

INTERCEPTING INTERFERENCE

CAMBIUM'S INDUSTRY LEADING WIRELESS BROADBAND EXPERTISE HELPS TO SUBSTANTIALLY REDUCE THE EFFECTS OF INTERFERENCE FOR POINT-TO-MULTIPOINT WIRELESS ACCESS AND DISTRIBUTION NETWORKS IN BOTH LICENSED AND UNLICENSED FREQUENCIES.



Wireless broadband has emerged as the most cost-effective technology for delivering high-speed Internet access to residential and business users, especially those in outlying and low-density environments. In the minds of many, the major challenge for wireless network providers is making sure of their equipment's ability to overcome the effects of interference to deliver service with both high performance and high reliability. It's a fact that wireless systems, whether operating in licensed or unlicensed frequencies, must cope with interference that can disrupt signals and cause transmission delays caused by errors. But it's also a fact that if a wireless system is designed and built from the ground up to operate in the presence of interference, it can deliver consistently reliable performance and connectivity, enhanced customer satisfaction and excellent ROI. At Cambium Networks, our RF expertise, experience in outdoor communications, and technology leadership help us design fixed wireless networks that tolerate outdoor interference more successfully than any other wireless broadband solution available.

Among the numerous features that make Cambium Networks successful at mitigating outdoor interference, two stand out. The first is the Cambium Air Interface Protocol, the fundamental system element that helps neutralize interference from external sources including ambient noise and interference from signals from other emitters and devices using the same frequency. The second is the fact that Cambium's entire Point-to-Multipoint (PMP) technology portfolio offers GPS synchronization to limit the network's own self-interference. Cambium provides proven PMP wireless network solutions for fixed outdoor networks in licensed or unlicensed bands and in line-of-sight (LOS), near-line of sight (nLOS) and Non Line of Sight (NLOS) environments. Most important, Cambium's wireless solutions can be fitted exactly to your specific requirements and business case.

INTERFERENCE AND RELIABILITY

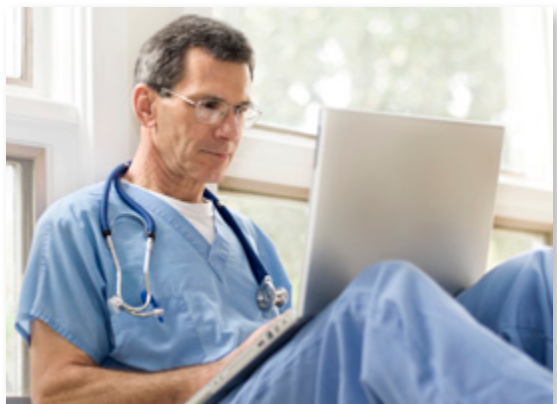
What exactly is interference and why is it such a problem? In the unlicensed wireless environment, interference can be defined as unwanted, competing radio signals in the same frequency band. These interfering signals can disrupt, delay and reduce the reliability and quality of your network traffic and performance. In licensed frequency bands where no outside signals are competing, the issue is self-interference, i.e., your own network's signals competing with each other. In either case, the results go beyond lower quality transmission; they extend to customer dissatisfaction, loss of competitive advantage and decreased return on investment.

EXCLUSIVITY AND FREE USE OF SPECTRUM

Basically there are two types of frequency bands in which wireless networks operate: the licensed and unlicensed bands. Characteristics of each include:

LICENSED FREQUENCIES. Licensed frequencies are bands reserved for the exclusive use of a public/private entity. Since the spectrum is clean and clear with no RF emitters (controlled by other entities) operating in the same frequency, wireless system reliability is greatly improved. Interference issues are largely confined to self-interference problems.

UNLICENSED FREQUENCIES. Frequently described as a "Free Use" environment, unlicensed frequencies provide spectrum that is available to virtually anyone that wants to use it. Signals from different transmitting organizations and entities may compete with one another for space, creating an environment in which interference and ambient noise — as well as self-interference — can be significant impairments to reliable communications. The sheer number of the competing signals in unlicensed spectrum places a premium on ensuring that the equipment you use is of exceptionally high quality and design.



INTERFERENCE INTERPRETED

What are the most common types of interference and how do they differ from one another? In general, there are three basic categories of interference:

SELF-INTERFERENCE. Emanating from an organization's own operating environment, self-interference is a factor in both licensed and unlicensed frequencies. In either band, self-interference occurs when distinct signals come from a network under your control, whether from the same tower location or from several miles away. Furthermore, the larger and denser the network grows, the more it will be exposed to self-interference and the reliability and performance issues it may cause.

How do you limit self-interference? In most cases, it is best dealt with in the network planning stage. In building or extending a wireless network, proper product design, advanced technology (such as Cambium's industry leading use of GPS synchronization) and the ability to reuse a frequency band within the spectrum can in most cases combine to reduce self-interference to a point at which it does not have a significant impact on network performance and reliability.

EXTERNAL INTERFERENCE. In unlicensed frequencies, interference is more difficult to manage, since the interference comes from networks and technology not under your control. Because a single access point can support hundreds of subscribers or end users, interference can have a substantial impact.

Other networks aren't the only culprits; more and more network interference is coming from a wide range of consumer devices — such as surveillance cameras, Wi-Fi hotspots, and microwave ovens — that may operate in or near the same frequency. The truth is, a simple baby monitor positioned too close to an access point can cause service disruption over 20 or more square miles. Furthermore, a network must be designed to not only deal with present interference sources, but must also be prepared to deal with potential future sources as the wireless environment evolves and usage of the spectrum expands.

AMBIENT NOISE. Also called the noise floor, ambient noise is simply background noise that is always present in a frequency band. It is caused by the growing numbers of wireless devices — from garage door openers to other wireless networks — operating in the same unlicensed frequency. These all crowd the spectrum and can be a significant factor in degrading signal and bandwidth. Ambient noise levels increase as more devices and networks are deployed in the spectrum.

"We've always liked the Cambium equipment because of its signal-to-noise ratio and the fact that it always performs well in very noisy environments."

Tim Chandler
President
CoastalCOMS

NEUTRALIZING INTERFERENCE

In the world of outdoor wireless broadband networking, interference is a fact of life. Much as you'd like to, you can't eliminate it or simply make it disappear. What you can do, however, is neutralize it. You can make sure it doesn't disrupt your network operations or your end users' performance and satisfaction. That's what's important. As a wireless pioneer, with more outdoor wireless experience than any manufacturer, Cambium Networks knows more about mitigating the effects of interference than virtually anyone. Our PMP networks, and our entire wireless portfolio of products, are designed from the ground up to ensure that the effects of interference will not adversely affect your network connectivity or performance, your end user satisfaction or your return on investment. Cambium's unique interference-neutralizing solutions include:

- **GPS SYNCHRONIZATION.** Cambium leads the wireless industry in its usage of powerful GPS synchronization capabilities in all its PMP networks. This valuable capability dramatically reduces self-interference in both licensed or unlicensed frequency bands. GPS synchronization allows all sites to be set to the exact same clock so network timing is very precise. As shown in the diagram, GPS satellite timing signals reach the GPS receivers in each of the network's access point radios establishing a common timing reference. This allows all the access point radios in the network — whether hundreds or

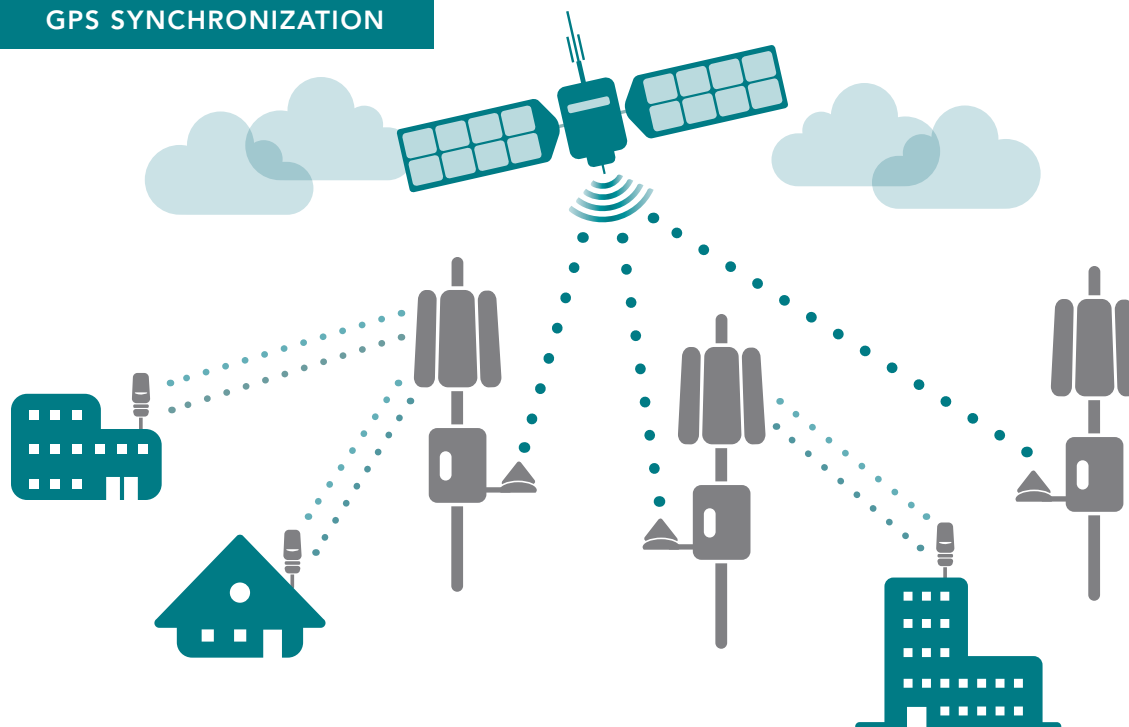
thousands — to transmit at the same time and alternatively receive as all of the subscriber modules in the network transmit at the same time in turn. This helps prevent radio signals transmitted by an access point transceiver to interfere with reception of a user signal by another access point transceiver, perhaps the most onerous kind of self-interference in time-division duplex radio networks. With GPS synchronization, you can be certain your network can scale and grow elegantly to serve increasing numbers of users and applications.

- **CAMBIUM AIR INTERFACE PROTOCOL.** As mentioned previously, for the most effective interference mitigation, it is crucial to have a network designed to prevent or reduce unwanted signals. This begins with the design approach taken in the Media Access Control (MAC) layer. Unlike many other systems, Cambium designs its MAC frame to carry radio data packets (RDP) of a relatively small size. If and when interference corrupts reception of an RDP, the small size means that retransmission of RDPs is kept to a minimum, assuring a negligible impact on overall network throughput. Cambium's PMP equipment also incorporates centralized request-grant transmission control that reduces demand contention and allows SMs to transmit data only when permitted by the access point, reducing data packet corruption and retransmission and maximizing throughput.

“We use the Cambium PMP solution because we've found it to be the most resilient connection in our type of urban business environment. The solution keeps the signal strength high, even with rain and interference, providing C/I ratios that allow us to deliver 100 percent throughput.”

Shane Hampton
Business Only Broadband

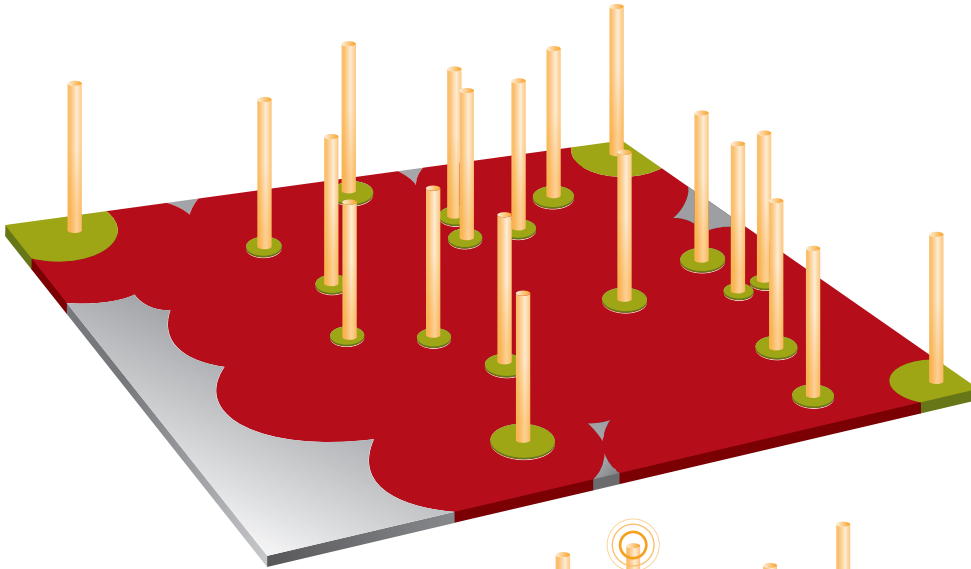
GPS SYNCHRONIZATION



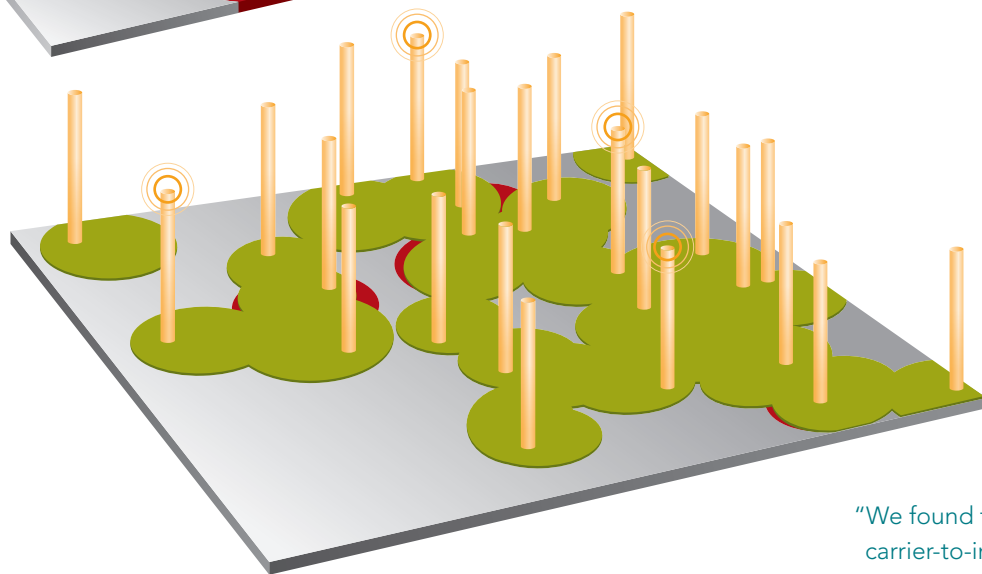
EQUIPMENT KEY:

- POINT-TO-MULTIPOINT ACCESS POINT CLUSTER & CLUSTER MANAGEMENT MODULE
- GPS ANTENNA
- POINT-TO-MULTIPOINT SUBSCRIBER MODULE

CARRIER-TO-INTERFERENCE RATIO



LEFT: POOR COVERAGE IN AN UNSYNCHRONIZED DENSE DEPLOYMENT DUE TO HIGH INTERFERENCE



RIGHT: PMP COVERAGE IN A SYNCHRONIZED DENSE DEPLOYMENT – LARGE AREA OF GOOD COVERAGE WITH LITTLE SELF INTERFERENCE LEVELS

Cambium PMP networks also reduce interference in many other ways, including:

- **DIRECTIONAL ANTENNAS.** Antennas focus RF transmissions and eliminate susceptibility to signals from outside of the transmission area. Cambium PMP products use directional antennas to focus and narrow the signal beamwidths to make them more efficient, strengthening the main signal while minimizing side and rear signal leakage and reducing interference to other transmissions. This reduces the noise floor from unwanted transmissions including emissions from other devices and networks in the spectrum.
- **NOISE FILTERS.** Cambium PMP networks also provide leading edge noise filters that help reduce the

effects of interference from signals in the neighboring frequencies, thus improving reliability of communications.

- **CARRIER-TO-INTERFERENCE RATIO (C/I) RATIO.** The C/I ratio measures signal strength versus interference strength. The lower the C/I ratio, the more difficult it is to distinguish the desired incoming signals from the interference. Cambium PMP networks are known for their exceptional ability to decode incoming signals and maximize performance in low C/I environments. Because of their unique design, Cambium radios need a minimum amount of signal above the interfering signal to operate successfully, as shown in the diagram. The result is, in many situations, Cambium radios will work where other radios cannot.

“We found that the carrier-to-interference ratio on the Cambium system is so small that the system can operate with substantial interference and still maintain higher-quality of service than alternative equipment. Even in congested bands, the Cambium equipment gives us great penetration in the high foliage areas and mitigates interference amazingly well.”

Mark Novey
Director of Information
Technology
Telpage

THE CAMBIUM ADVANTAGE

Cambium Networks is an acknowledged industry innovator and leader in the design and deployment of outdoor wireless broadband networks. We offer industry leading experience in developing wireless broadband networks that successfully defend systems under siege from

interference caused by unwanted internal and external RF transmissions. Our experience enables us to strengthen our networks' defenses against interference with powerful, advanced, industry leading solutions.

CAMBIUM'S INTERFERENCE SOLUTIONS AT A GLANCE

INTERFERENCE TYPE	TYPICAL TECHNIQUES USED	TYPICAL APPLICATIONS
OTHER EMITTERS	<ul style="list-style-type: none">• Directional Antenna• Antenna Isolation• Noise Filters• Air Interface Protocol	<ul style="list-style-type: none">• Residential Connectivity Wide Area Network• Small to Medium Business Connectivity in WAN
AMBIENT NOISE	<ul style="list-style-type: none">• Directional Antenna• Antenna Isolation• Noise Filters• Air Interface Protocol	<ul style="list-style-type: none">• Government Connectivity in WAN• Enterprise Campus Connectivity
SELF INTERFERENCE	<ul style="list-style-type: none">• Directional Antenna• Antenna Isolation• Synchronization	

ABOUT CAMBIUM NETWORKS

Cambium Networks is an independent company providing world-class wireless broadband and microwave solutions for military, government, municipal and enterprise customers around the world. Cambium Networks currently has more than 3.2 million products deployed and provides reliable, secure, cost-effective connectivity in thousands of networks in over 150 countries.