Antenna innovation

How the antenna industry is trying to keep up with advances in mobile phone technology. By **David Barker**.

While the mobile phone has seen major developments over the last 25 years, the mobile phone network relies on rf propagation for the delivery of information – and the delivery of rf energy has evolved more slowly than its baseband counterparts.

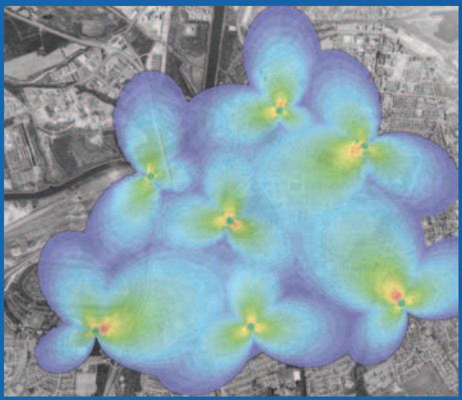
The humble base station antenna, responsible for the delivery and reception of rf, has evolved the slowest. Unfortunately, rf physics – including antennas – is bound by Maxwell's Laws and these don't promise a doubling in performance any time soon.

Making the antenna 'beam' shaped – so that energy is directed towards the ground using a beam which has between 6 and 12° of beamwidth in the vertical plane, and over a sector of between 60 and 90° of beamwidth in the horizontal plane – is considered the optimum means of delivering rf energy from a network of cellular three sector sites. This provides for a tessellation of sectors, which maximises the coverage footprint and minimises overlaps from a minimum number of site locations.

This optimal antenna beam pattern dictates the antenna size and form factor (because of Maxwell's Laws), typically an array of radiating elements packaged as a panel of between 1.5m and 2.5m in length, and a few hundred mm wide, depending upon rf frequency band(s). But an antenna cannot be made smaller without a change in beam pattern.

Antenna evolution

There are approximately 10million cellular antennas deployed in the world, with about 95% of the form factor described above. It is entirely possible to increase network capacity by adding more antennas, or more antenna real estate to a site. This approach might be simply for a new spectrum band, for new technologies, to support MIMO, or to create additional sectors for increased spectral reuse. It is also entirely



possible to add multiple antenna arrays together in one much larger radome and create very narrow beams which are directed to mobile users and traffic hot spots.

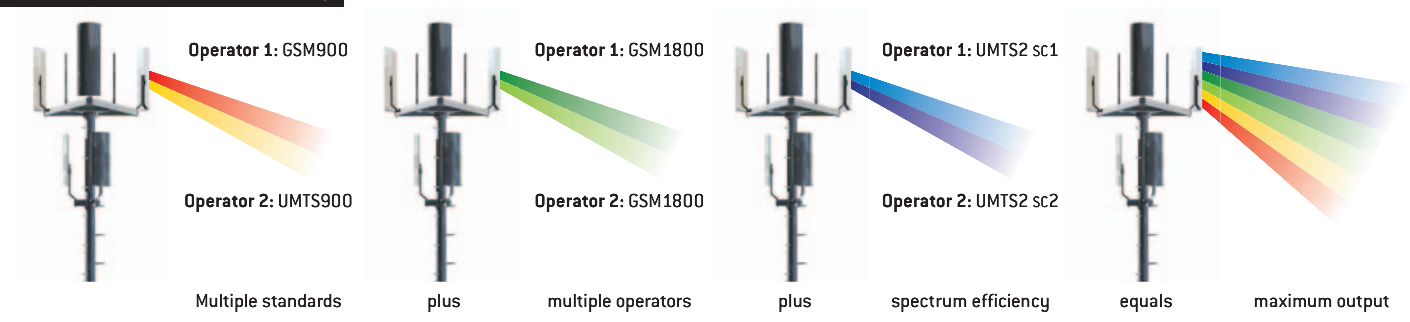
Such 'smart antenna' techniques, designed to collapse spectral reuse in time and space, require complex and often expensive phased array electronics and amplifiers behind every antenna array element. While such techniques were available 10 years ago, they have not been adopted because the current ecosystem of a couple of million sites was designed for panel type antennas and for wind loading, zoning and other factors.

While these fundamental laws have been followed with antennas, there have been some progressive developments in cellular antennas. Companies such as Kathrein and Andrew introduced X-Polar antennas in the 1990s. This removed the need for spatial diversity at sites which required at least a pair of antennas.

This meant antenna deployments could be halved, easing rentals, zoning and tower loads. Spatial diversity configurations are still used in some environments, but X-Polar antennas now dominate. When CDMA based technologies, such as UMTS, were deployed, they were designed to

The humble base station antenna, responsible for the delivery and reception of rf transmissions, has evolved the slowest of all elements in the mobile phone network. And the three sector approach remains the optimal method of maximising coverage.

Fig 1: Maximising antenna efficiency



reuse spectrum at every sector and site, across a network of sites. This meant that cochannel intersite rf interference had to be managed carefully through beam tilt optimisation. Too much interference meant loss of capacity; while attempting to eliminate interference by aggressive downtilting created service gaps between sites. This coverage/capacity trade off led to the introduction of variable electrical tilt antennas (VET). This, in turn, led to remote electrical tilt (RET) antennas, where antenna tilts could be tweaked continuously and optimised without sending a rigger up the mast.

Antennas in the early 1990s were single band – 900MHz in Europe and most of the rest of the world, and 800MHz in the US and a few other countries. In the mid 1990s, an 1800MHz band was introduced in Europe and a 1900MHz band in the US. This led to the development of dual band antennas.

Typically, antenna vendors arranged the elements of two very different bands into one radome without sacrificing antenna size. Often, a 900 band antenna and 900+1800 dual band were the same size; the dimensions being dictated by the lower frequency band. Then, in the early 2000s, many operators offered three bands, including several European operators offering 900, 1800 and 2100MHz. This led to the introduction of triple band X-Polar RET antennas, which brings us to the present day.

There is also some emergence of fully active antennas, in which each antenna element in an array has its own amplifier and up conversion stages. These active antenna arrays deliver the same beam pattern as their passive counterparts (60 to 90° horizontal and 6 to 12° vertical), but do so in a more power efficient manner. The power amplifiers are at the radiating elements and there are several power devices, rather than a big amplifier sending a signal across an array of passive elements.

Such solutions are useful where very long feeder runs (and hence large power amplification) would otherwise have been required, or simply where power savings are vital. Active antenna arrays can offer some uplink noise figure gains because signals can be processed at the element. However, such active antenna arrays require fibre based connections, restricting vendor/base station flexibility and interchangeability. They are currently restricted currently to single band applications and there are significant rf and baseband electronics at the tower top.

But new spectrum bands being released – including 700MHz and AWS (1700/2100MHz) in the US and 800MHz 'digital dividend' and 2.6GHz in Europe and other parts of the world. Furthermore, existing spectrum bands are being deregulated to allow 2G, 3G and 4G technologies to coexist in the same bands.

This means operators are starting to share networks to save costs and this may become more prevalent over the next decade. Some observers may wonder why competing operators would share assets. Capital efficiency is a primary concern of ceos and reducing the assets deployed and the recurring operating expenses is a double benefit to the bottom line.

Finally, we are promised the truly broadband mobile data rates enabling services such as video streaming and web surfing when this new spectrum is used and LTE and MIMO techniques are exploited.

All these developments, fuelled by the explosive growth in data services, lead to one thing – more antennas on more sites using the currently evolved base station antenna.

However, Quintel antennas obey rf physics and Maxwell's Laws, but have been designed to support multiple independently tilting RET beams.

These antennas make it possible to combine two different operators or two different access technologies on one antenna array – for example, GSM850 and LTE700 signals tilted independently for optimisation purposes or for two network sharing operators in the same band who are using the same technology, but want to maintain some network design independence.

Therefore, a triple band antenna assembly with Quintel technology means six independent tilts can be achieved to meet the network design needs of two different, yet sharing, operators, or for different access technologies in each band (see figure 1).

Quintel's antenna technology has the potential to bring benefits similar to those brought by X-Polar antennas during the 1990s – halving the number of antennas, yet achieving the same performance and flexibility while respecting Maxwell's Laws.

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