AVIAT NETWORKS

OUTPUT POWER: THE MOST CRITICAL ELEMENT OF MICROWAVE RADIO

WHY OUTPUT POWER IS THE MOST IMPORTANT BUT OFTEN-OVERLOOKED RADIO CAPABILITY

Output power (i.e., system gain) of microwave radios is still the most important consideration in evaluating wireless backhaul equipment options. Not only is output power the No. 1 arbiter of a potent microwave radio but also the primary way in which an operator can minimize its total cost of ownership (TCO). In this white paper, we will look at how the problem of TCO, as well as those of availability and capacity, can be solved by implementation of high output power microwave radio.

WHY OUTPUT POWER IS STILL IMPORTANT

Output power (i.e., system gain) has long been the immutable standard by which to judge the powerfulness of a microwave radio. At the end of the day, nothing clarifies exactly what you have installed in your microwave backhaul like raw dBm. With more output power, you can have:

- Smaller antennas
- Longer paths
- Higher capacity

While higher output power radios allow for smaller antennas and longer paths, antennas and path length are more or less fixed for a given microwave hop once it is established. However, for an existing hop, network designers could easily increase capacity by turning up the radio power and without changing out equipment—if such a radio existed.

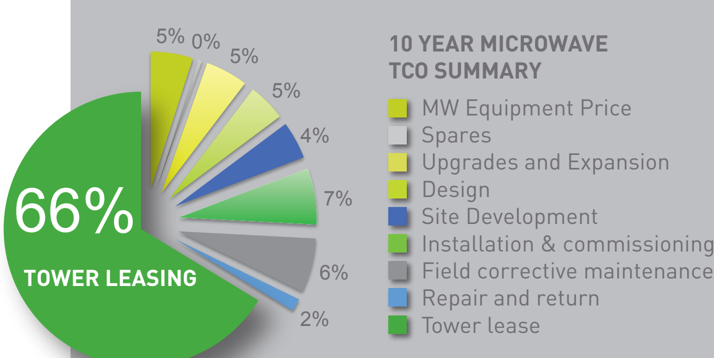
To alter antenna size or path length means heavy-duty labor climbing up and down towers and out-and-out tower relocation, respectively. So for existing microwave backhaul sites, the main benefit with higher output power radios is higher capacity.

Conversely, if network designers are implementing greenfield sites, they can take full advantage of higher power radio capabilities by using smaller antennas, planning longer paths and raising normal and peak capacity expectations for any given backhaul route.

Overall, when architecting a microwave radio network, all these factors pose problems for path planners. All these problems are a subset of a larger issue: Total cost of ownership (TCO). However, if you can have longer paths, higher availability, more capacity at higher modulations and smaller antennas and lower tower loads, you will effect lower overall TCO.

TCO MODEL FOR A NORTH AMERICAN MOBILE OPERATOR

As a result of tower leases, OPEX represents the single largest contributor to total cost of ownership (TCO). Increasingly, operators make decisions about backhaul solutions based mostly—sometimes solely—on price, i.e., initial CAPEX. While initial CAPEX is important, if the goal is lowest TCO, this can be problematic. As stated, initial CAPEX is not the most significant contributor to total cost.



ONGOING OPEX KEY

The dominant factor in OPEX is related to the cost of towers (i.e., leasing costs or structural costs in cases where operators own the towers). In any event, the cost is in the tower—including tower space for antennas and cable runs, tower loading which drives structural costs, shelter/cabinet space and power and continuing change fees that are regularly paid to tower companies.

LARGEST PROPORTION OF TCO RELATES TO ANTENNAS

The largest proportion of tower cost is related to antenna size. Microwave products with features that enable smaller antennas as well as lower tower loading, reduced indoor space and fewer cables are the most important TCO considerations for operators.

PROBLEM NO. 1: TOTAL COST OF OWNERSHIP

Let's start by looking at microwave TCO. When choosing a backhaul solution, total cost of ownership (TCO) is a critical but often-overlooked, consideration. TCO is not widely understood and not knowing about it can lead to poor choices in backhaul technology and obscure the relative importance of features. For example, some aspects of microwave radio that are critical to lower TCO but not often given enough attention include:

- Path length
- Availability
- Capacity and modulation
- Antenna diameter and tower loading

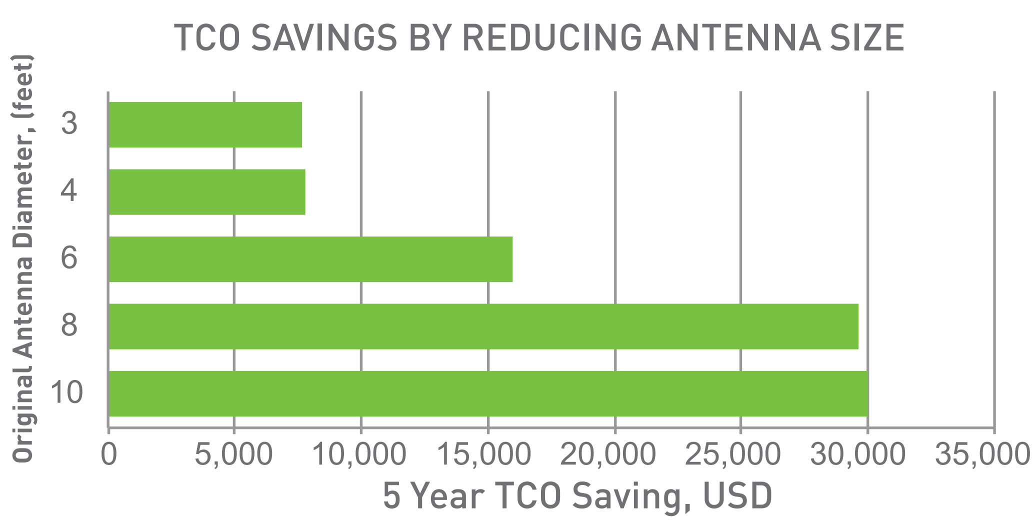
SOLUTION: HIGH OUTPUT POWER LOWERS TCO

Many microwave network operators resort to ever-larger dish antennas in their quest for overall higher gain. The problem is that these large dishes put an enormous static and dynamic load on towers. Plus, there is an upper limit to how large dishes can get. Regarding tower leasing costs, larger dishes will also necessitate higher operating expense (OPEX) on the part of the operator.

Rather than take the blunt approach of implementing so much bulky hardware at the top of some very spindly towers, higher system gain radios enable the use of normal or even downsized antennas. And smaller antennas have larger beamwidths, so they are much easier to align, enabling you to avoid installation issues. Also, they are less subject to antenna misalignment, which can happen with very large, narrow beamwidth antennas during storms or strong winds.

If you have a standard power radio, you may need to resort to larger size dish antennas in order to achieve the overall gain you need to complete a link of any really significant distance (>30 km). But antenna sizes of 8 feet in diameter and greater begin to take a toll on the static load bearing strength of towers and, more importantly, the dynamic load when under stress from the wind. And tower loads do not increase linearly. For example, an eight-foot antenna will place 39 percent more static stress on a tower than a six-foot antenna. Dynamic loads from windy conditions increase even more with each step up in antenna size.

In addition, larger antennas create higher leasing costs for tower space. And just as larger antennas create disproportionately higher loads, so do bigger dishes make for outsize tower costs. You can see how progressively larger antennas regressively impact TCO (in the figure below). However, a high system gain radio that is capable of an extra 7dB compared to normal power radios will let you go from an eight-foot to a six-foot antenna, which translates to around $15,000 TCO savings over five years.



The smaller the antenna, the bigger TCO Savings

AVAILABILITY: TYPICAL POWER VS. EXTRA HIGH POWER RADIO

RADIO	CONFIGURATION	TX OUTPUT POWER	PATH LENGTH	SITE A ANTENNAS	SITE B ANTENNAS	AVAILABILITY	ANNUAL OUTAGE
Typical Power	MHSB-SD	29.50 dBm	48.28 km	8'/6'	6'/6'	99.99953%	2.5 minutes
Extra High Power	MHSB-SD	37.50 dBm	48.28 km	6'/4'	6'/4'	99.99992%	0.4 minutes

LONGER HOPS AFFECT TCO

In line-of-sight (LOS) microwave backhaul, path length is determined by the total unobstructed distance between transceivers. Trees, mountains and, ultimately, curvature of the Earth all have an effect on viable microwave path distance. Then there is the reality that radio signals attenuate over distance. For example, let's compare a couple of typical length North America microwave paths. The first one is about 35 kilometers long. The second is 50 kilometers long. Everything else held constant, over the 15 kilometers difference between these two paths 3 dB of signal will be lost. Bottom line, there is only so far you can go with a single link between sites.

When planning greenfield microwave paths, radios with higher system gain allow designers to create longer hops than they would otherwise be able to achieve with typical power radios. For existing paths that begin to experience fading using normal power radios, a network designer could resort to a higher system gain radio to re-establish the path. For example, in a typical distance North America microwave hop, an additional 7dBm in output power could mean at least an extra 30 kilometers in hop length at the same availability, capacity and antenna size.

In terms of quantifying the impact of hop length, in many cases extra output power can reduce the need to deploy extra sites. Sites can run anywhere from $100,000 to $1 million USD to construct when including shelters, cabinets, towers and ancillary equipment. Removing just one site from a network spur or ring can achieve huge cost reduction, overall.

PROBLEM NO. 2: AVAILABILITY

Generally, availability is stated in terms of percentages. High availability is typically accepted as 99.999 percent uptime—commonly known as Five-Nines. Virtually all microwave paths could be categorized as necessitating Fine-Nines availability. But some paths need even more availability.

Availability can be affected by a number of variables. Factors affecting availability relate to overall system gain of the antenna, radio transmit power and transmission line system as well as the point to which the radio can receive error free signals (i.e., sensibility). Typical power radios with traditional system gain will have the most difficulty overcoming atmospheric conditions that adversely impact propagation especially for long distance paths. Climatic models that use average annual temperature, rain rate and atmospheric pressure take this last factor into consideration for availability.

CAPACITY: 11 GHZ VS. 6 GHZ RADIOS

RADIO	CONFIGURATION	TX OUTPUT POWER	PATH LENGTH	SITE A ANTENNAS	SITE B ANTENNAS	CAPACITY
Typical Power	MHSB-6 GHz	29.50 dBm	19.31 km	6'	6'	239 Mbps
Extra High Power	MHSB - 11 GHZ	34.50 dBm	19.31 km	4'	4'	254 Mbps

Furthermore, transmit power and sensibility are determined by channel size, modulation scheme and link capacity. These factors and other variables such as k-factor (i.e., bending of the microwave beam) help determine feasibility of microwave line of sight and must be considered to calculate availability.

SOLUTION: HIGH OUTPUT POWER IMPROVES AVAILABILITY

As atmospheric conditions take their toll on a microwave radio link, availability will drop. A typical power radio is more susceptible to fading than an extra high power radio. When it comes to resilience against fading, the name of the game is sufficient fade margin—the difference between the unfaded signal and receiver threshold. In other words, the higher the transmitter (Tx) power the higher the fade margin, which lessens the likelihood of an outage. Overall, higher system gain radio configurations can cover greater distances and overcome atmospheric conditions that make propagation difficult.

For example, let's consider one deployment scenario using a typical power radio (29.5 dBm) and the same scenario using an extra high-power radio (37.5 dBm). With a path length of 48.28 km and using an 8-foot/6-foot antenna Space Diversity (SD) configuration at the transmission site and a 6-foot/6-foot antenna SD configuration at the receiving site, link availability equals 99.9953 percent [equal to 2.5 minutes outage per year].On the same path using an extra high-power radio, the sites can be changed to a 6-foot/4-foot SD antenna configuration at the transmission site and a 6-foot/4-foot SD antenna configuration at the receiving site that results in a new availability of 99.9992 percent [equal to 0.4 minutes outage per year].

Therefore, not only can you use lighter weight and easier-to-install antennas with an extra high power radio but also increase availability to hard-to obtain Six-Nines. This very important threshold can sometimes be seen in the requirements for the most mission-critical radio applications.

Also it's worth mentioning that, in some cases, extra high power radios provide enough system gain to allow you to eliminate the second antenna at each site, dispensing with SD configurations entirely.

PROBLEM NO. 3: CAPACITY

With the migration to 4G well underway, LTE and LTE Advanced-capable smartphones and other wireless devices are putting a strain on aggregation networks for more throughput. Not only are the telephone companies feeling the pressure to make more capacity available but also the private network operators—public safety, utilities and oil and gas, among others. To provide higher capacity, microwave backhaul must resort to higher QAM modulations at some point (here we will not consider extreme case modulations, i.e., 512 QAM and higher).

The problem with higher QAM schemes is that with each step up in modulation, bits per symbol increase. In those cases, symbols are placed ever closer together in the radio constellation. The closer the symbols are to each other in the constellation, the higher the chance for error in radio transmission at the far end of a link as it gets increasingly difficult for the receiver to distinguish among symbols.

SOLUTION: HIGH OUTPUT POWER INCREASES CAPACITY

What with the more data-intensive uses all stripes of mobile device users require, backhaul networks face a capacity demand increase unprecedented in the history of wireless communications. To increase capacity on existing links, network designers must fix microwave radios at a higher QAM modulation. Unfortunately, when network designers step up radios in QAM modulation, availability declines due to lower system gain/lower power supported at higher modulations. That's if they continue to use a typical power radio.

However, if a radio with higher system gain can be used, this will solve the problem of extra capacity by providing the power to maintain link availability even at a higher QAM scheme. Therefore, operators can run an extra high power radio at higher QAM modulations to accommodate demands for more capacity without compromising availability.

As an example, let's compare a typical power radio and an extra high power radio under the same path length (44.26 km) and availability requirements (99.999 percent). Specifically, for the typical power radio (28.5 dBm), link availability needs to be 99.99908 percent. To maintain this level of availability, the radio must be fixed at 64 QAM, resulting in a capacity throughput of 138 Mbps with a total calculated outage of 289 seconds per year.

In contrast, an extra high power radio (37.5 dBm) that offers a higher availability of 99.99991 percent can operate two modulations higher at 256 QAM. Given the higher availability and higher fixed modulation, the extra high power radio delivers 178 Mbps capacity throughput with a calculated 29.02 seconds outage per year.

The extra high power radio has a raw 40 Mbps advantage on the typical power radio for a total 29 percent increase in capacity. Network designers can utilize this improvement to reduce antenna size and still maintain higher capacity at the same Five-Nines availability, as well as lower TCO.
In other cases, a microwave path can be coordinated to use extra high power radios running in the 11 GHz band to substitute for typical power radios running in the 6 GHz range. For example, for a North America microwave path of around 19.31 km long using a typical power radio (29.5 dBm) and a 6-foot antenna, switching to an extra high power radio (34.5 dBm) will boost capacity by roughly 7 percent per channel while also using a smaller 4-foot antenna and maintaining overall link availability at 99.999 percent.

This is a great option for dense urban sites that already host many 6 GHz radios and cannot accommodate another one. But an extra high power radio in the 11 GHz band can be deployed without interfering with any of the current radios while running wider channels.

DELIVERING THE SOLUTION: THE AVIAT IRU 600 EHP

The most recent Aviat Networks microwave radio for the North America market, the Eclipse IRU 600 EHP has the highest system gain across all QAM modulation schemes at 39dBm, as measured at the RFU interface. This is five times more output power than is available in standard high power radios.

With the highest transmitter output power of any microwave radio on the market network designers can have the peace of mind to be able to design microwave links with smaller antennas, longer paths and higher capacity. Because these elements of a microwave link are also more cost-effective than their direct counterparts, they all have a net positive impact on TCO.

For more on the IRU 600 EHP radio, email marketing@aviatnet.com.

*Typical Tx output at 6GHz, measured at RFU output. Valid for all modulations.

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