tait communications

Under the Hood:

Coverage theory for Public Safety networks - a System Engineer's view

White Paper

tait communications

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This paper provides network operators some insight into how a System Engineer can design for network coverage that meets specific requirements. It addresses three basic techniques, which, used individually or in combination, can overcome geographical or urbanization influences, to increase coverage reliability.

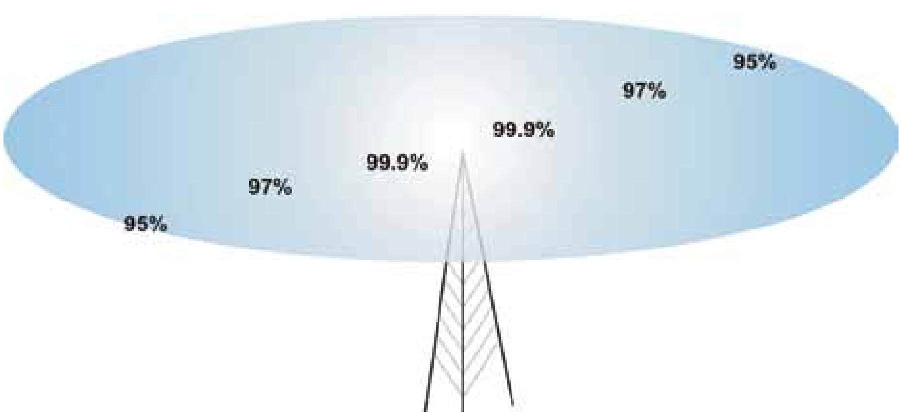
While this paper is especially relevant for the critical coverage requirements of Public Safety operators, the principles described are equally applicable for other sectors.

COVERAGE THEORY

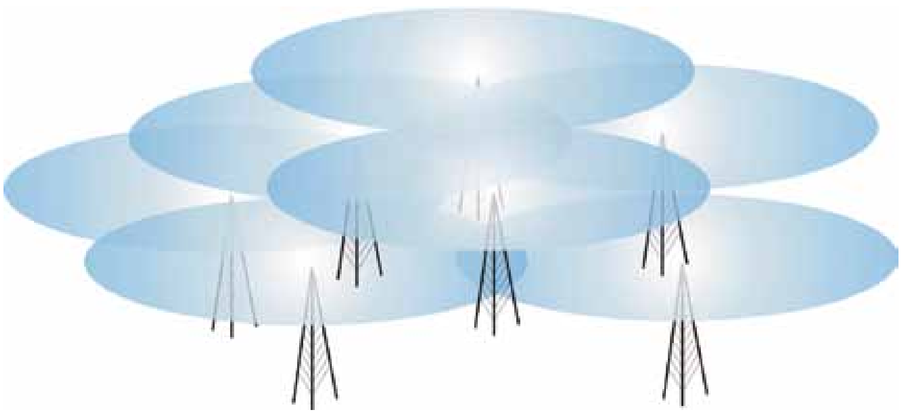
At the risk of stating the obvious, reliable coverage is possibly the single most critical requirement for Public Safety communications. It is also one of the most complex. Geographical and urbanization influences, and wide coverage areas have traditionally challenged radio communications. But today's Public Safety Officers work in rapidly changing environments, where security, data transfer and usage protocols must also be managed.

To provide coverage for modern Public Safety networks takes a deep understanding of coverage theory, the different principles and approaches available and the experience of implementing the practical. The stakes are high, and coverage cannot be left to chance.

"Coverage reliability" is an engineer's way of stating the probability that Public Safety officers can communicate clearly, at any time and any place in their coverage area. Typically, Public Safety agencies specify a service area reliability of 97%. To achieve this, a System Engineer would generally select sites so that coverage reliability at the boundary of the service area is no less than 95%.



Obviously, locations closer to a site will generally have higher coverage reliability than those further away. Reliability increases as the received signal power gets stronger, in relation to the minimum power required for a signal of the specified quality. So the easiest option – the brute force approach – is to install more sites, closer together.



Luckily, there are better, more efficient and less costly approaches available to the designer of modern communications systems.

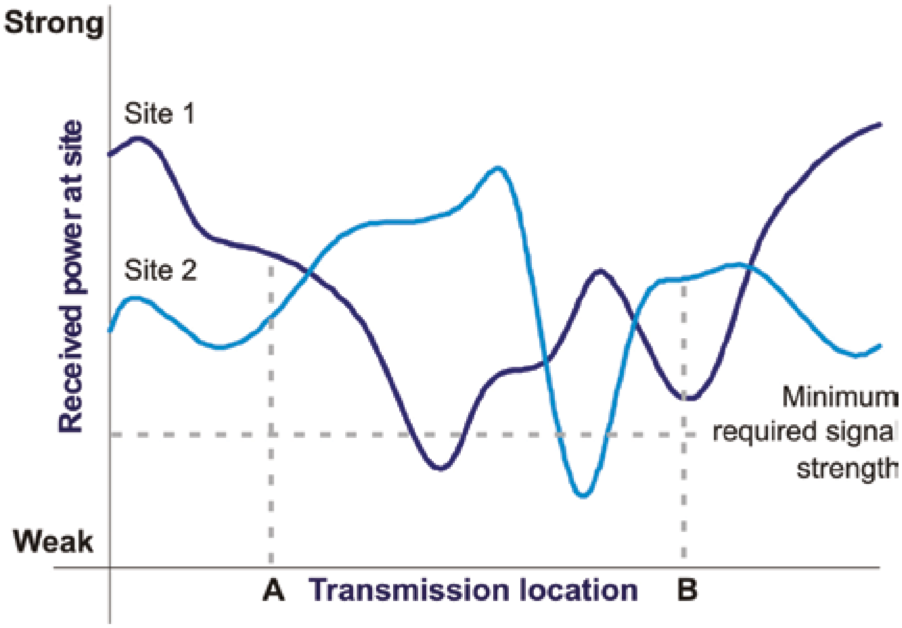
APPLYING THEORY TO IMPROVE COVERAGE PERFORMANCE AND RELIABILITY

When Systems Engineers design communications systems, they have at their disposal three approaches to predict, measure and improve coverage performance and reliability:

- Simulcast
- Macro Diversity
- Micro Diversity

Used individually or in any combination, all three rely on the fact that under the right conditions, signals to and from separate sites that are received or transmitted on separate antennas will fade independently. In other words, at any point in the service area, if a signal received at one site is low in power then the chances are that the same signal at another site (or another antenna) is higher.

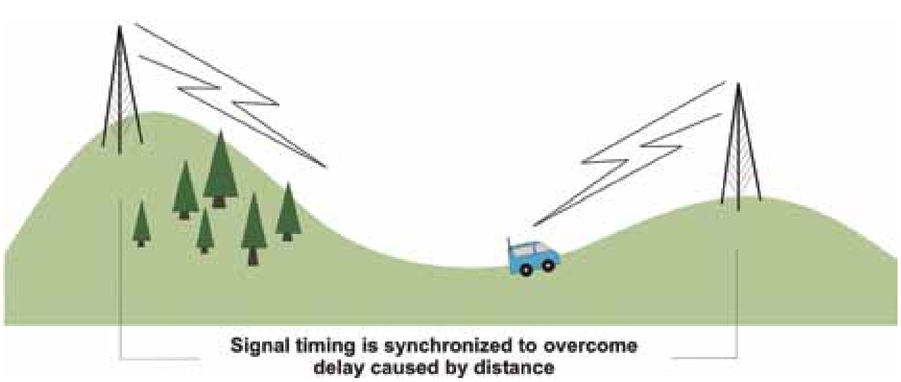
In the diagram, Site 1 receives the stronger signal from the mobile at location A, (although an acceptable signal is also available at Site 2). At location B, Site 2 receives the stronger signal.



SIMULCAST

Simulcast systems transmit the same information from multiple sites at the same time, on the same frequency, with coverage of adjacent sites overlapping. By reusing the same channel frequencies at multiple sites, Simulcast allows spectrally-efficient implementations of wide area systems. Because the same frequencies are used at each site, officers can roam across the total coverage area without fear of dropping their call as they move from the coverage area of one site to another.

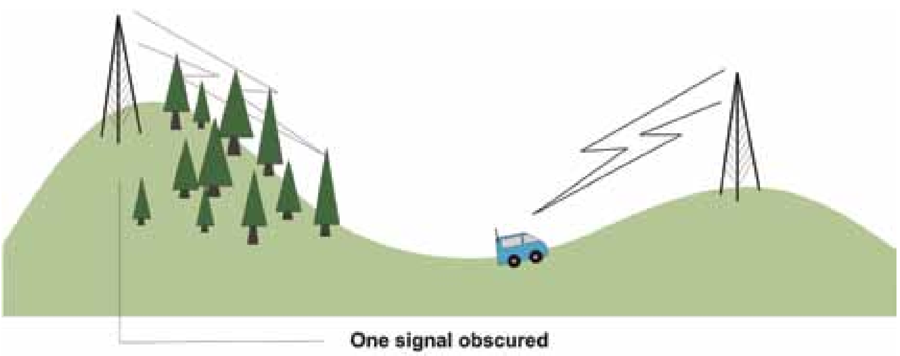
However the Simulcast system must be carefully matched, synchronized and designed to achieve these benefits.



If it is well designed, a Simulcast system increases coverage reliability where coverage from two (or more) sites overlap. This increase can be explained using elementary probability theory:

Let's assume that a Simulcast system has two sites with overlapping coverage and a minimum coverage reliability of 77.6% on the coverage contour of each site. This means that there is a 22.4% chance that the signal from a site will be below the specified communications quality on the coverage contour. That's a pretty high chance of communications failure, definitely not acceptable for public safety. Fortunately, there are two sites. So if signal power from one site is too low, then the chances are good that the signal power from the other site will be high enough - assuming that the two signals fade independently.

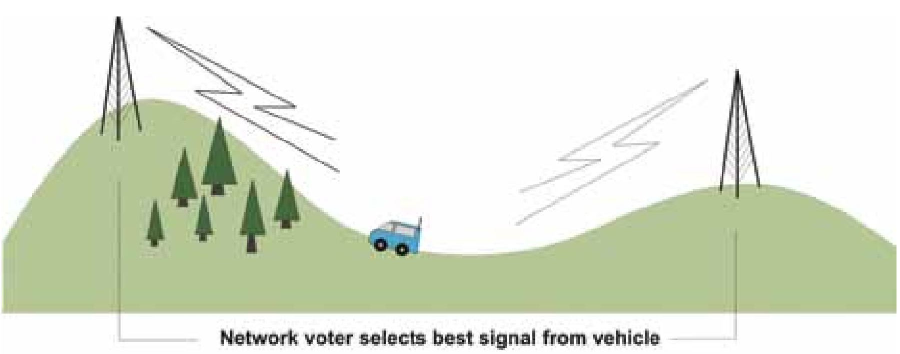
The chances of both signals being too low for public safety quality communications (a communications outage) is (0.224)*(0.224) or 5%. So coverage reliability at this location is actually 95%, as desired for a public safety system.



Simulcast transmissions take place from base station transmitters, so they affect the down link (talk out) performance of a communications system.

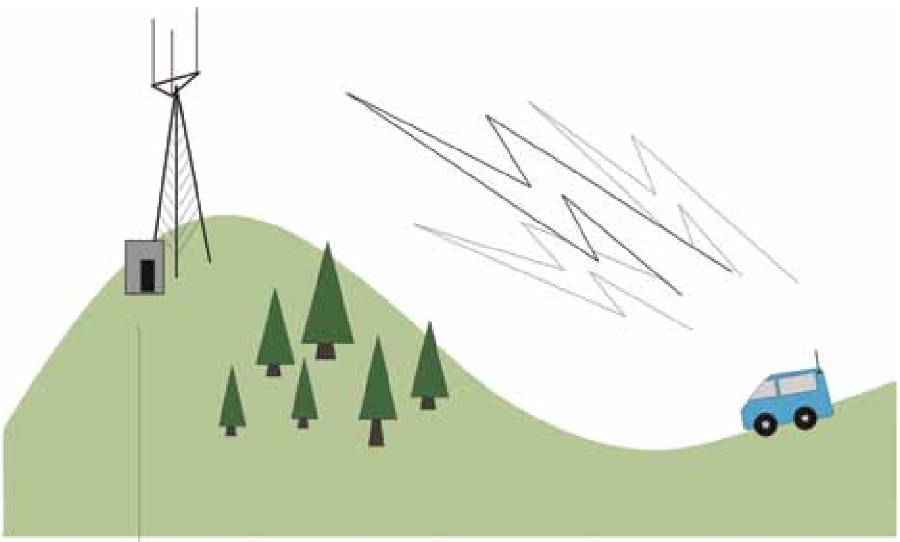
MACRO DIVERSITY

Macro Diversity is commonly used in conjunction with Simulcast. For example where it is more economical to have a single, high power transmit site and multiple receiver-only sites, scenario, macro diversity balances the coverage of the uplink and downlink.



MICRO DIVERSITY

Micro Diversity relies on the installation of multiple receive antennas, physically spaced far enough apart so that they receive signals that fade independently. These systems select the best signal from the multiple antennas, or combine them to maximize the signal-to-noise ratio available to the receiver.



Micro Diversity combats the effects of the signal fading as a terminal moves through an urban area but it does not increase the coverage reliability in the same mathematical sense as Simulcast and Macro Diversity. Instead, it reduces the amount of received faded signal power needed to produce an output of the specified quality, increasing the coverage area of a given site.

To be sure that the signal received at each antenna fades independently, antennas need to be spaced horizontally by several wavelengths – signal wavelengths get longer as the frequency decreases. Typically, three antennas are arranged at the vertices of an isosceles triangle. As a result, antenna spacing becomes very difficult in practice, at least in the lower LMR frequency bands.

Micro Diversity isn't widely implemented in LMR systems (except Tetra and IDEN technologies) although it is widely used on cellular and other wireless networks. This is in part because of the lower channel frequencies typically utilized in land mobile radio systems.

However as data rates, modulation complexity and frequencies increase we can expect to see Micro Diversity as a more commonly used tool in the system engineer's tool box.

PROFESSIONAL EXPERTISE: THE KEY TO COVERAGE RELIABILITY

Regardless of geographical spread, network complexity, or any other variables, the constant, critical requirement for Public Safety communications is coverage reliability. Operators cannot leave coverage design to chance.

Planning a new network or upgrading a current one, operators must depend on experienced professionals who understand and can apply a range of coverage theory. By investigating the options, then verifying and validating, this experience is proven when the network goes live.

TAIT COMMUNICATIONS

Tait Communications is a global leader in designing and delivering radio solutions which are the right fit for a variety of industries including; public safety agencies, government services and utilities.

MORE INFORMATION

For more information on coverage, please contact your nearest Tait dealer.

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