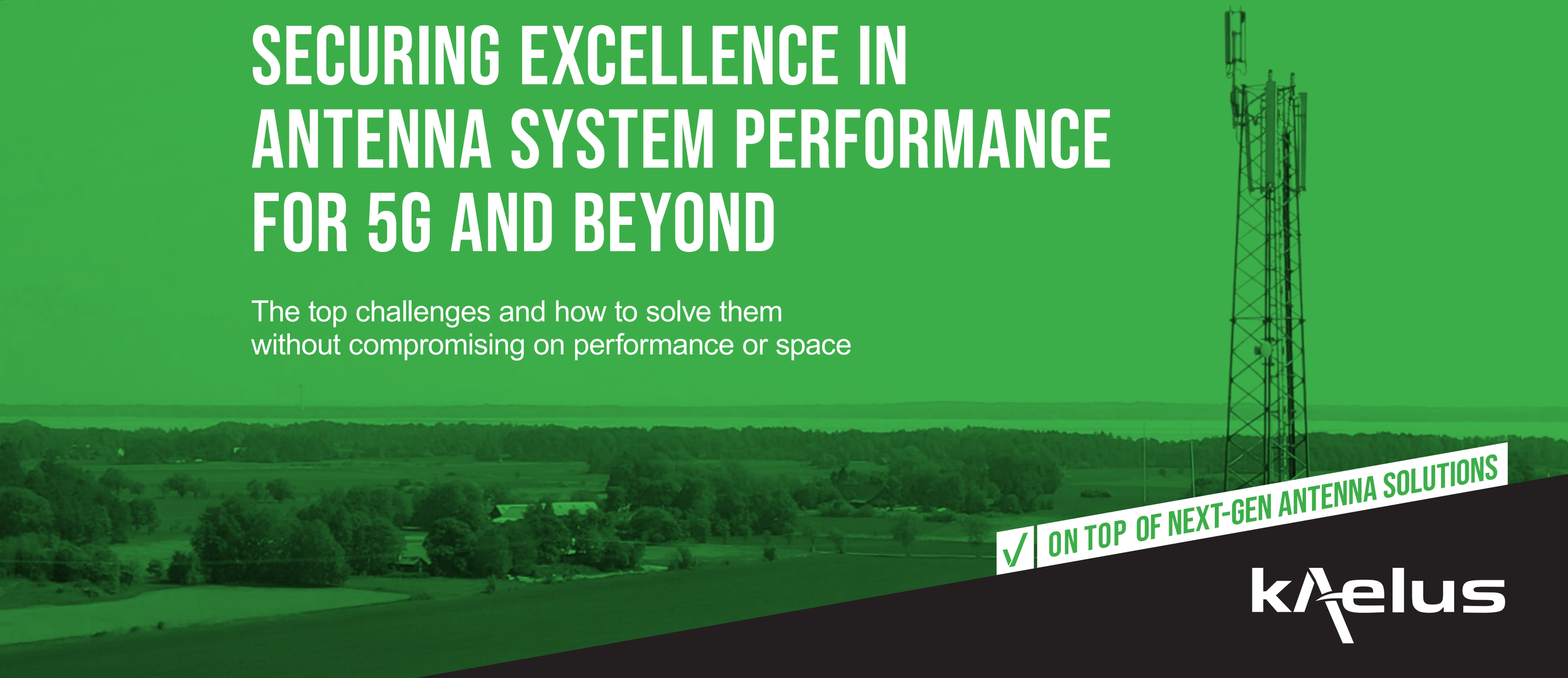
SECURING EXCELLENCE IN ANTENNA SYSTEM PERFORMANCE FOR 5G AND BEYOND

The top challenges and how to solve them
without compromising on performance or space



✓ ON TOP OF NEXT-GEN ANTENNA SOLUTIONS

kAelus

How do we address the more complex world of 5G?

With each previous generation of mobile connectivity, from 2G through 4G, we've seen a steady increase of complexity in the antenna tower architecture. This is a natural result of deploying multiple generations in parallel. It's also because each new generation requires increasingly complex technology to support higher speeds and capacities. With the arrival of 5G, we're challenged to roll out more frequencies, antenna systems and other equipment into our tower tops than ever before.

The stakes are too high to make too much of a compromise on network performance in order to save space and money. Industry and society will increasingly depend on reliable, high-speed connections. As a result, the user experience will be severely affected if connections drop or promised speeds are frequently throttled. PIM, other interference or a weak uplink could all be the root cause.

We're still not sure what all the applications for 5G will be. But we do know one thing for sure – the ability to realize its full potential depends to a great extent on mobile operators and infrastructure providers like you but also on antenna system providers like us. It will be essential for all of us to gain increased knowledge and insights to ensure the best possible mobile network.

Regardless whether you're already in the process of rolling out 5G or still waiting for frequencies to be awarded, preparing to solve the 5G puzzle now is crucial. At Kaelus, we want to share our knowledge about some of the key challenges but also about best practices and insights to help you find the right solution for your unique situation. We hope this guide will give you the knowledge and tools to enable the connected society of tomorrow with cost-effective ways of securing outstanding mobile connectivity.

Top three challenges for 5G antenna system performance

The increase in interference, especially PIM, caused by greater signal complexity has become a major challenge for mobile operators. In turn, PIM and other factors can lead to uplink degradation. This can hold back the downlink and network capacity as a whole. At the same time, finding a cost-effective and space-efficient way of addressing the PIM and uplink challenges is a challenge in and of itself.

1. Increased signal complexity poses new interference challenges

How good are you at hearing someone speaking softly in a crowded and noisy room filled with other people shouting? Chances are you won't catch everything that was said. That's exactly what happens when you have a noisy signal environment in your radio towers.

With the addition of 5G to the mix of existing frequencies, we're entering a far more complex frequency world. This is especially the case considering that 5G demands higher frequencies such as 3.5 GHz. The fact that 5G is also being deployed on a non-standalone (NSA) basis alongside 4G is another contributor to the increase in signal complexity. We also have more equipment closer to or integrated into antennas and are stuffing more frequencies into the same box.

Radio receiver sensitivity has increased with each mobile network generation, and with 5G it is now higher than ever. Passive intermodulation (PIM) can saturate all received bands and make the radio less sensitive. As a result, it becomes more difficult to receive or capture quieter and wanted signals.

All of this means that we have far greater signal complexity and more frequencies in closer proximity to one another. As a result, the risk of interference, especially PIM, is now higher than ever. Your task is to consider what it will take to insulate your network from degradation due to interference.

»You can only effectively serve customers and generate revenue as far as the uplink reaches.«

2. A weak uplink could be the Achilles' heel of your network coverage

As much as the downlink is often prioritized in 5G, it's important not to forget an essential fact: there's no downlink without an uplink. For example, approximately <300kbps in uplink can affect downlink performance. In turn, downlink degradation due to a weak uplink can be caused by PIM in NSA deployments with the uplink on insufficiently strong 4G. The uplink can also severely affect the downlink performance in 3.5 GHz SA mode due to link imbalance and PIM.

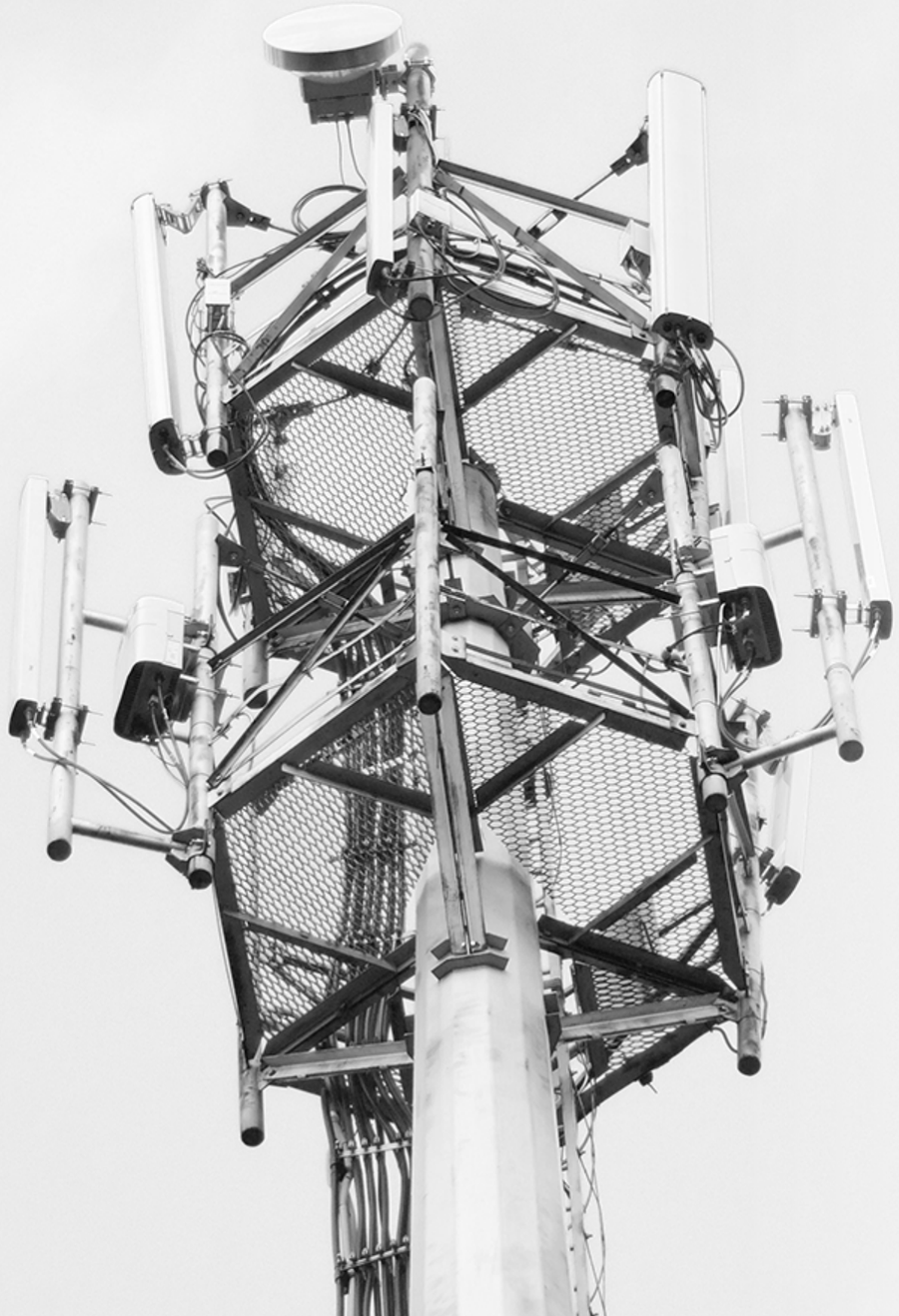
> *A 1dB drop in uplink sensitivity caused by PIM can decrease wireless coverage by up to 11%*
>
> – "Reducing PIM on cell site towers in the 5G era" by Christopher Stockman

One of the most significant signs of an insufficient uplink is to compare uplink and downlink network coverage. This is where we often see that the uplink does not reach as far as the downlink. As a result, you can only effectively serve customers and generate revenue as far as the uplink reaches.

The GSM Association (GSMA)'s 5G Implementation Guidelines demonstrated the weakness of the uplink on 3.5 GHz frequencies:

> *with 50 MB/s in downlink and only 5MB/s in uplink, the uplink coverage was found to already be 16.2 dB shorter, with 64T64R.*

All of this demands new and more effective approaches to uplink amplification as well as excellent PIM performance. Mobile operators have been trying to get amplification as close to the antenna as possible for a long time now to improve the signal. 5G presents new challenges and opportunities for doing that. Your task is to determine the best way to make the most of these opportunities and stay on top of PIM.



3. Overcrowded towers lead to cost inefficiencies

Increased signal complexity also takes up more tower-top space, and that can be problematic for several reasons. One is that tower landlords charge many operators by the number of boxes. This means that costs can increase as you add more boxes to accommodate the needs of 5G. If you aren't careful, your box count can increase rapidly – both to deploy the additional signals and to optimize them.

Tower loading is also a crucial parameter for cost control and avoiding a greater regulatory burden. More boxes result in more weight. But more importantly, multiple antennas can be heavy, and the MIMO antennas used for 5G tend to require large areas. These can also add a significant amount of wind load to the tower.

If you don't plan ahead to keep tower loading under control, you may end up spending large sums to quickly upgrade some equipment. Another symptom of crowded towers is that installations are made more complex, which means they could take longer and cost more. This also increases the likelihood that something could go wrong.

Solving the interference and uplink challenges involves even more equipment, including interference filters and amplifiers. As a result, mobile operators like you are challenged to find smart ways to save space and keep costs under control while further optimizing network performance.

What it will take to secure excellence in antenna system performance

To solve the challenges presented above, you'll need to analyze your individual interference situation. This paves the way for finding tailormade filtering and PIM performance solutions that can withstand the test of time. By improving uplink coverage with adequate amplification, you can increase your revenue generating area. Saving space with truly integrated antenna systems is also good for your bottom line.

How to stay on top of PIM and other interference with tailormade solutions

If you're a 2G-4G operator, you probably have a wide range of existing equipment already up in your towers. If you're a greenfield operator just entering the 5G game, your situation will be completely different. Antenna system setups also differ widely across regions due to differing environmental conditions and regulations. As a result, every interference situation is unique, and there's no one-size-fits-all solution.

It's also crucial to take a long-term perspective because PIM can change over time in short bursts or more lasting shifts. For instance, PIM degradation can be caused by lightning strikes or other adverse weather events. External elements in the landscape like roof construction and scaffolding can cause PIM as well. PIM can also increase or decrease as equipment heats up and gets worn in.

All of this calls for tailormade solutions. For example, interference filtering should be tailored to your individual interference needs. Customizing your antenna system to take into account your regional weather situation will also help prevent PIM degradation. This is one key aspect of antenna systems designed to maintain reliable PIM performance over time. Another is to ensure these systems are easy to install and monitor with PIM test and measurement tools.

Bottom line

Analyze your unique interference situation and don't settle for anything less than tailormade solutions for PIM and interference filtering. Take into account PIM performance changes over time. Find systems with reliable, lasting build quality appropriate for your region's environmental conditions.

PIM best practice:

Commonly seen specifications for antennas are 143 to 153 dBc IM3 levels with two +43dBm (20 Watt) per carrier tones.

How to tactically amplify the uplink and increase the revenue generating area

Plan ahead for amplification needs to ensure a smooth rollout in both urban and non-urban areas. This is crucial for not missing out on the potential of a larger revenue generating area. Will you use carrier aggregation (CA), de-coupling (DC) or supplementary uplink (SUL)? Given that some of these involve running the uplink on a lower 4G band or moving all or part of the uplink to 4G, you'll need to be tactical about how you amplify.

Consider how much uplink is required to support various downlink speeds without causing significant delays:

- 1 Mbps downlink requires minimum 128 kbps in uplink
- 2 Mbps downlink requires minimum 256 kbps in uplink
- +3 Mbps downlink requires minimum 350 kbps in uplink

If the minimum uplinks set out above are not available, the time to content will be set by the slow uplink, not the potential speed of the downlink. In addition to impacting downlink performance, uplink limitations can also degrade the dropped call rate.

Suburban and rural areas are more often neglected, so this is where there is more potential for improving network capacity and the revenue generating area. Tower-Mounted Amplification (TMA) is highly effective for extending the uplink into these areas. It is also well suited for boosting performance, improving speed and adapting to any uplink/downlink frame structure.

Bottom line

Don't neglect uplink coverage. Keep track of how much your uplink needs to be amplified to maintain your target downlink speed. Use TMA to extend the uplink beyond urban areas as far as the downlink and increase the revenue generating area.

Amplification best practice:

TMAs in TDD networks typically improve the system receiver noise figure by 2 dB (+cable losses), resulting in increased downlink throughput and decreased delays in time to content.

How to create a business case for 5G antenna system performance excellence

You've probably already been doing some consolidation and integration to the extent possible. But a truly integrated antenna system takes this to the next level. This involves packing uplink amplification and interference filtering with excellent PIM performance into antenna systems supporting all generations from 2G to 5G. As a result, you gain the flexibility and cost efficiency needed to reduce tower loading and the box count so that costs can be kept under control.

Business case checklist for next-gen integrated antenna systems

Use this checklist as inspiration to calculate how much you can benefit from truly integrated antenna systems.

Revenue generating area

- ✓ How much can you increase revenue generating areas with TMA?
- ✓ How much additional revenue will this lead to compared with the cost of TMAs?
- ! On average, the revenue generating area can be increased by 53% with TMA

Tower loading costs

- ✓ How much are you paying per box?
- ✓ How much could you reduce your box count with integrated solutions?
- ✓ How much do your tower tops weigh and how much do you pay per kg?
- ✓ How much would a 10% decrease in your tower loading costs be compared with the cost of implementing truly integrated antenna systems?
- ! Top-class integrated antenna systems weigh about 10% less than the industry average

Performance benefits

- ✓ Estimate how much you can improve 5G network performance in terms of downlink and uplink speeds using TMA, adequate interference filtering and superior long-term PIM performance.
- ✓ Estimate the correlation of network performance improvements with new customer contracts and customer retention.
- ✓ Calculate how much your estimated network performance improvement would increase your revenue.

Key learnings for enabling the connected society of tomorrow

We hope you now have a better grasp of why 5G poses new challenges and how to address them. Let's recap the key learnings from this guide:

- More frequencies, higher channels and more equipment can cause more PIM and other interference than before
- A weak uplink can hold back the downlink
- Tailormade solutions built to last are essential for interference filtering and PIM
- TMA is an effective means of amplifying the uplink and increasing the revenue generating area
- Truly integrated antenna systems can both decrease tower loading costs and increase network performance

All of this will help you more successfully deploy 5G and future mobile network generations. The connected society of tomorrow is in your hands, and now you should have more knowledge and tools to make it a reality.

ON TOP

Kaelus – on top of next-gen antenna systems

At Kaelus, our vision is to set a new standard of excellence in antenna system performance for 5G and beyond, empowering the connected society of tomorrow. We enable mobile operators like you to deliver outstanding mobile connectivity across the globe. Backed by excellent PIM performance, our next-generation complete antenna system solutions are tailored to operator needs.

All under one roof, we design and manufacture top RF conditioning, antenna technology and PIM test equipment, integrating and optimizing them together. They are also custom designed to meet specific frequency needs and real-world environmental requirements while saving space and reducing box count.

As a result, you no longer have to choose between excellent network performance and reduced tower loading. With Kaelus, you can have your cake and eat it too.

Discuss your unique needs with a Kaelus tower-top expert for tailormade solutions that are future-proof and cost-effective.

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