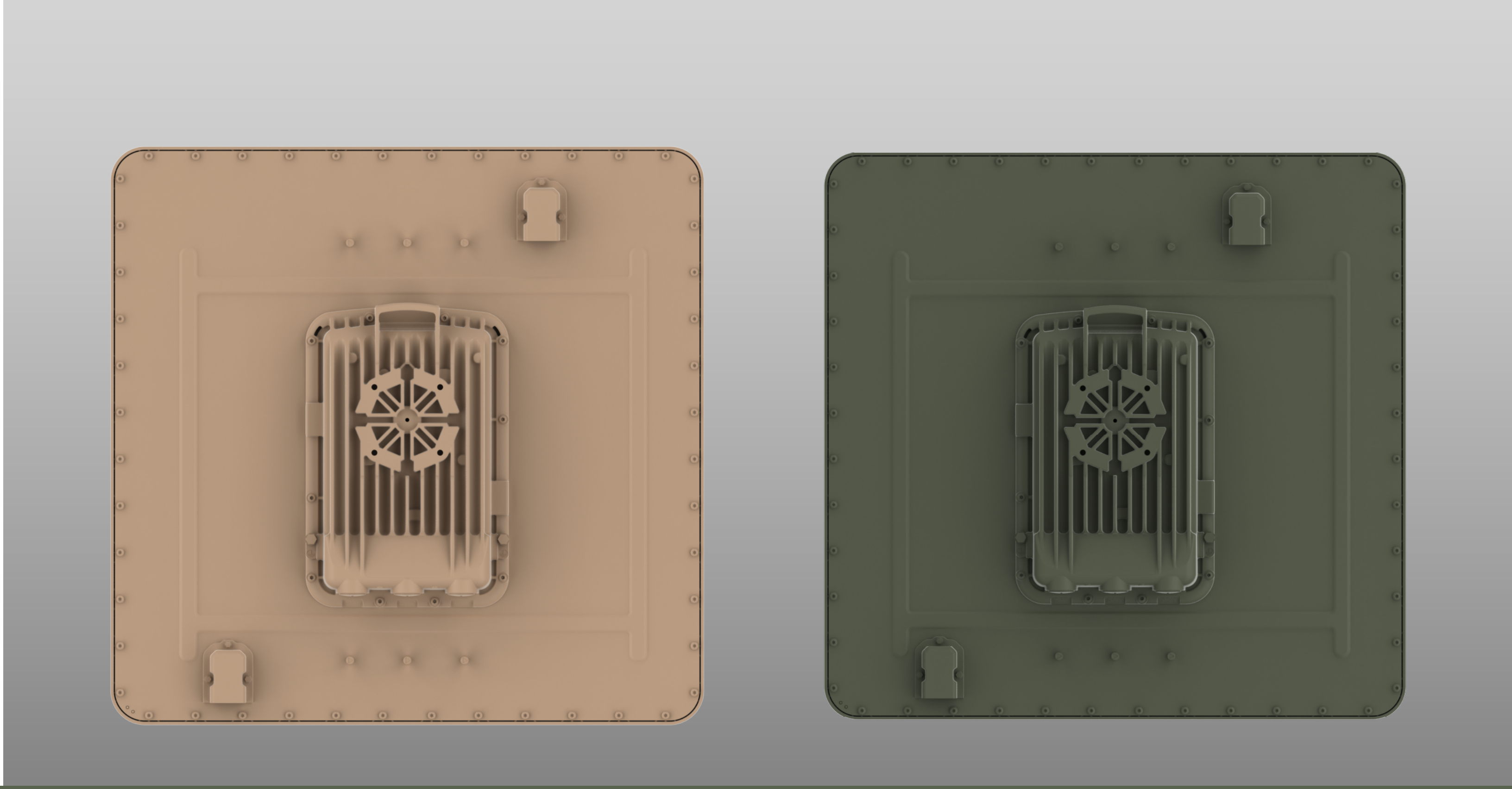


Cambium Networks™ SOLUTION PAPER

PTP 700 Beam Steering

Defense and national security networks require wireless technology that can be set up quickly and perform in harsh environments with RF interference and jamming. One of the biggest challenges in deploying wireless networks is antenna alignment. Electronic beam steering addresses this challenge by removing manual alignment systems from the equation. As the name implies, electronic beam steering allows an RF signal to be steered in a desired direction without physically moving the antenna.

Benefits of Beam Steering

Beam steering enables rapid and simple antenna alignment while providing secure communications in congested and contested environments. Its many benefits include:

Improved Link Performance

Beam steering improves link performance by directing more energy in the direction of the remote antenna through beamforming. Beamforming provides significant gain improvement over a fixed beam sector antenna with comparable coverage, resulting in more radiated power in the desired direction.

Easier Link Alignment

Beam steering simplifies link alignment by performing it electronically and precisely without manual or mechanical support. Manual alignment of antennas requires a person at each end of the link to physically change the antenna direction using visual or audible tools that provide feedback on the radio signal strength.

Less Cost, Weight, and Complexity than Mechanical Positioners

Electromechanical positioners automate manual antenna alignment tasks using motorized gimbals along with direct signal strength feedback from the radio. While positioners can improve accuracy, they take longer

to scan all possible azimuth and elevation angles and require additional equipment, adding cost, weight, and complexity.

Low Probability of Intercept and Detection (LPI/LPD)

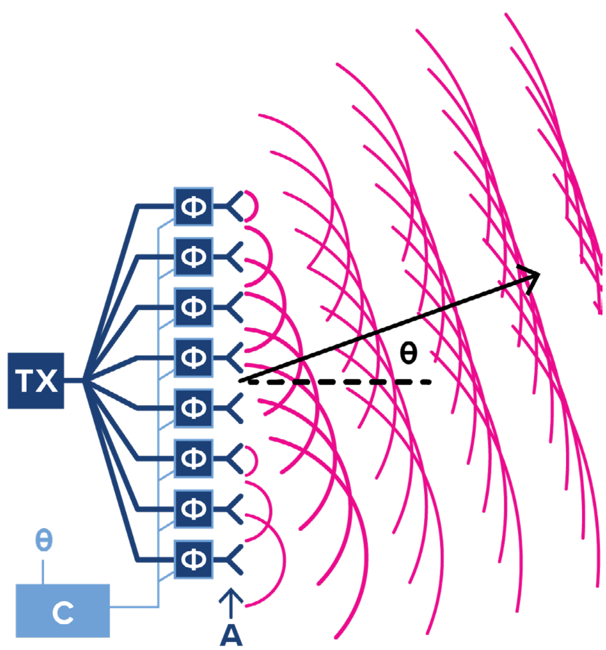
Beam steering can lower the probability of an RF signal being intercepted or detected, known as LPI/LPD. By increasing the power radiated in a desired direction, it reduces the power radiated in other directions, narrowing the beamwidth and suppressing antenna sidelobes.

Interoperability with Fixed Beam Antennas

Beam steering can interoperate with fixed beam antennas. In cases where only one end of a radio link presents alignment challenges, a beam steering antenna can be used at that end while the other end uses a fixed beam antenna.

Technology

Beam steering is commonly implemented with phased array antennas, which consist of a 2-dimensional matrix of individual “phase shifters” and “patch” antenna elements. Because the elements are physically spaced apart, RF signals transmitted at the same time from different patches will arrive at a point in space at slightly different times due to some traveling longer distances. The antenna array has control logic that allows signals to be transmitted with different phases at each patch. By shifting the phase at each element, the antenna can cause all the signals to arrive at a given point in phase, known as constructive interference. By coordinating the phase shifts, the antenna can steer the RF transmission to the location of a known receiver. The same phase shifting benefits the receiver as well, as the signal is received at each patch at slightly different times and is then put back in phase before sending to the radio receiver.



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Beam steering antennas must go through an alignment process to identify the precise location of the remote radio. This involves a scan across azimuth and elevation combined with received signal strength measurements to identify the location. This is coordinated with the remote radio, so they are not scanning at the same time. It is also typically performed in two phases, starting with a course scan to quickly identify the approximate location of the remote radio, followed by a fine scan to identify the precise location. For fixed links, the alignment results can be saved to more quickly re-establish alignment after power outages or other interruptions.

Beam steering antennas can use a similar approach to attenuate RF signals from unwanted sources that would otherwise interfere with the desired signals. By dedicating some patches to interference sources and shifting the phase of those signals, the system can leverage destructive interference to create nulls and cancel the unwanted signal. Because some patches are dedicated to null steering, there is typically a reduction in main beam gain.

One artifact of directional antennas is lower undesirable radiation in directions other than the main beam, known as sidelobes. These reduce the energy available to the main lobe and can also cause interference with other radios. With phased array antennas, this artifact can be suppressed by iteratively adjusting beam patterns to minimize unwanted sidelobes.

Alternatives to Beam Steering

RF Switching

RF switching refers to switching between multiple directional antenna elements instead of phased array beam steering. It limits the performance of the antenna, increases beam width, and reduces LPI/LPD and interference mitigation.

MIMO

MIMO (multiple input, multiple output) technology improves transmit power and throughput using multipath effects but does not alone provide beam steering or null steering. It is typically implemented with two or four omnidirectional antennas, limiting beam steering gain and not providing LPI/LPD.

Cambium Networks' Beam Steering Capabilities

PTP 700 Beam Steering ODU

The PTP 700 Beam Steering Outdoor Unit (ODU) is designed to address specific challenges such as antenna alignment in harsh environments, interference mitigation, and weight limitations. It provides ±60° azimuth coverage and supports situations where electromechanical positioners are impractical.

The PTP 700 Beam Steering ODU combines electronic beamforming for tactical installations and industry-leading spectral efficiency. It enables automatic antenna alignment in seconds and offers high-level interference mitigation.

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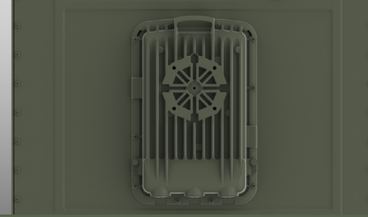

Alignment Process

The beam steering alignment process includes multiple stages:

1. Antenna alignment is initiated using the Installation Wizard, or by using the Force Realignment control.
2. The primary radio transmits the downlink acquisition signal using the sector pattern.
3. The secondary radio performs a coarse search across the antenna coverage using the direction pattern and locates the optimum coarse scan angle.
4. The secondary then performs a localized fine search using the directional pattern to refine the selection of optimum scan angle.
5. The secondary then transmits the uplink acquisition signal using the aligned directional pattern.
6. The primary receives the uplink acquisition signal and performs coarse and fine scans with the directional antenna to locate the optimum scan angle.
7. Both radios transition to OFDM modulation, starting at BPSK.

Additionally, scan progress can be monitored, as final scan angles are displayed in GUI. Alignment is saved for persistence across reboots, or for when the links drop unexpectedly. Automatic alignment can be restarted using a GUI control. This alignment process supports interworking with a fixed beam ODU at either end. Automatic alignment can also be disabled, giving the operator a choice of sector or fixed beam directional antenna.

Null Steering: A Cutting-Edge Capability

Null steering is achieved by adapting the antenna pattern to maximize signal-to-noise ratio (SNR) while minimizing interference. This is done using machine learning algorithms that create radiation patterns with nulls in the directions of multiple interferers, with an improvement of up to 20 dB depending on conditions.

PTP 700 Beam Steering Weight and Power Comparison

Model	Weight	Power
PTP 700 Beam Steering ODU	9.1 kg (20.1 lb)	40W
PTP 700 Fixed Beam + TD 90	16.6 kg (36.7 lb)	91W

Additional Capabilities and Benefits

- **Improved Signal Quality:** Directional control minimizes signal loss and maximizes signal strength.
- **Reduced Interference:** Proper alignment and null steering prevent interference from other signals.
- **Extended Range:** Optimized angles allow for longer transmission distances.
- **Increased Throughput:** Better alignment supports higher data rates.
- **Energy Efficiency:** Precise focus reduces power consumption, ideal for remote installations.
- **Flexibility and Scalability:** Adjustable angles allow for network adaptability and scalability.
- **Enhanced Reliability:** Proper alignment ensures resilience to weather conditions and stability.

Conclusion

The PTP 700 Beam Steering ODU expands on the capabilities of the PTP 700 product line, offering automatic alignment, interference mitigation, and reduced complexity. Its smart antenna features improve spectral efficiency, making it ideal for tactical situations requiring quick setup and performance in harsh environments.

About Cambium Networks

Cambium Networks enables service providers, enterprises, industrial organizations, and governments to deliver exceptional digital experiences and device connectivity with compelling economics. Our ONE Network platform simplifies management of Cambium Networks' wired and wireless broadband and network edge technologies. Our customers can focus more resources on managing their business rather than the network. We make connectivity that just works.

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