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White paper

Time to raise the bar on base station antennas

Evolving technology drives adoption of recommended standards

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Executive summary

In February 2013, a committee representing base station antenna manufacturers and mobile operators completed work on a comprehensive set of recommended standards for base station antennas. Approved by the Next Generation Mobile Network (NGMN) Alliance, these recommended base station antenna standards represent a significant step forward for the wireless industry. As more antenna manufacturers embrace the standards, it will help wireless providers make more informed, accurate and cost-effective decisions regarding base station antennas and ultimately lead to improved network performance, growth and profitability.

This paper provides an overview of the development and content of the BASTA standards and explores ways in which they will benefit those involved in network design, maintenance and management. It also suggests steps wireless network providers can take in working with antenna manufacturers to accelerate the implementation of the recommended standards.

The need for standardization

The performance of a base station antenna is a key factor in the overall performance and quality of the cellular communication link. Over time, base station antennas have grown significantly more capable and complex. As antenna configurations become increasingly intricate and performance characteristics multiply, comparing antennas becomes more difficult.

The first generation of base station antennas consisted mainly of vertically polarized omnidirectional antennas whose RF performance could be characterized by basic variables such as frequency range, gain and circularity. Soon after, antenna manufacturers began to incorporate improvements, including fixed electrical tilt and sectorization. As a result, characteristics such as front-to-back ratio and 3 dB azimuth beamwidth became important when comparing products. Adding cross-polarization increased the number of performance variables, and this aspect was multiplied when variable electrical tilt was introduced to the mix.

Historically, the wireless industry has suffered from a lack of commonly defined and accepted standards regarding how base station antenna specifications are measured and presented. An antenna's physical properties, RF performance measurements, and even the meaning of common terms such as "gain" can vary depending on the manufacturer. For the wireless provider, it is difficult to know how a specific antenna will perform within its specific network, let alone choose which antenna might provide the best fit.

Today, RF performance is just one of several facets of an antenna that network operators must consider during planning and purchasing. A variety of environmental characteristics, testing protocols and manufacturing processes must also be considered and, somehow, fairly compared. The difficulty for wireless providers, however, is being able to make meaningful side-by-side comparisons between antennas.

The wireless operators recognized the issue, as can be seen in this quote from the NGMN Alliance, an operator-driven organization providing direction and guidance to the vendor and standards communities.

NGMN committee develops recommended standards

In June 2010, under the auspices of the NGMN Alliance, a committee representing base station antenna manufacturers and mobile operators came together to discuss the development of a set of recommended standards to help guide the industry. The project became known as the base station antenna standards working group (BASTA) and was co-chaired by representatives from CommScope and Telecom Italia. Other companies represented on the committee included Deutsche Telekom, Kathrein, Powerwave, RFS, and Huawei. The objective was to develop globally accepted terminology, definitions and measurements that would apply to all base station antennas, making it easier for wireless network operators to evaluate, compare and select the best antenna for their specific needs.

In February 2013, the working group released a paper titled, Recommendation on Base Station Antenna Standards[1], which was approved and endorsed by the NGMN Alliance. The paper addresses the performance criteria of base station antennas (BSAs) by making recommendations on standards for electrical and mechanical parameters, and by providing guidance on measurement practices in performance validation and production. It also addresses recommendations on applying existing environmental and reliability standards to BSAs.

"Currently, ambiguities in antenna specifications resulting from a lack of standards make it difficult for today's RF engineering departments and supply chain managers to competently compare antenna products. Miscommunication during the procurement process on specification definitions and compliance to them is likely commonplace."

—NGMN press release, February 20, 2013

These recommendations cover a wide range of topics, including:

- Antenna terms and definitions
- RF specifications: general and optional
- RF parameters: validation and specifications
- Mechanical parameters and specifications
- Environmental standards
- Reliability standards
- Pattern and gain measurements
- Electrical testing during production
- Labeling

In all, the recommendations cover 127 topics and subtopics and span 115 pages. Each recommended standard was developed using a scientific approach that applies statistical methodology in order to calculate and validate the recommended specification. As a result, the standards enable wireless providers to evaluate and compare antennas based on well-defined statistical methods.

As the NGMN represents most of the major global wireless operators—and most of the major BSA vendors participated on the BASTA committee—the BASTA recommendations can be viewed as an industry consensus on how BSAs should be represented from a supply chain and engineering perspective.

"The NGMN Alliance recommendations are the first comprehensive, global set of guidelines and principles focusing on the base station antenna, and are supported by major base station antenna manufacturers as well as the world's leading MNOs."

—NGMN press release, February 20, 2013

Standards reflect a customer-centric approach

As can be seen in a wide variety of technology sectors, the introduction and acceptance of global standards can be expected to have significant positive effects for wireless service providers. Specifically within the telecommunications sector, adherence to BSA standards can drive quality and performance improvements, streamline purchasing and improve overall network coverage, capacity and quality of service (QoS).

Issues

- Wireless engineers and supply chain managers cannot accurately compare BSAs from different vendor
- Inconsistent representation of antenna performance spc ifications
- No standard analysis procedure for calculating antenna specifications from measured data
- Lack of consensus about which specs are critical and how they relate to network performance
- No common approach to how frequency, gain, and pattern data are represented in the radio planning files used to design cellular networks
- No consistency on how vendors perform environmental reliability testing to validate their products
- Pattern and gain measurement techniques can vary from vendor to vendor
- The RFQ process is cumbersome due to each vendor having its own version of antenna specification sheets

Benefits

- Enables precise comparison between antenna products by clearly defining the parameters used to specify antenna performance
- Applies "best-practice" statistical analysis to the calculation of antenna specifications
- Provides guidance on:
  - Why individual specifications are important for network performance
  - How radio planning file data is based on manufacturers' antenna measurements
  - How vendors should apply ETSI environmental testing standards to BSAs
  - Best-practice antenna measurements
  - Simplifies the RFQ process by providing a format for an "electronic" specification sheet

The beneficiaries of these improvements will clearly be those responsible for designing, deploying, and managing wireless networks. For them, the wide-scale implementation of the BASTA standards could translate into improvements in everything from network design and implementation to RF performance and system growth. The following are just a few of the areas in which the standards can have a significant impact.

Purchasing

Most notably, standardizing base station antenna testing and specifications would enable operators to make accurate, head-to-head comparisons between competing antennas. Currently, in order to accurately compare features and specifications, operators must translate specifications using different units of measure into a common term.

In some cases, the specifications being measured are so dissimilar that accurately comparing these is impossible. Should the operator be able to approximate a comparison, the process adds time and expense to the selection process. Adopting a common language to define and measure specifications would also enable the operator to better assess and compare the cost-effectiveness of different antenna products, leading to higher per-unit value.

Network performance

Industry-wide adoption of the BASTA recommendations would also set expectations for a minimum level of antenna performance. The telecommunications market has been plagued in recent years by poorly engineered, low-priced products that are promoted to have performance specifications as good as expertly designed and expertly manufactured industry-leading solutions. The specifications, however, are often based on obscure measurements that mask the antenna's true performance.

In terms of quality assurance, antennas that meet the BASTA recommended specifications would be similar to electronic products bearing the IEC or UL certifications. There is far greater chance that operators can predict how the antenna will perform within their system. In cases where antennas far exceed certain specifications, operators can more easily differentiate meaningful product performance.

Planning and growth

A common language of antenna specifications, as defined by the recommended standards, better enables operators to assess various resources available to support potential growth strategies. For example, operators looking to overlay LTE as part of their network modernization program would be able to focus on antennas with excellent signal-to-noise ratio (SNR). At the same time, accepted antenna specifications would also make it easier for manufacturers of other components—such as remote radio units (RRUs) and baseband units (BBUs)—to create more dependable technology roadmaps.

Leveling the playing field: two examples

One of the key improvements the BASTA standards make is standardizing how performance values are measured and defined. The following two examples demonstrate how performance characteristics can vary depending on the manufacturer and, in some cases, alter the way specifications are presented. The potential confusion not only impacts the purchasing process but can affect network planning and modernization, system upgrades and key performance indicators, including quality of service.

Gain

Antenna gain is a relative measurement that compares the gain of the specified antenna to that of a theoretical antenna, either isotropic or dipole. If the maximum gain is given in dBi or dBd, it is clear which theoretical antenna is used. If the measurement is simply given as dB, there is no way to know which reference antenna was used. In addition, BSA manufacturers can list either their maximum (or near maximum) gain, the default industry standard, or their minimum gain—that is, the lowest gain measured during design validation.

Few, if any, vendors regularly base their specifications on minimum gain, as it would characterize the overall antenna performance too conservatively. Likewise, using maximum gain to design a network could lead to poor-quality service, as it does not reflect the typical performance of the antenna. The BASTA standard applies engineering best practices to measuring, calculating, and applying the critical antenna gain specification. As illustrated in Figure 1, the recommended BASTA standards are precise and comprehensive in how gain is to be defined and measured.

3.2.3 Gain

Parameter definition

Antenna gain is a measure of input power concentration in the main beam direction as a ratio relative to an isotropic antenna source. It is determined as the ratio of the maximum power density in the main beam peak direction, at a defined input power, compared to the power density of a lossless isotropic radiator with the same input power. It is defined in the farfield of the antenna.

Specification definition

- The gain is a mean value
- The gain is specified in dBi
- Gain is specified as a mean value for the specific low, mid, and high downtilt angles of the specified tilt range for each sub-band.
- In addition, the "over all tilts" gain is specified as a mean value plus a tolerance of +/- 1.5 standard deviations for each sub-band. All tilt angles are included in the calculation (in measurement intervals of 1 degree).
- Gain validation is statistically determined and the recommended methodology is described in Section 4.5
- The gain specification is based on the mean value as measured on all relevant ports, over the specified frequency ranges, and at the specified tilt settings. Sub-bands of the full frequency range of a broadband antenna must be specified.
- The standard frequencies of gain data points averaged will include all the low, mid, and high common frequencies in the Tx/Rx bands within the band, or sub-band, over which the gain is specified
- The repeatability margin associated with a specified mean gain is that the value measured on all samples, at all times, on all calibrated test ranges shall not be more than 0.8 dB lower than the specified value
- A discussion of the measurement accuracy that can be expected when measuring gain on a farfield range is discussed in Section 8.5
- A discussion of measurement guidelines when measuring gain is discussed in Section 8.2

Figure 1: The recommended BASTA standard for gain is given. Source: Recommendation on Base Station Antenna Standards; NGMN Alliance; January 2013

Front-to-back ratio (F/B)

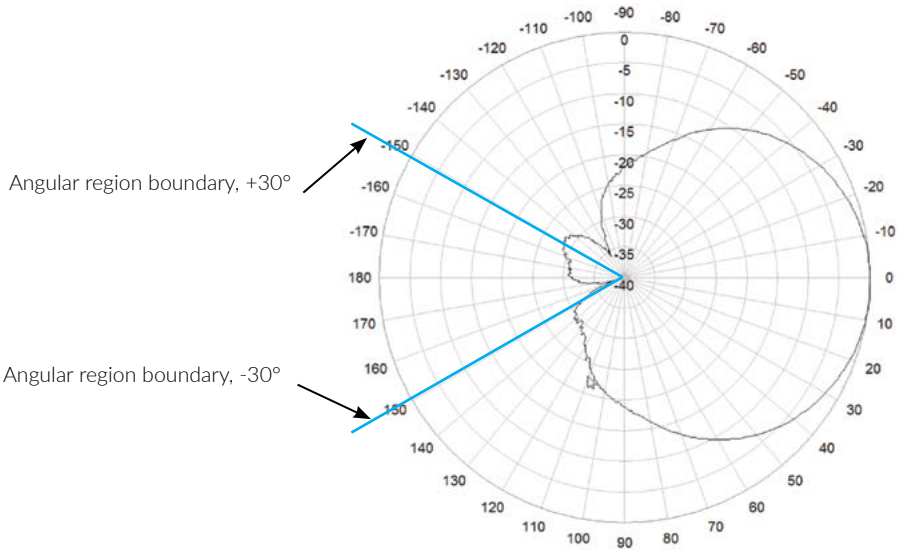
As with gain, the antenna's front-to-back ratio will vary with frequency and tilt and can be measured in various ways. For example, one definition of F/B measures the difference in the radiated power level between the beam peak maximum and a bearing 180 degrees opposite. This definition is the industry's default standard, but is not the only one used by manufacturers or wireless providers. In fact, there are at least eight definitions used to calculate F/B from antenna beam pattern measurements.

Figure 2 shows how the BASTA recommendations would eliminate the F/B confusion by standardizing the measure of front-to-back ratio as the total (co-polar and cross-polar) power over 180 degrees (±30) across all possible tilts and frequencies. The BASTA working group determined that this F/B definition provided the most meaningful information to engineers designing cellular networks.

3.2.13 Front-to-back (F/B) ratio, total power, +/- 30 degrees

Parameter definition

The front-to-back ratio, total power, +/- 30 degrees, is defined as the ratio of power gain between the beam peak and rear ±30 degree angular region of the azimuth cut, using the backward (180 degree) direction as the reference.



Specification definition

- F/B is a minimum value in dB
- It is subject to a statistical validation for a single-sided parameter
- This parameter is to be defined for the nominal sub-bands in a broadband antenna. Unless otherwise noted it will be assumed the specification is for the full electrical downtilt range, and for all the ports associated with each frequency sub-band of the antenna.
- Section 2.5 addresses the total power radiation pattern

Figure 2: By standardizing the measure of front-to-back ratio, the BASTA standard eliminates F/B confusion.
Source: Recommendation on Base Station Antenna Standards; NGMN Alliance; January 2013

The catalyst for adoption—operators are the key

Currently, the BASTA standards exist as a set of nonbinding suggested guidelines for antenna manufacturers. In order to deliver the benefits such as those outlined above, the recommended standards must be adopted and implemented by antenna manufacturers on a wide scale. This will require manufacturers to make changes throughout their organizations—from product development and testing to reformatting and publishing performance data.

With the exception of those operators and manufacturers, like CommScope, who were heavily involved in developing the recommendations, some manufacturers may need to be incentivized to institute the necessary internal changes. That incentive will come from operators looking to streamline the planning and purchasing process, improve the quality and consistency of their network performance, and ensure the greatest value for their BSAs.

There are several ways wireless network operators can facilitate and accelerate the adoption and implementation of the BASTA standards. The easiest and most immediate way to elevate this issue is for wireless carriers to begin requesting manufacturers to submit only BASTA-compliant specifications in response to requests for quotes (RFQs). This will drive antenna manufacturers to align their processes and testing protocols to follow BASTA-recommended guidelines.

Additionally, wireless operators have an opportunity to stress the importance of the standards during the initial stages of the network design and antenna evaluation process. Raising the issue during meetings or correspondence with the antenna manufacturer lets them know that adherence to BASTA recommendations is an important part of a successful partnership.

The industry needs BASTA adoption to grow

For the wireless operator—whether building a new cellular network or upgrading an existing site—selecting the right antenna is crucial in terms of network performance and profitability. As the industry evolves and advances, the job of evaluating and comparing the growing number of BSAs becomes increasingly more challenging. The inability to distinguish a well-engineered antenna from a poorly-produced, low-cost alternative will become more common and more costly.

BASTA-recommended guidelines are designed to reduce the confusion and complexity of antenna selection by enabling wireless operators to make an “apples-to-apples” comparison. Industry-wide adoption of the standards can improve everything from the purchasing process to network performance and profitability.

Ultimately, adoption and implementation of the BASTA guidelines is up to the antenna manufacturers, with each having to determine how quickly and to what extent they will participate. However, wireless operators can play a significant role in determining whether wide-scale implementation of BASTA begins in the very near future or years down the road.

End notes

[1] Recommendation on Base Station Antenna Standards; NGMN Alliance; January 2013.

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