The Growing Visual Impact of Wireless Antennas in the Urban Landscape: Strategies for Coexistence

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A few decades ago, antennas were almost unnoticed in the urban and suburban landscape, except for home television receive antennas. At that time, such areas had a few AM, FM, and television broadcast antennas that were sometimes collocated (although less so in the United States) and served wide areas. The low-capacity land mobile radio systems that existed then also used antennas sited on relatively few high towers or building sites, covering large areas but with little total capacity compared to today's cellular systems.

The introduction of cellular radio technology in the later 1970s and 1980s started a major change in the installation of antennas in populated areas. There are three factors that contributed to cellular capacity: available spectrum, technology (e.g. modulation efficiency), and frequency reuse through multiple antenna sites on the same frequency.[1] While it is hard to quantify the quantitative contributions of these three factors, it is very likely that frequency reuse is the largest contributor in the exponential increase in mobile cellular capacity since the beginning of the cellular era for the simple reason that the increases in the other two factors have been modest and cannot by themselves account for the orders of magnitude increases in capacity. Frequency reuse depends on an ever denser network of cellular base stations, which in turn results in both a higher spatial density in populated areas (and other areas of high spatial traffic density like major roads) and lower antenna heights. Thus, while towers greater than 30 m in height will continue to exist in areas with low spatial traffic density, in other areas they will be replaced with multiple towers serving their former service area, each at a lower height.

Opposition to cell site construction is not new and results from a variety of factors including the classic NIMBY/"not in my backyard" concern of individuals who want modern infrastructure but do not think its building blocks should have an impact on their immediate environment. Some come from concerns about RF safety even if installations meet generally accepted national and international safety limits for human exposure. Some come from concerns that a cell site's physical design is a major deviation from the architectural theme or special characteristics of the surrounding area. In the United States, national law pays special attention to this issue in areas with endangered species, in historic areas, and in areas that are controlled by Native Americans — the indigenous people of the country.[2]

In other areas there are concerns about visual impact that are less regulated by law. There have been local government concerns over whether specific base station designs in specific locations were compatible with the character of the location. Intractable situations have sometimes been resolved with nonstandard designs such as "fake tree" based antenna towers and even church steeples specifically designed to have a dual purpose of hosting base station antennas that are carefully designed into the construction.

But with the densification expected in 5G cellular systems, the number of base station sites and their spatial density will grow dramatically, and the height of their antenna elements will decrease. In the United States alone more than 200,000 new base stations are expected. Because of the modest height needed for the new dense networks, many of these will be mounted on utility poles, particularly in suburban areas. Others will be on free standing small towers/poles with heights of less than 10 m. Finally, some will be mounted low on existing buildings at locations less than 10 m off the ground. In all these cases the antenna elements and the transmit/receive/backhaul electronics will in many cases be more visible to neighbors than they have been in the more traditional higher locations.

FIGURE 1. Antenna element for a small cellular base station mounted on a utility pole at a height of about 10 m.

In Figs. 1 and 2 we show an antenna and the electronics package for a base station design in present commercial use for small base stations mounted on utility poles with antenna element heights in the 10 m range. The antenna shown in Fig. 1 is a design covered with wood and results in a diameter only slightly larger than the pole on which it is mounted and an exterior surface similar to the pole. Thus, the physical design of the antenna element blends in well with both the pole and the surrounding suburban environment. However, the electronics package for this base station, shown in Fig. 2, has quite a different visual impact.

This package of electronics that performs the base station

[1] Real Wireless Ltd, "4G Capacity Gains: Final Report," 2011 (https://www.ofcom.org.uk/__data/assets/pdf_file/0025/72790/4gcapacitygainsfinalreport.pdf)

[2] https://www.fcc.gov/general/tower-and-antenna-siting

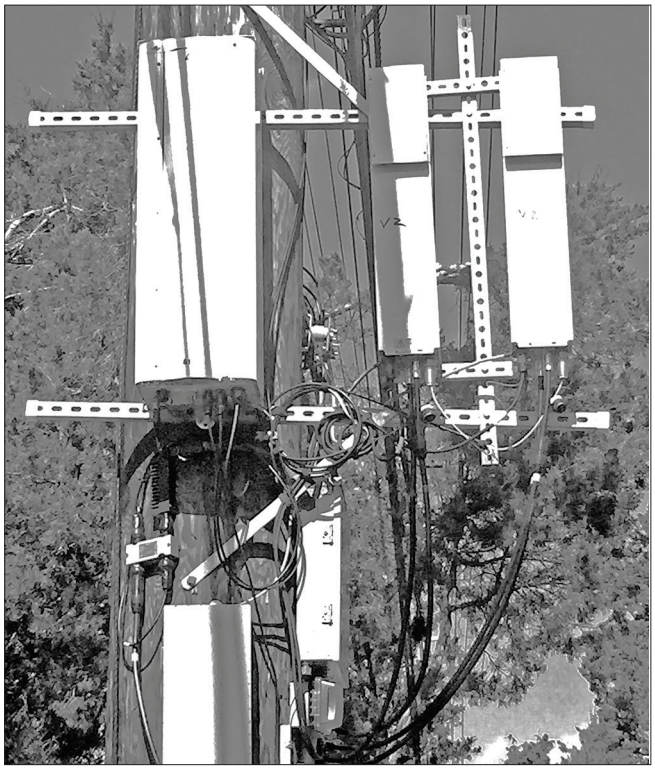

FIGURE 2. Electronics package for a commercial small cellular base station mounted on a utility pole.

function is about 3 m off the ground and is clearly visible at eye level by all those in the neighborhood. It consists of a somewhat chaotic metal framework that supports many boxes comprising the system as well as numerous loose cables connecting the boxes to each other and the antenna further up the pole.

It should not be surprising that neighbors do not like such installations. Do they reflect well on our profession? Is not the goal of engineering to build systems that perform a useful function but also meet realistic constraints including cost, weight, size, power consumption, and so on? Approximate visual compatibility of base stations with the surrounding environment, particularly in populated areas, is a reasonable goal for such designs. In political jurisdictions where local governments have to approve construction of such base stations, such design will facilitate and speed the needed approvals. But even in jurisdictions without the need for such approvals, there are pragmatic reasons to be sensitive to the local environment and its characteristics.

Thomas P. "Tip" O'Neill, a prominent member of the U.S. Congress from 1953 to 1987, is famous for his observation "All politics is local." While extending cellular service and upgrading it to 5G is very popular, the creation of large numbers of small bases stations in neighborhoods with ugly equipment and cables near eye level could result in a grass roots backlash that could slow future construction and even national legislation that could disadvantage the industry.

Thus, there are a variety of reasons to pay attention to the physical design of cellular infrastructure as large numbers of new base stations are built to make high speed 5G service ubiquitous. While many engineers who are the primary readers of this publication may not be trained in developing physical designs for outdoor base station equipment that considers the environment of the base station, they may wish to consider the systems implications of what might happen if the industry is viewed as being insensitive to the neighbors of the new smaller base stations.

Biography

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