OPTIMIZED ANTENNA RADIATION PATTERNS REDUCE OVERALL NETWORK INTERFERENCE

A study using Mentum Planet network planning software

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About Mentum

Mentum provides industry-leading software and service solutions enabling wireless operators, equipment vendors and consultants to efficiently plan, manage and optimize wireless access and backhaul networks, plan coverage expansions and launch new broadband wireless networks. Its advanced software solutions, including Mentum Planet, Mentum Ellipse, Mentum Fusion, Mentum CellPlanner, Mentum LinkPlanner along with Mentum Geodata, enable network operators and engineers to maximize their design potential. Through the company's global presence and focused business approach, it helps more than 375 customers in 120 countries define their wireless networks. Mentum is headquartered in Paris, with offices in Dallas, Ottawa, Hong Kong, Stockholm and Tokyo. For more information, please go to http://www.mentum.com

About Alpha Wireless

Alpha Wireless design and supply high performance base station antennas for 4G applications - LTE and WiMAX. Using patented technology its antennas minimise network interference, while maintaining a competitive price. Customers include Samsung, Alvarion, Airspan, Juni and Clearwire. For more information, please go to http://www.alphaantennas.com/

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Introduction

Mobile network users always look for the best quality of service (QoS). The QoS depends on many factors such as the technology, the coverage, the capacity of the mobile network, etc. Interference is a factor as important as coverage because while there is less interference, there is better QoS.

The traditional antennas for the mobile networks generate interferences but the intensity of these interferences depends on its radiation pattern. The choice of suitable antennas is important to provide good QoS.

Mentum Planet™ tool support advanced antennas (E.g. Multi-beam antennas, Quad-pole antennas, multi-sector configurations) and offer a good representation of physical antennas (E.g. modelling of antenna ports, e-controllers, etc.). This tool has the available Antenna Editors, and lets you organize, view, and manage all elements of the antenna system.

Network Interference

Interference is anything which interferes with the integrity of a signal travelling between a transmitter and a receiver. In cellular networks, this can often be caused by frequency reuse that is the practice of reusing bandwidth across the network. Therefore stray radiation from one cell, can disrupt transmission in other nearby cells using the same frequency. This becomes even more pertinent in LTE networks where a frequency reuse of one is quite common.

Voice is more forgiving than data. But, data corrupted due to interference may have to be re-transmitted, and this puts additional pressure on the network. Figure 1 shows the growth in data traffic from 2010-2015, and a 26X increase is predicted. This will put severe strain on networks, so reducing interference so that capacity is not wasted, will become more important.
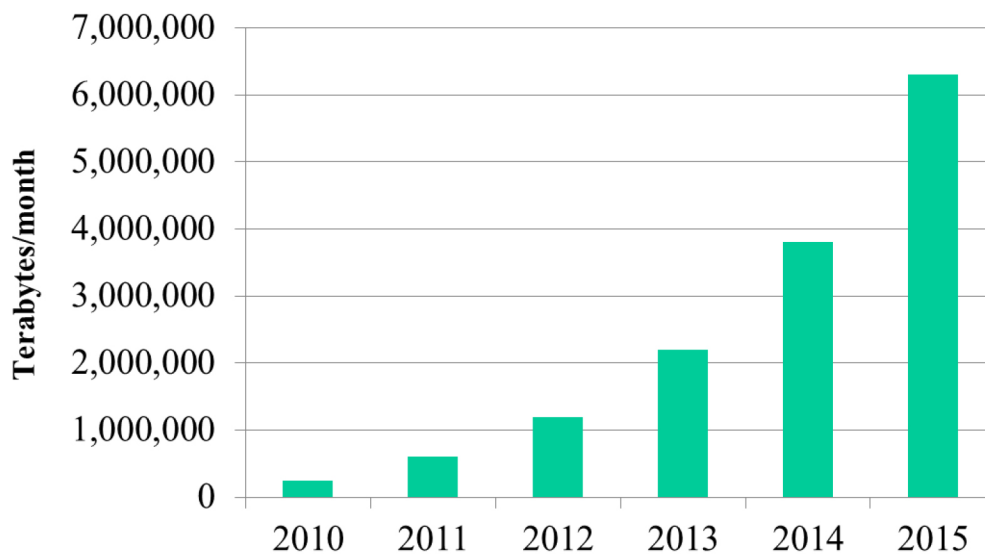

Fig 1: Global mobile data traffic will increase 26X from 2010 to 2015.

(Source: Cisco Visual Networking Index; Global Data Traffic Forecast 2010-2015)

Antennas and Interference

Badly designed base station antennas are one source of interference.

An antenna radiation pattern describes how an antenna emits radiation. Figure 2 shows an example. Traditionally, the antenna radiation description is represented by a horizontal and vertical cross-section of this 3D pattern. Figure 3 shows a horizontal cross section (azimuth) in black, and a vertical cross section (elevation) in red.

In addition to the main antenna beam (lobe), the antenna creates some unwanted radiation, in the form of upper sidelobes, lower sidelobes and backlobes. The upper sidelobes are the main source of network interference, and their effect is the main emphasis of this study. One objective of good antenna design is to suppress all upper sidelobes to at least 18dB below peak. Figure 4 shows an example of good and bad upper sidelobe suppression.
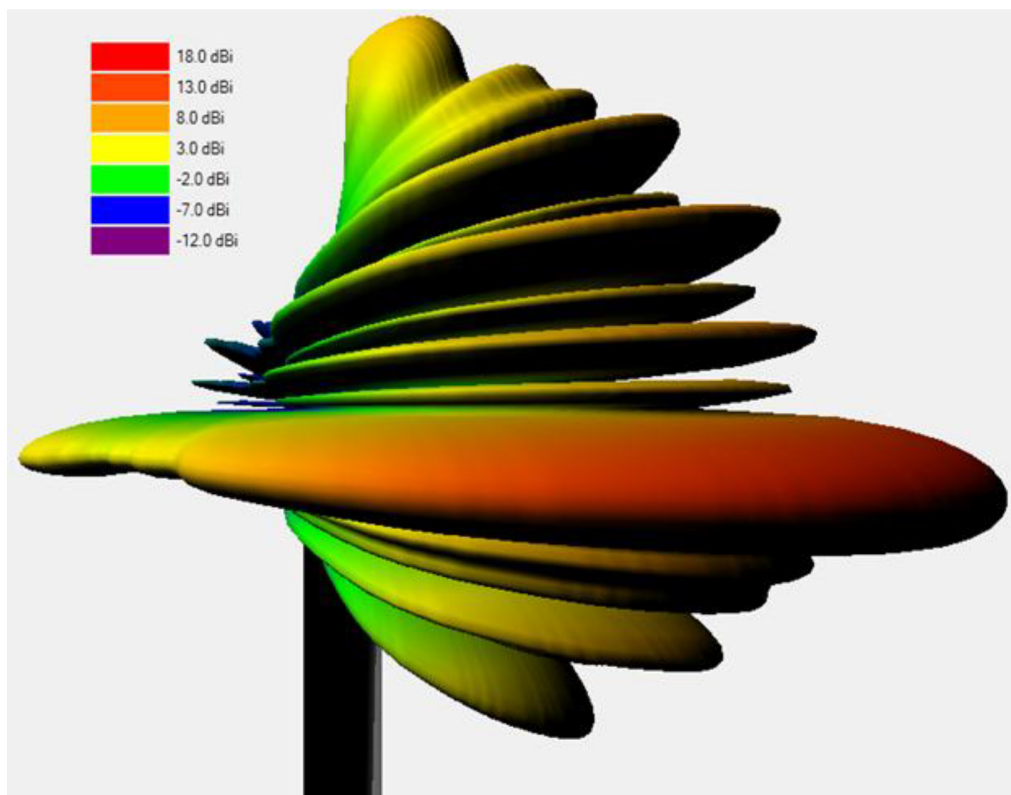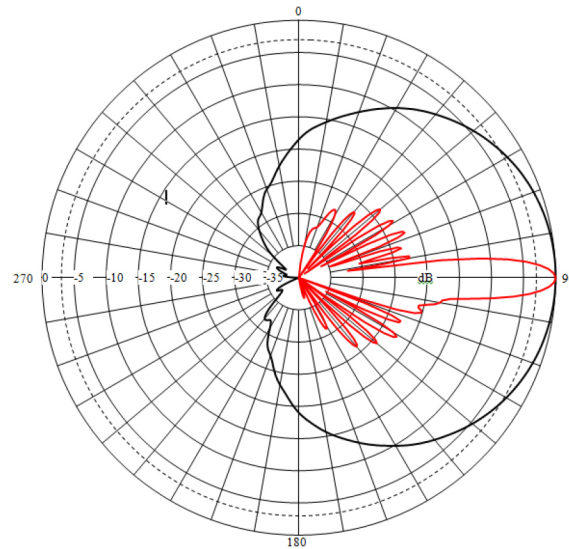

Fig. 2: Antenna Pattern (3D)
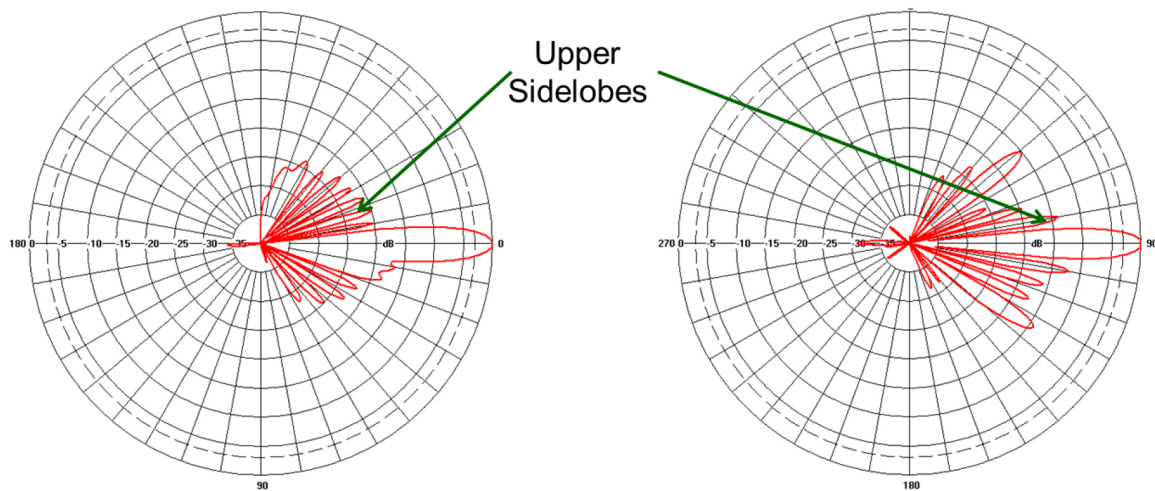
Fig. 3: Azimuth and Elevation Patterns

Fig. 4: Upper Sidelobes – Optimized versus non-optimized antennas

How do upper sidelobes contribute to interference? Figure 5 illustrates the problem. The main beam (shown in yellow) defines the cell boundary. Adjusting the downtilt of the antenna increases or decreases the cell boundary. The unwanted upper sidelobes (shown in green) are a known source of interference in cellular networks. When the antenna has no downtilt (main beam pointing at boresight) the upper side-lobes travel upwards and there is little chance of interference. However, when downtilt is applied to the

antenna these unwanted upper sidelobes can now be directed towards neighbouring cells which causes interference if the same frequency is being used.
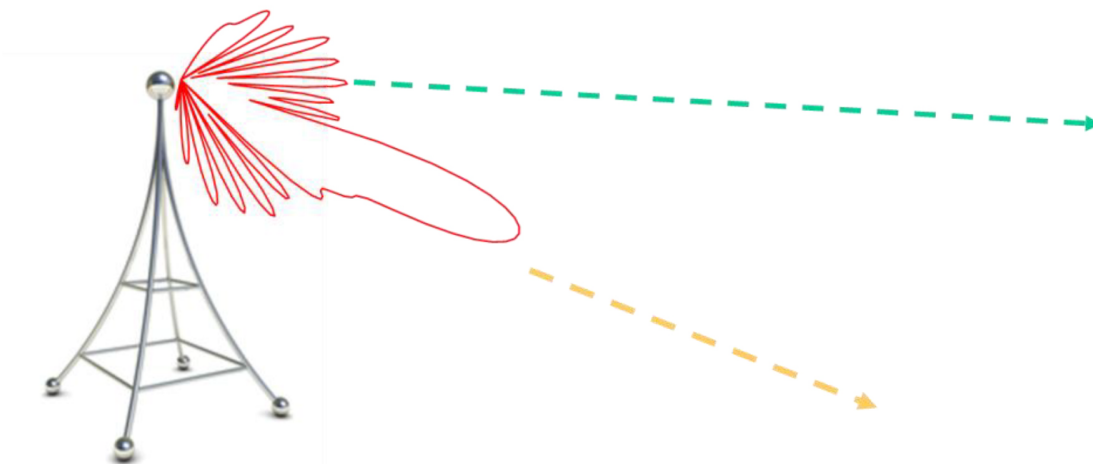

Fig. 5: Effect of Upper Sidelobes

Using Mentum Planet to measure the effects of upper sidelobes

Mentum Planet is a popular planning and optimization software tool for wireless access networks.

The objective of this study is to analyze, using Mentum Planet, the effects on a network of using antennas with optimized radiation patterns versus using antennas with non-optimized radiation patterns. Alpha Wireless antennas will be used for the former, and a radiation pattern from a more typical antenna (i.e. non-optimized) will be used for the latter.

Project Set-up

The city of Paris was used as an example of a high density network. Both the downtown and suburban areas were analysed. Figure 6 shows a summary of the study area.
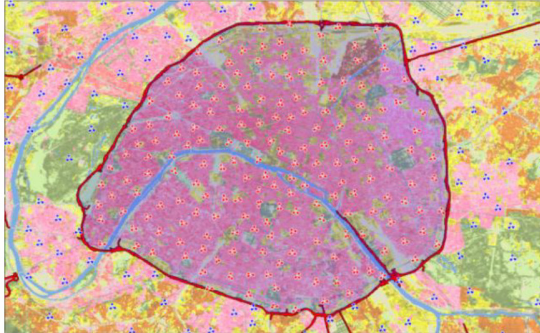
Downtown Paris

84.9km^2 – 183 sites

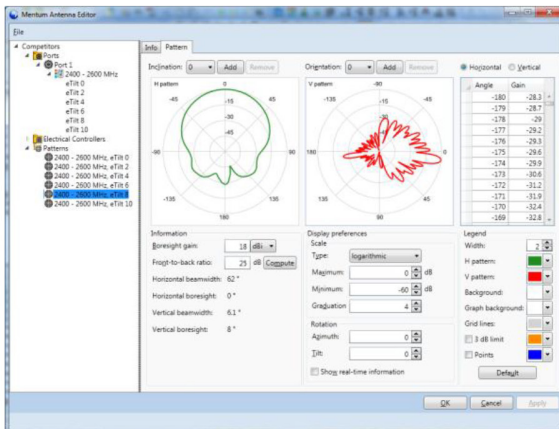*Inter-site distance – 0.5-.7km*

Suburban Paris

1688 km^2 – 625 sites

Inter-site distance – 1-4km

Fig. 6: Study Network

Figure 7 shows the antenna patterns used. Two scenarios were explored using the software. The first with all non-optimised antennas (typical), the second with all optimised parts (Alpha Wireless).

Non-optimized antenna pattern used

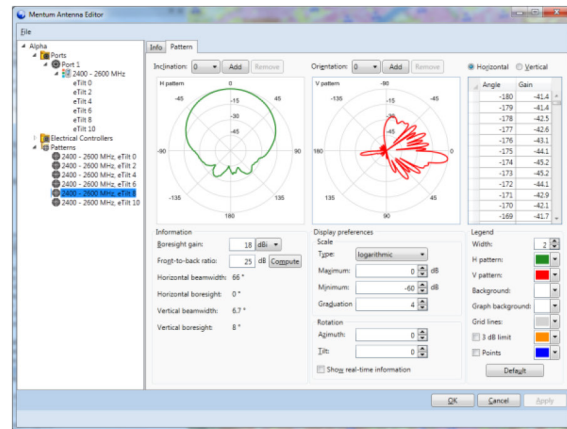*Optimized antenna pattern used*

Fig. 7: Antenna patterns used

The network type was defined as follows:

- LTE TDD
    - Frequency Band: 2.6 GHz
    - Bandwidth: 20 MHz
    - Downlink/Uplink configuration: DSUUDDSUUD

- • Special Sub frame Configuration: 3
- • Single carrier – Frequency reuse of 1
- • Mobile Equipment
  - • 7dB noise figure
  - • 24 dBm transmit power

Project Implementation

The performance of both antenna types was evaluated by using Mentum Planet to generate coverage maps of the following performance indicators in both downtown and suburban Paris.

- • Receive Signal Receive Power (RSRP)
- • Receive Signal Receive Quality (RSRQ) and or Downlink C/(N+I)
- • Downlink Average Data Rate[1]

Project Results - Downtown

Figure 8 shows a comparison of Receive Signal Receive Power (RSRP) in dBm across downtown Paris. The downtown area of Paris is extremely well covered, in terms of RSRP. More than 97% of the downtown area is indeed receiving a RSRP level above -125 dBm. As a consequence, the impact of using optimised antennas is limited, as can be seen in Figure 8.
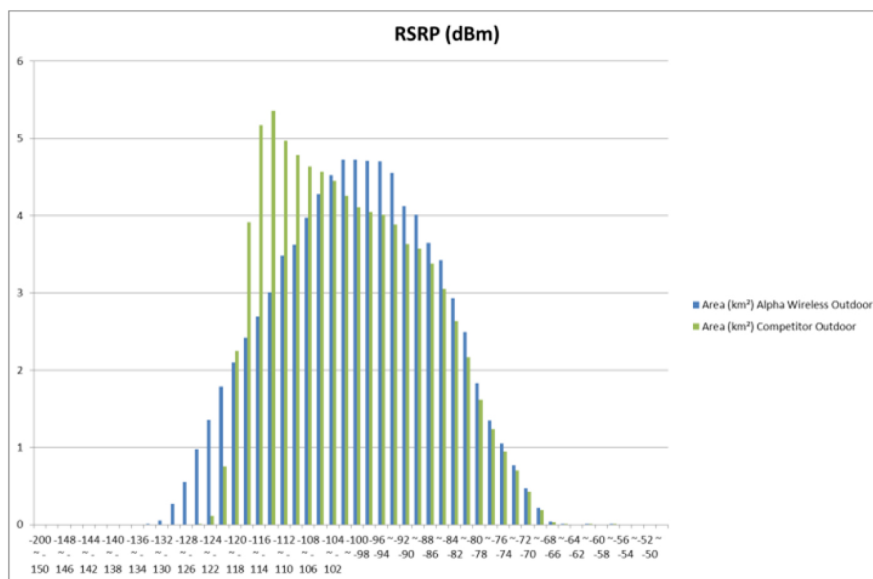
Fig. 8 – RSRP (Downtown)

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[1] The downlink average data rate accounts for all modulations and coding schemes supported by the eNodeB and the UE, along with their receptive coverage probabilities.

In terms of RSRQ, the difference between using optimised and non-optimised antennas is much greater. Due to its upper sidelobe suppression capabilities, the optimised antenna helps to reduce interference levels, which has a direct impact on RSRQ levels. As can be seen in Figure 9, the density of high RSRQ levels (above -13dB) is much higher with optimised antennas than it is with non-optimised antennas. Similarly, the density of low RSRQ levels is much lower. It is clear that the

use of optimised antennas has reduced the interference levels and contributed to turning areas of low RSRQ levels (below -13dB) to higher levels.
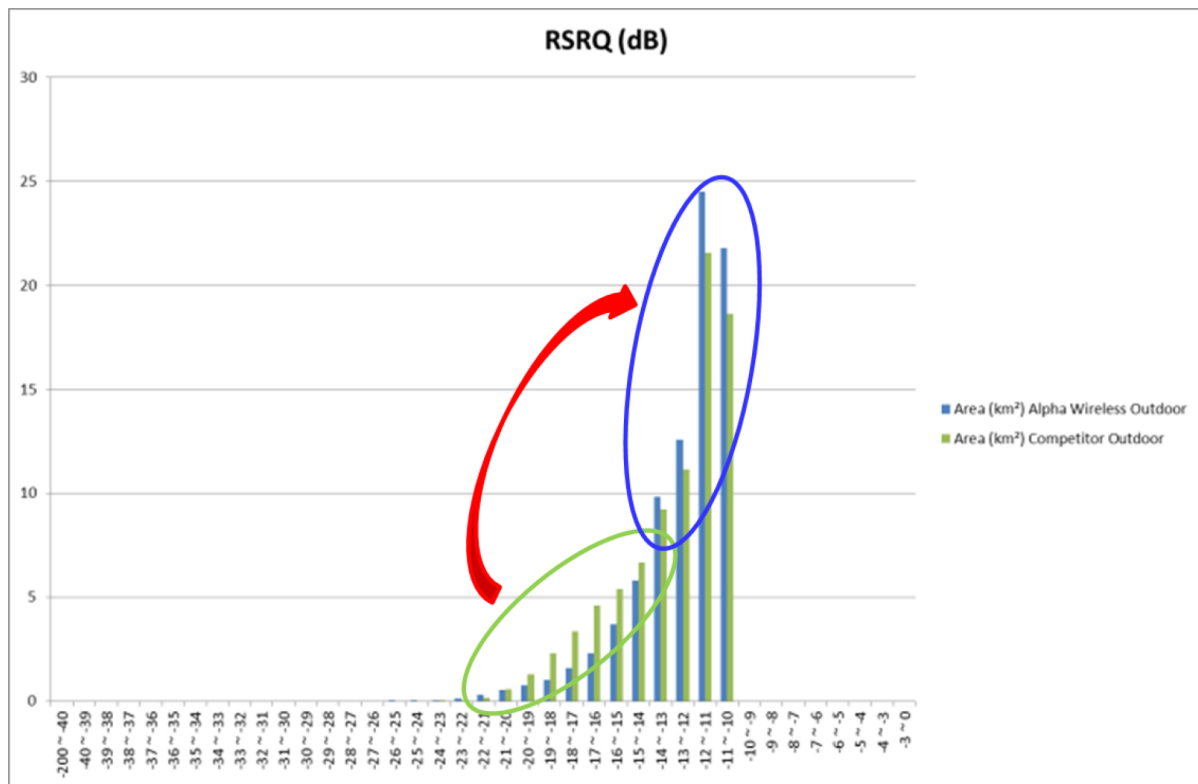

Fig. 9 – RSRQ (Downtown)

The reduction of interference levels directly impacts the CINR levels (as can be seen with the RSRQ in the previous section), which in turn impacts the data rate experienced by mobile users. As can be seen in Figure 10, areas of low data rates (below 6 Mbps) are considerably reduced thanks to the use of optimised antennas. Additionally, optimised antennas help to increase the highest data rates (above 42 Mbps) to a level that cannot be achieved using the non-optimised antennas.
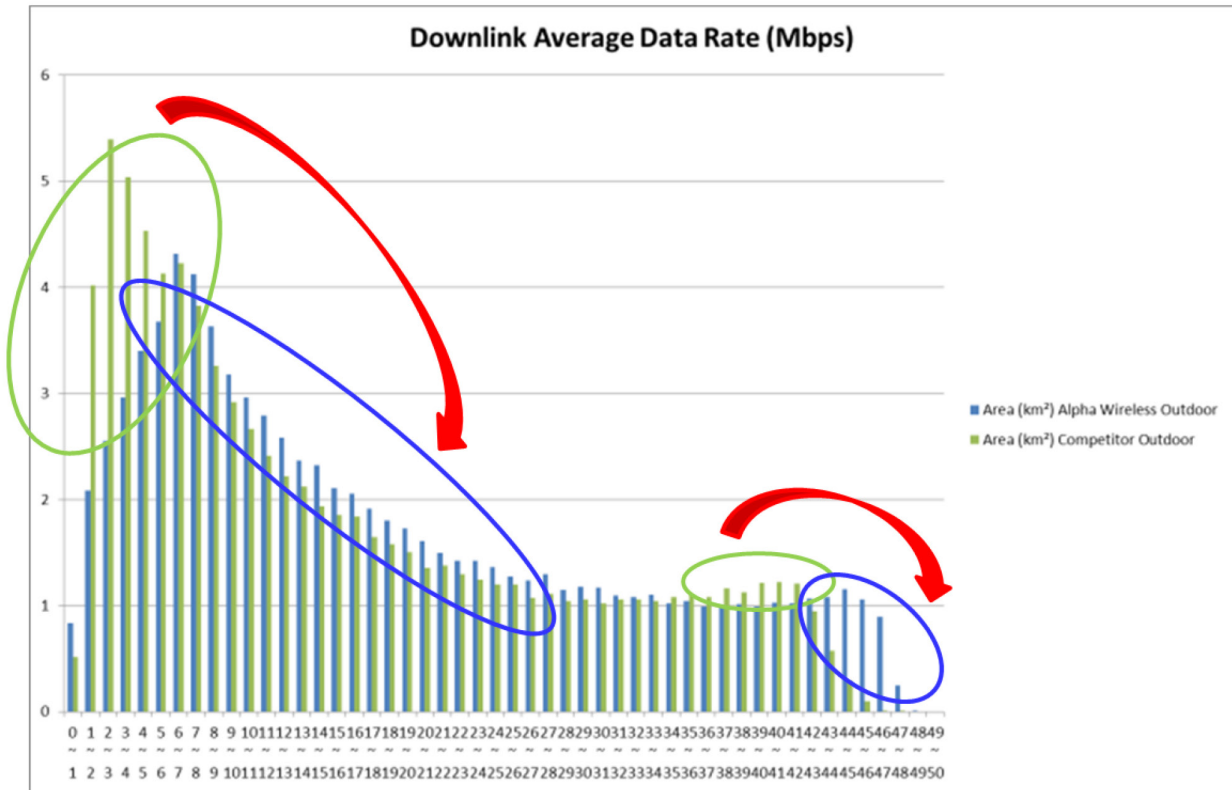
Fig. 10 – Downlink Rate (Downtown)

Project Results - Suburbs

Unlike the downtown area, the suburbs encompasses areas that are not necessarily fully covered. As can be seen in Figure 11, the use of optimised antennas helps to fill the coverage holes (areas of RSRP levels below -120 dBm are considerably reduced compared to the use of non-optimised antennas).
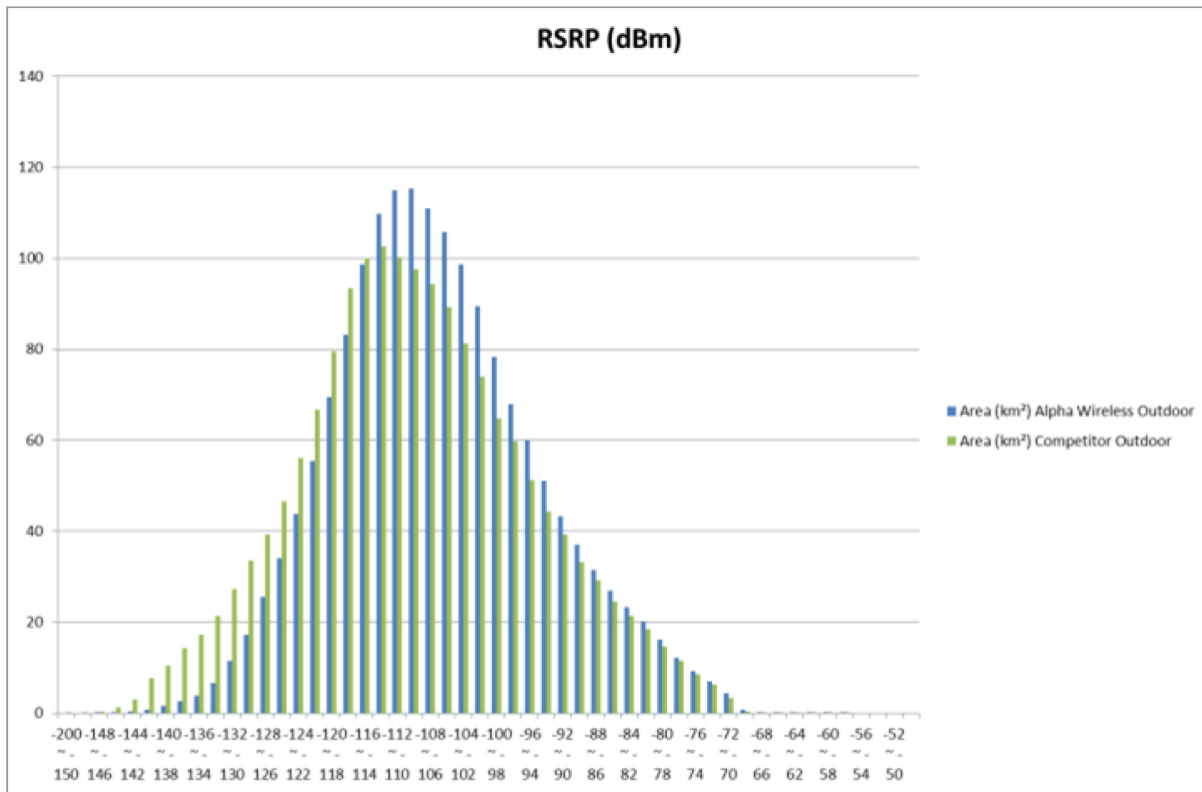
Fig. 11 – RSRP (Suburbs)

Just as in the downtown area, the upper sidelobe suppression capabilities of optimised antennas helps to reduce the interference levels which has a direct impact on Downlink C/(N+I) levels. As presented in Figure 12, the density of high Downlink C/(N+I) levels (above 10dB) is much higher with optimised antennas than it is with non-optimised antennas. Similarly, the density of low Downlink C/(N+I) levels is much lower. It is clear that the use of optimised antennas has reduced the interference levels and contributed to turning areas of low Downlink C/(N+I) levels to higher levels.
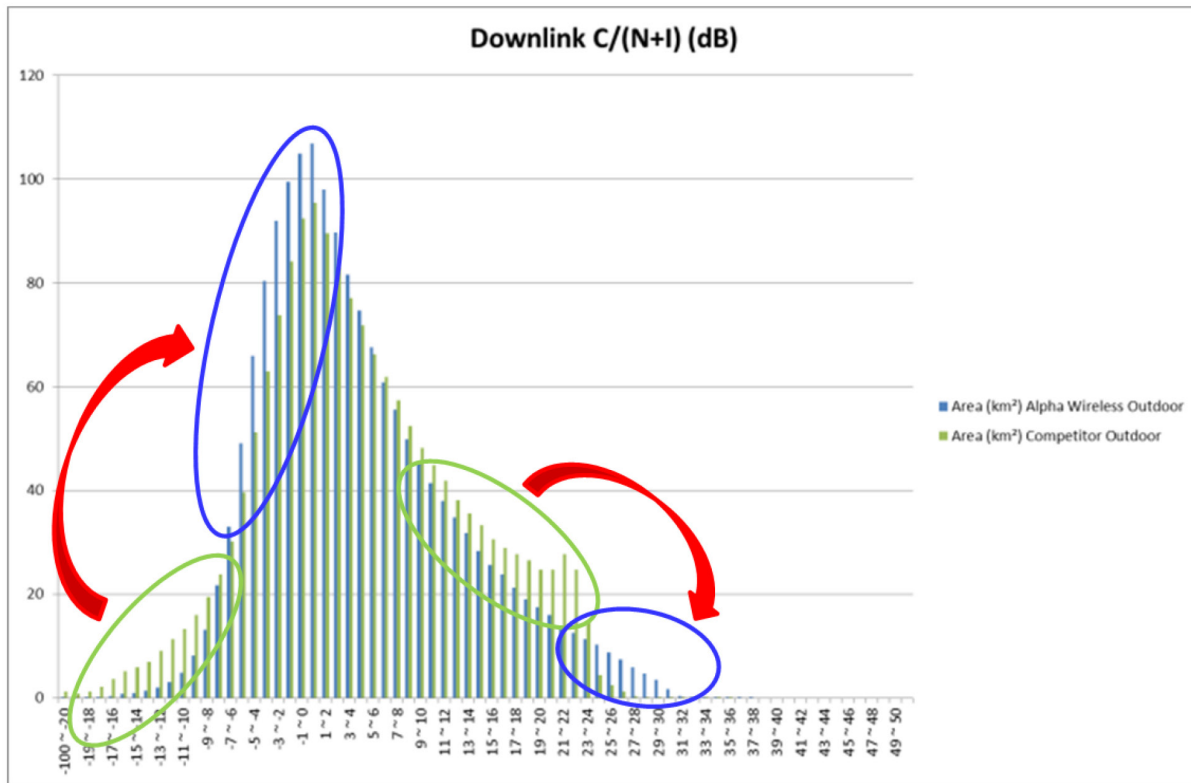
Fig. 12 – C/(N+I) (Suburbs)

The better downlink C/(N+I) levels observed with optimised antennas directly translates into higher down-link average data rates, as shown in Figure 13. In particular, it is worth noting that the areas of no data rate (data rate of 0 Mbps, where coverage is missing) are significantly reduced, and that high data rates unachieved with the non-optimised antennas are reached due to the use of optimized antennas.
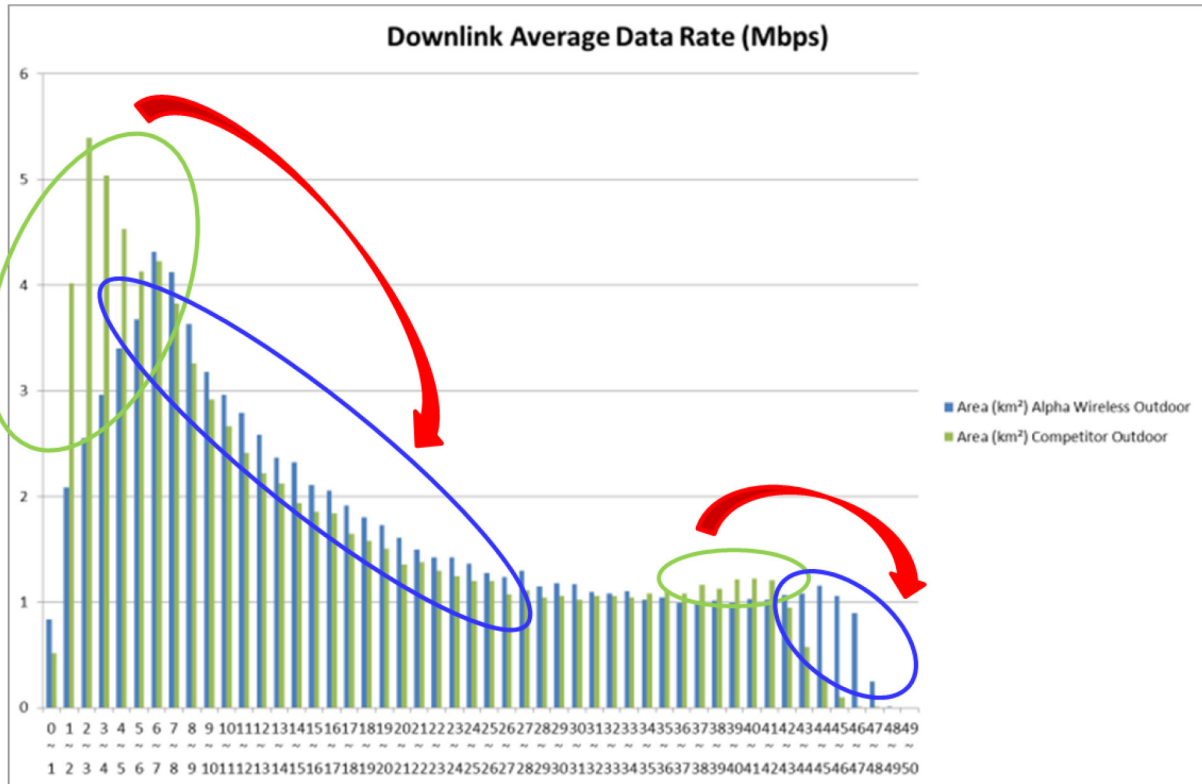
Fig. 13 – Downlink Data Rate (Suburbs)

Project Results - Summary

Table 1 summarises the improvement in coverage gain for data rates of <5Mbps and >42Mbps. Improvements of 40-200% were achieved. Significant improvements, which can only lead to greater user satisfaction.

	Optimized Antenna (non-covered area)	Non-optimized Antenna (non-covered area)	Coverage Gain
<5Mbps Downtown	13.9%	23%	40%
>42Mbps Downtown	3.6%	2.1%	70%
<5Mbps Suburban	1.3%	4.5%	70%
>42Mbps Suburban	6.5%	2.3%	200%

Table 1: Improvement Summary

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Conclusions

Your base station antenna choice can impact on the efficiency of your network. Inadequate upper side-lobe suppression in an antenna design can lead to increased interference, which can only result in less and more dissatisfied network users. In this study, a large city network was analysed using both optimised and non-optimised antenna parts, and gains in coverage area from 40-200% were achieved using antennas with optimised radiation patterns.