Antenna Beam Efficiency in Urban 4G/5G Networks

In interference-limited urban environments, beam efficiency can measurably improve low/mid-band FDD system performance.

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A robust predictor of performance

Antenna efficiency has a direct, measurable impact on how users experience mobile services (throughput, coverage, uplink performance, etc.) and on network performance metrics such as energy consumption and system capacity. The radiated efficiency and beam efficiency of an antenna system are the result of R&D investment, engineering choices, and advanced manufacturing techniques. High efficiency signals high quality engineering.

In dense urban environments with short inter-site distances, low- and mid-band FDD spectrum is deployed to deliver effective indoor and outdoor coverage; however, density often creates interference-limited networks. In these scenarios, antennas with high beam efficiency can focus energy on the parts of the cell where it is most needed to improve the signal to interference and noise ratio (SINR).

Omdia has identified two key ways to think about antenna beam efficiency when planning and operating dense urban networks, as follows:

- **Improved beam efficiency delivers the biggest gains to cell edge users—the customers that need it most.** Based on Ericsson simulations, a 10% improvement in beam efficiency delivers an approximately 20% increase to downlink and uplink throughput for 5th percentile users, such as indoor customers or those at the edge of coverage. Significant gains are also achieved for 50th percentile mid-cell users (a throughput increase of approximately 12%).
- **Digital twins and simulations are fundamental to RAN design/optimization and are proven to be reliable. Nevertheless, to verify antenna performance, operators can run field trials in real-world scenarios.** Like-for-like antenna trials are relatively low cost and provide valuable field data to scale and optimize post-trial deployment. To isolate antenna performance, operators should retain all site configurations, including RAN optimization parameters, radios, cables, connectors, and other relevant components.

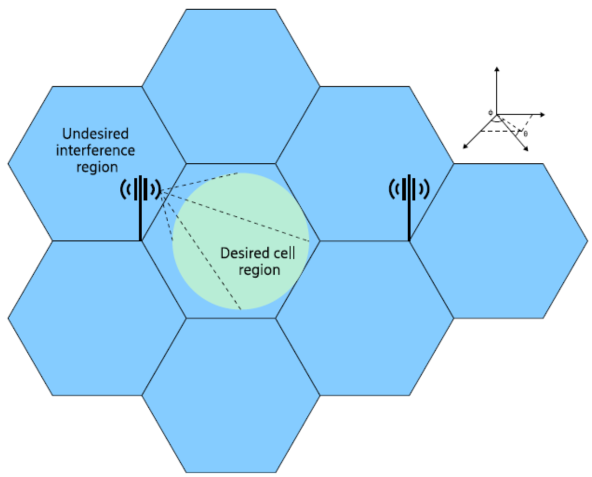
Focus energy on user demand

Radiation efficiency is the percentage of the power provided to the antenna port that is radiated versus lost as heat in conductors and dielectric materials. A radiation efficiency of 85% therefore means that 15% of the transmitted energy is dissipated.

Beam efficiency is the percentage of the total transmitted power that is radiated in the main beam. In a mobile network, this refers to the power directed to the intended cell area (**Figure 1**).

A beam efficiency of 80%, for example, means that 20% of the energy is either wasted into the sky (radiated below the antenna, creating electromagnetic field challenges) or worse, leaked into neighboring cells and causing interference.

Figure 1: Beam efficiency in a three-sector cell grid



Source: Ericsson

The gains from greater beam efficiency can be substantial. **Table 1** simulates the relative throughput gains from an 11% improvement in beam efficiency, normalized to 200Mbps data transfer, across different user distributions.

Table 1: Relative throughput gain for different user distributions

	Downlink	Uplink
Beam efficiency improvement	11%	11%
Cell edge user (5th percentile)	18%	21%
Median user (50th percentile)	**13%**	**12%**
Best user (95th percentile)	11%	6%

Source: Ericsson

Conclusions

In high density urban networks, beam efficiency is a robust predictor of network performance and user experience. For operators focused on upgrading FDD systems to support strong 5G standalone (SA) networks and the evolution to 5G Advanced, a focus on maximizing performance at the antenna will generate measurable gains in service quality. Such a focus will also improve the ability of the rest of the RF chain and wider network to serve customers.

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