencing system is based on properties gathered by satellites. All North American topographical maps produced before 1980 are based on the NAD-27 datum.

### **12. What are *ducts*?**

Ducts are anomalous radio-propagation conditions and potential nightmares for unsuspecting microwave engineers. When the refractivity gradient decreases beyond the critical gradient, the radius of curvature for the wave will become smaller than that of Earth's. The wave will either strike the Earth and undergo surface reflection, or enter a region of standard refraction and be refracted back upward, only to reenter the area of refractivity gradient that causes downward refraction. This refractive condition is called "trapping" (or "blackout fading") because the wave is confined to a narrow region of the troposphere. Many areas in the US are prone to ducts (California's coastal area, for example). In fact, equatorial regions are the most vulnerable to ducts, but in temperate climates the probability of ducting is lower. In addition, ducting probability follows seasonal variations. Conventional techniques used to combat other types of



fading, such as increased margins or diversity techniques, have little or no influence on blackout fading caused by ducts.

### **13. Does rain ever affect microwave links at frequencies below 10 GHz?**

In most parts of the world rain begins to affect microwave links only above 10 GHz; however, there are recorded cases in subtropical regions where extremely intense rain actually affected microwave links at frequencies as low as 8 GHz.

### **14. I have been asked to design a microwave path covering more than 40 miles across the sea between islands. What things do I need to consider?**

Over-the-water paths can be tricky. Here are some things to look for:

- ✓ Your main concern will be reflections off the water (multipath).
- ✓ For the length of the hop, space diversity will absolutely be required, although it may not be sufficient. You may have to use frequency diversity as well (if allowed).
- ✓ For the space diversity improvement to be optimal, you have to perform a very detailed analysis of the antenna placement on the tower.
- ✓ Some ducting issues may also appear in certain areas, but since there is not sufficient information about this specific link and its location, we won't address it here.

### **15. We are installing a long over-the-water microwave link that requires space diversity, but we do not have the capability to install two large antennas with sufficient vertical separation. Can we use a horizontal separation of 30 feet?**

Unfortunately, horizontal separation will not improve this link's outage probability. Even if you cannot achieve 30 feet of vertical separation, 5 to 10 feet would be beneficial. Some studies indicate that the improvement achieved with such a small vertical separation can be much better than the theoretically calculated value.

### **16. Should I use vertical or horizontal polarization for over-the-water paths?**

For over-the-water paths at frequencies above about 3 GHz, vertical polarization is better than horizontal polarization. At grazing angles greater than about  $0.7^\circ$ , a reduction in the surface reflection of 2 to 17 dB can be expected over that at horizontal polarization.

### **17. What is frequency coordination?**

Frequency coordination is a bilateral process that involves the sharing of technical operating information between parties using the same spectrum. The procedures are based upon the Federal Communications Commission's (FCC) coordination and licensing requirements found in FCC Rules, Part 101, as well as related industry practices that have evolved over the years. (In 1996 the FCC adopted Part 101, which combined the Private and Common Carrier point-to-point



frequency bands under one consolidated Rule Part.) The frequency coordination process involves several distinct but interrelated elements: interference analysis, notification, and response.

**18. What is QRSS and is it sufficient to test a T1 circuit?**

Whether public or private, T1 circuits and network equipment must be properly tested and maintained to perform to maximum efficiency. For many T1 transmission systems, the bit error rate tests use the Quasi Random Signal Sequence (QRSS) pattern, an imitation of live traffic. However, it is a good idea to use some of the stress test patterns as well. Stress patterns will detect B8ZS and AMI mismatch along the T1 circuit that would not be detected by using the QRSS test pattern alone. Mixed T1 circuits containing leased lines, fiber-optic circuits, and microwave links, should be tested end-to-end, long-term (24 hours), and with the multiple test patterns.

**19. Which is higher, the calculated improvement factor for frequency diversity or that for space diversity?**

Above 3 GHz, space diversity improvement is nearly always higher (better) than frequency diversity, and is, therefore, selected unless the diversity spacing exceeds about 5% (300 MHz in the 6 GHz band, for example).

**20. What is EIRP?**

Effective Isotropically Radiated Power (EIRP) expresses how much transmitted power is radiated in a desired direction. The unit of measure is dBW or dBm since we are talking about power.

$$\text{EIRP [dBm]} = \text{Pt [dBm]} + \text{Loss [dB]} + \text{Antenna Gain [dBi]}$$

*Where:*

Pt = the output power of the transmitter in dBm or dBW

Loss = the line loss in dB (transmission line connecting the transmitter to the antenna)

Antenna gain is measured in dBi

**21. Where can I find the latest value for the magnetic declination at certain locations in North America?**

There are several declination calculators available online. NOAA has one: [www.ngdc.noaa.gov/geomag/magfield.shtml](http://www.ngdc.noaa.gov/geomag/magfield.shtml) as does Natural Resources, Canada: [http://geomag.nrcan.gc.ca/apps/mdcal\\_e.php](http://geomag.nrcan.gc.ca/apps/mdcal_e.php). Remember, declination not only changes from place to place but over time.



## **22. What do I need to consider before using a license-exempt microwave point-to-point radio?**

We are surrounded by radio waves transmitted by both licensed (known and predictable) and unlicensed (unknown and unpredictable) equipment. Interference, therefore, is the main concern. Determine your risk tolerance for interference and ask the tower or structure owner about their interference policy. Next, 1) determine the distance and pick the frequency; 2) determine the required bandwidth (link capacity); 3) perform the path engineering; and 4) determine the required and allowed antenna size.

## **23. What is *homologation*?**

In telecommunications, homologation is the act of certifying equipment or processes against the corresponding telecom standard. For example, equipment is often sold and installed in countries other than their country of manufacture. Because different countries often have different functionality and safety requirements, in order for products to be sold in other countries, suppliers must undergo a certification process—homologation. Quite often, frequency allocations and channeling plans for wireless services (cellular, PCS, microwave, satellite, etc.) also differ among countries. If equipment is approved by the FCC and meets certain minimum requirements, it is considered certified. In other countries, government regulations are used to exclude foreign manufacturers from their markets. Governments accomplish this by making suppliers meet stringent requirements and standards, and quite often suppliers must also customize their hardware design. While this is not necessarily technically demanding, homologation can be a time consuming process.

## **24. Do I need to register my tower?**

Typically, owners of antenna towers taller than 200 feet (60m) above ground level, or that could potentially intersect flight pathways of a nearby airport, must register their structures with the FCC. The structures' placement must also be studied by the Federal Aviation Administration (FAA). Previously, registering an antenna was the site licensee's responsibility, but since 1995, the owner of the real property is accountable.

## **25. Can a guyed tower be used in urban or suburban areas?**

Generally, there are two types of towers: guyed and self-supporting. Each type has different limitations regarding its capacity, stability, and versatility. Guyed towers are slender, generally three- or four-sided lattice construction, and are uniform in dimension over their length. They are supported by guy wires attached at various levels on the tower and anchored to concrete blocks on the ground. Under normal circumstances, a guyed tower requires a radius of 80% of the tower's height, which in turn can necessitate having a large piece of land to guy a single tower. For this reason they are usually used in rural areas only.

**26. What is a *millimeter-wave band*?**

The millimeter-wave band is defined as that between 30 and 300 GHz. Refer to CIC's technical paper, *Millimeter-Wave Radios in Backhaul Networks* (<http://www.cicusa.com/pages/newsroomPage2.asp?nid=56&l=2>).

**27. What is the main concern in designing a microwave network for an electric utility?**

Because these networks are used for both communication between operations and administrative staff as well as for the distribution and collection of data related to control equipment, electric and other utility telecommunications networks have some specific requirements that are different from other telecom networks. Some examples include SCADA (Supervisory Control and Data Acquisition), powerline fault location, loop and ring protective schemes, and direct transfer trip protective relaying. SCADA systems are used extensively by power, water, gas, and other utility companies to monitor and manage distribution facilities. The only variable that can be controlled is the communication channel transit time that includes free-space delays, channel banks, microwave terminals and repeaters, waveguides, etc. The typical transit (channel delay) time objective for the communications channel is 10 to 15 milliseconds end-to-end.

**28. What is *angle diversity*?**

Angle diversity is a propagation improvement method in which two feeders are placed inside a single parabolic dish antenna. The method has been used in line-of-sight digital microwave links since the mid-1980s and in troposcatter links since the 1950s. The angle diversity antenna is a single dish with two feeds vertically offset by about 1°. Angle diversity is most effective when path outages are dominated by dispersive fade activity (dispersive fade outage approaches or exceeds flat fade outage). Optimum angle diversity improvements are obtained only through an antenna alignment procedure that matches the antenna size and alignment to the path and its climatic characteristics. Angle diversity dishes require a more exacting, long-term alignment procedure than that for space- and non-diversity antennas. Depending on path geometry and climatic conditions, angle diversity improvements of perhaps 20, or even more, can be achieved.

**29. Do free-space laser communications systems compete with microwave systems?**

No, free space laser communications systems are wireless connections through the atmosphere using the optical part of the frequency spectrum and, therefore, cannot be categorized as either wireless or wireline systems in the classical sense. They work only under clear line-of-sight conditions between each unit, eliminating the need for securing rights-of-way, buried cable installations, and government licensing. Rain and snow can cause attenuation up to approximately 40 dB/km and 100 dB/km, respectively. But fog, by far, is the biggest problem. In extremely heavy fog, attenuation as high as 300 dB/km has been reported, yet microwave systems are typically not affected by snow or fog.



### **30. Where can I get additional practical information about microwave point-to-point systems?**

Visit Communication Infrastructure Corporation's Web site at [www.cicusa.com](http://www.cicusa.com) and click on the News & Resources link. Here you can download additional Q&A papers, technical and white papers, as well as learn where to buy the following books:

*Transmission Systems Design Handbook for Wireless Networks*, Harvey Lehpamer; Artech House, 2002; ISBN 1-58053-243-8.

*Microwave Transmission Networks – Planning, Design and Deployment*, Harvey Lehpamer; McGraw-Hill, 2004; ISBN 0-07-143249-3.