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Ericsson Microwave Outlook

Opportunities with antenna innovations

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Opportunities with antenna innovations

Gone are the days when the choice of antenna was limited to what frequency band and which reflector size to use. Driven by advancements in microwave technology, the antenna toolbox has expanded to provide diverse options and possibilities.

Innovations and new requirements are expanding the antenna palette, fueled by increased capacity demand, spectrum scarcity, and denser networks. Selecting the right antenna from the wide range available can yield significant increases in both capacity and spectrum efficiency.

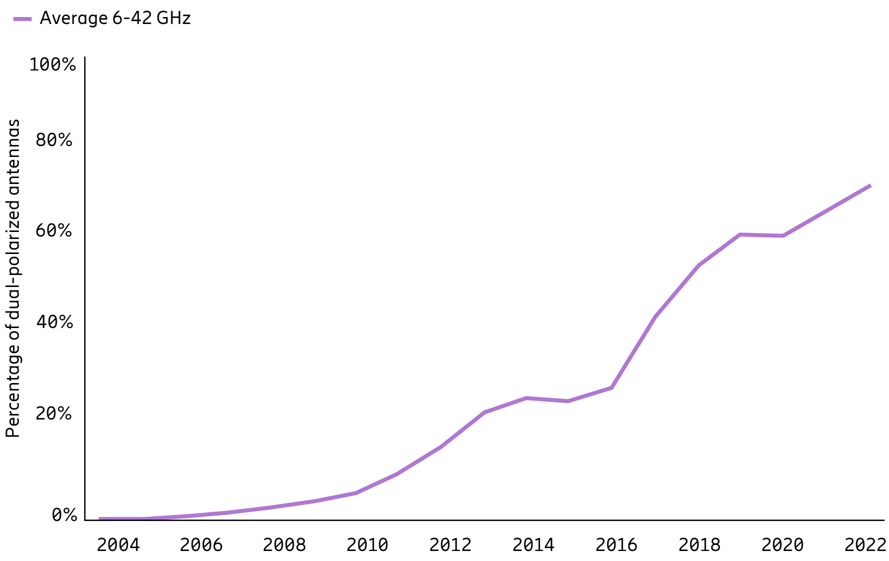
Dual-polarized antennas
Dual-polarized antennas have been around for decades, but with increasing capacity demands and the introduction of Cross Polarization Interference Cancellation (XPIC). Dual-polarized antenna volumes have surged to around 70 percent (see Figure 6). These antennas make it possible to double capacity over a single antenna by combining both polarizations in the same hardware. Most new installations either use XPIC from the start or are at least hardware-prepared for it.

A further doubling of capacity can be achieved by using radios with built-in carrier aggregation, or symmetric power splitters, to combine two radios on one antenna polarization. In combination with dual polarization, four times the capacity can be gained in a 4+0 hop over one antenna.

Class 4 antennas
ETSI Class 4 antennas have been around for about 10 years, but usage is still low in most markets. There is significant untapped potential here for densifying microwave networks and reducing spectrum costs. A class 4 antenna's sidelobes are 10–15 dB lower than class 3, which increases the ability to reuse frequencies in the network.

When using the same number of frequency channels, it is possible to have 40 percent additional links in the same geographical area – and when combined with automatic transmit power control (ATPC), network capacity can even be doubled.

Figure 6: New deployment of dual-polarized antennas



Source: Ericsson 2023

E-band and sway compensation
The introduction of E-band frequencies enables multi-gigabit capacities with compact antennas, of which the most common antennas today are 0.3 m and 0.6 m reflectors. E-band can also be combined with a traditional frequency band in the same multi-band antenna. This reduces weight and space occupied in the mast and combines the best of both worlds in one link: High E-band capacity, with high availability over long distances. Since the emergence of combined E-bands and traditional bands, their numbers have steadily grown and interest in combining two or more traditional bands is increasing.

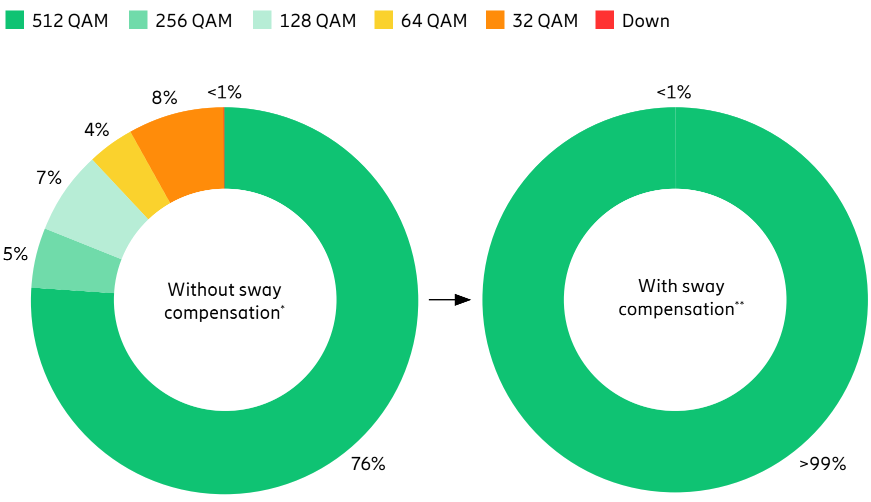
E-band also drives innovation in the antenna domain. Compact high-gain E-band antennas focus the signal into a narrow beam, but with greater focus comes a higher risk of misalignment that puts tougher requirements on the stability of the mounting structure.

Sway profiles can be divided into two groups: a fast variant, which is typically induced by winds, and a slow variant, which finds its origin in non-uniform thermal deformation, also called the sunflower effect. In many cases, the sway is so small that it does not affect the link, but there are masts where this can be an issue.

Mast sway can be neutralized by a sway compensation antenna. This is similar to a conventional reflector antenna with the ability to detect misalignment and adapt the beam direction to keep the highest possible gain pointing towards the far end.

This innovative antenna is a solution to known problems and creates new possibilities. In Figure 7, we can see the benefits of link stabilization. The pie diagrams show the modulation that a 6.7 km E-band link in southern Europe can sustain.

Figure 7: Sway compensation antenna field trial on 28 m monopole



Source: Ericsson 2023

* 3-day period with solar-induced bending
** 1 month with solar-induced bending, rain, wind, multipath

A sway compensation field trial was performed with a 6.7 km E-band hop in southern Europe, near the coast. A link with traffic, with a sway compensation antenna at 28 m height, was monitored.

A 0.6 m sway compensation antenna enables 30 percent longer hops than a 0.3 m regular antenna.

30%

A 0.9 m sway compensation antenna enables 80 percent longer hops than a 0.3 m regular antenna.

80%

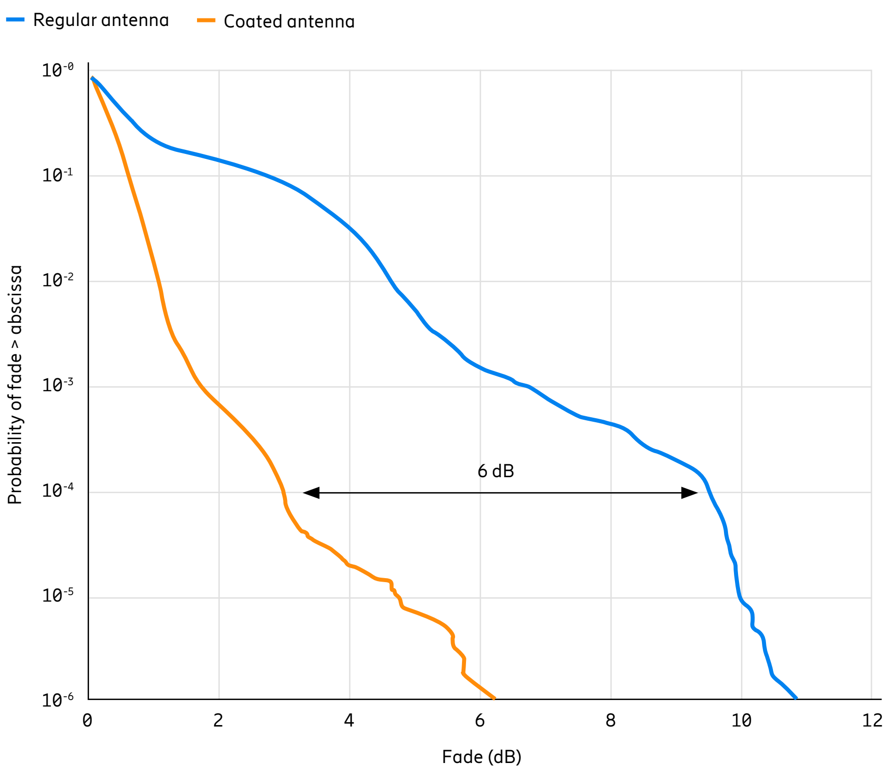
Configuration: 10 Gbps E-band link, 64 QAM, 2 GHz CS, 99.9 percent availability, typical European rain zone.

The link is equipped with a 0.6 m reflector (half-power bandwidth at around 0.5 degrees) mounted at the top of a monopole. When sway compensation is off, the variation of received power throughout the day is too large to keep the highest modulation for about one-quarter of the time. The effect of turning on sway compensation is visible in the diagram on the right, where the adverse effect of sway has disappeared.

In addition to widening deployment options, sway compensation enables even higher antenna gains by extending range or boosting link availability. Let's look at some concrete examples for 10 Gbps E-band links and assume the available infrastructure suffers from sway, and only 0.3 m reflectors, or smaller, can be used. The maximal distance of this link with 99.9 percent availability is 3.8 km. By eliminating sway, a 0.6 m antenna can be used without problem and the maximal link distance becomes 4.9 km, an increase of about 30 percent.

The stabilization algorithms enable use of even larger antennas: A 0.9 m antenna gives a maximal distance of 7 km, which is an 80 percent increase compared to distance achieved by a 0.3 m antenna without sway compensation.

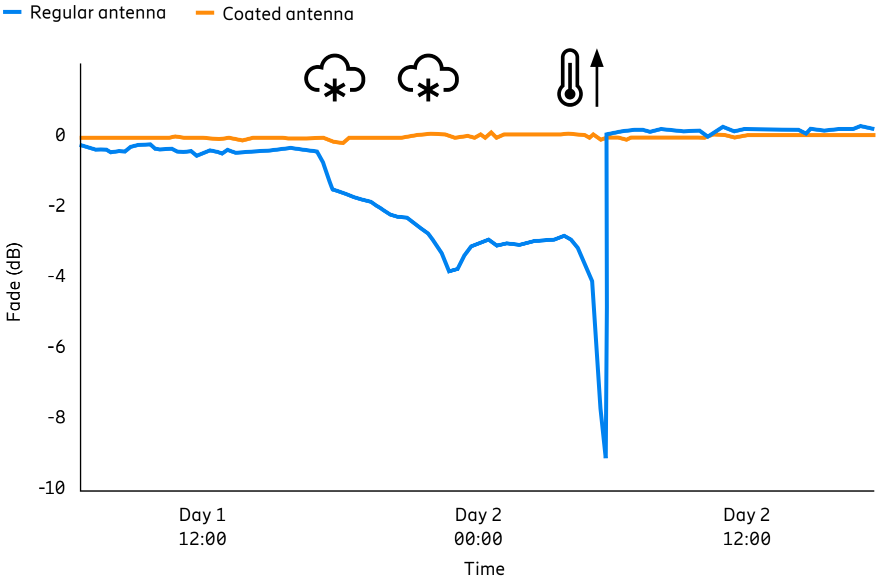
Figure 8: Comparing fading on E-band links with water-repellent coated and non-coated antennas



Source: Ericsson 2023

Statistics collected from December 2021 to June 2022 on a 200 m E-band hop with 2 parallel links, 1 with and 1 without water-repellent radome coating. The water-repellent coating gives up to 6 dB less fading at 10^{-4} level.

Figure 9: Snow fading event — field trial with water-repellent radome coating on E-band links



Source: Ericsson 2023

A snow fading event: The uncoated link is attenuated by 4 dB while the snow is dry, and >9 dB when the snow is wet. The coated link stays unaffected.

Water-repellent radome

Sway is not the only environmental influence on performance. The most common culprit is water. In raindrop form, it is a well-known source of attenuation. There is also the wet-radome effect. This moisture can be water drops, ice, or (melting) snow. Especially during heavy precipitation, the film formed on the radome can eat away dBs in the link budget. This effect is most pronounced at E-band, but also noticeable at lower frequencies. This attenuation can be compensated with higher output power or larger antennas, or accepted by planning for shorter links or lower availability.

Fortunately, water on the radome can be reduced by water-repellent coatings for microwave antennas, which add protection that does not affect radio wave propagation, and can significantly reduce water build-up on antennas.

Figure 10: Snow sliding off the coated radome

Regular antenna

Antenna with water-repellent coated radome

Source: Ericsson 2023

In this figure we see two parallel E-band links, one with a regular antenna and one with an antenna coated with water-repellent material. Wet snow sticks to the uncoated radome, while it slides off the coated one.

The performance benefits can be evaluated by examining two parallel E-band links. Both are equipped with identical reflector antennas, but the radomes of one are treated with a water-repellent material. The short distance, less than 200 m, is well-suited for this analysis since the rain attenuation in the air is negligible and the fading is due to the wet radome alone.

The hydrophobic coating removes water quickly and there is no (or much less) water film build-up. This results in fades of shorter duration that are less pronounced. Figure 8 shows the fading statistics over a multi-month period. The benefit is clear: The probability of all fades, large and small, is reduced significantly.

For microwave link planners, the times of year when the weather is at its worst are the most relevant for predicting availability. At the tail of the curve, we can see that this is where the coating really makes a difference. If we consider the 0.01 percent worst fades (corresponding to the 99.99 percent percentile), we can see the link with water-repellent coating has fades that are 6 dB less than those of the link without special coating.

Snow affects microwave links differently to water, as can be seen in Figure 9. When it is dry, the impact is limited, but wet snow introduces much higher losses, and as it melts the link experiences increasing degradation until suddenly it slides off the antenna and the received power is restored to its nominal level.

In a worst-case scenario, the temperature drops again before the thawed snow slides off, and the wet snow refreezes solid on the antenna. This can cause sustained periods of lower received power and if the blockage is severe it has to be cleared manually from the antenna.

Water-repellent radome coatings prevent this by protecting against water or snow clinging to the antenna's radome and building up a film (shown in the second image in Figure 10). The potential resulting opex savings is evident from a trial in the Nordics where the amount of (cumbersome and costly) site visits to an antenna susceptible to snow and ice blockages dropped to one-third compared to the previous year.

Antennas are now, more than ever, playing a key role in getting the most out of microwave links. The diverse set of antenna options and innovations discussed in this article testify to the positive impacts that conscious choices of antennas can have on capacity, hop length, spectral efficiency, network densification and reduction of opex.

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www.ericsson.com

Ericsson
SE-164 80 Stockholm, Sweden
Telephone +46 10 719 0000
www.ericsson.com

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