WHITE PAPER

P25 Simulcast coverage explained:

How to achieve P25 coverage similar to analog Simulcast

EXECUTIVE SUMMARY

When migrating from an analog LMR system to a digital standard like P25, coverage is a vital consideration. It's important that the coverage provided by the new digital system is as good as - or better than - the analog system it is replacing. It's important to determine the number of sites required to provide reliable communication throughout the service area; your officers' safety depends on it. But additional sites have a major impact on system cost.

This paper summarizes the coverage implications of migrating to P25 Phase 1 Simulcast, and how to achieve coverage that is similar to analog simulcast.

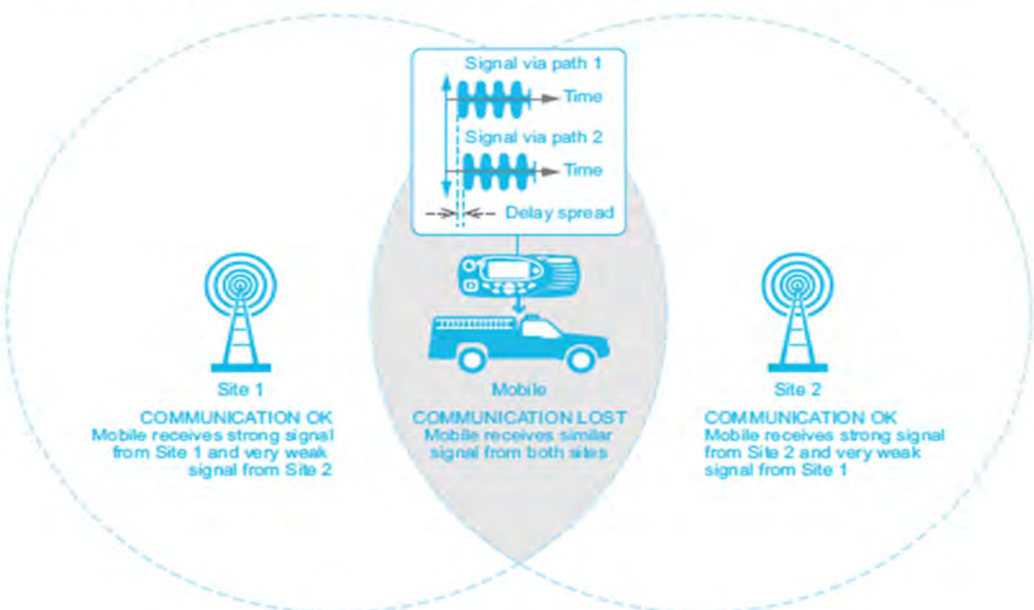
Find out about:

- The case for simulcast
- Considering modulation
- Matching analog simulcast coverage
- Other resources

Efficient radio system design achieves maximum coverage from the minimum number of sites, using the minimum spectrum (channels). With sufficient frequencies, interference can be minimized by ensuring neighboring radio sites use different channels. This creates P25 coverage that is very similar to legacy analog systems – P25 modulation and symbol rates were specified to achieve exactly that.

However, sometimes the availability and/or cost of frequencies may mean that some or all sites must use the same frequencies. Where two or more neighbouring sites' coverage overlaps, an officer with a mobile radio (mobile or portable) would receive signals at similar levels from each site. This might sound beneficial, but in practice, the time difference between receiving the signals from these sites (delay spread) causes the received audio to quickly become distorted and unintelligible.

DELAY SPREAD IN COVERAGE OVERLAP BETWEEN NEIGHBORING BASE STATIONS



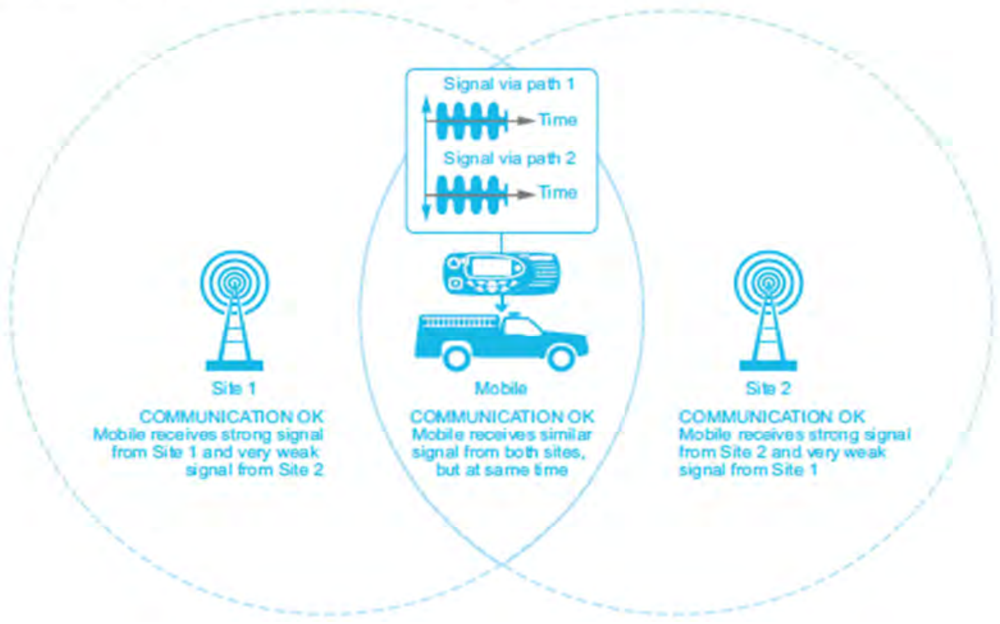
THE CASE FOR SIMULCAST

Where neighboring sites use different frequencies, all we are concerned about is the delay spread of the signal from the site the mobile radio is currently registered to, as the radio simply rejects the signals from the other sites. Delay spread within the coverage area of a site rarely exceeds 10us, which is insignificant and has little effect on received audio quality. (An exception to this might be in mountainous areas.)

However, where neighbouring sites use the same transmit frequencies, we are concerned about the time difference between receiving signals from all of these sites. For an officer travelling through an ‘overlap’ area, delay spread can make received audio unintelligible.

To overcome this, coverage design engineers can control the timing, frequency and power of transmissions in the overlap; delay spread between signals from each site can be so small that little perceivable audio distortion occurs. These are simulcast systems.

EFFECT OF SIMULCAST IN IMPROVING DELAY SPREAD RESILIENCE



Lack of available frequencies is not the only reason to use a Simulcast system - it is also beneficial where tall buildings or geographical features impact on reception. For example, in a city, mobile radios continually change from site to site as officers drive between buildings, causing the reception to break up. With simulcast, all sites transmit at the same frequency and time, so audio quality is maintained because no switching between sites is necessary.

Where neighbouring radio sites use different frequencies, P25 coverage will be very similar to a legacy analog system. In P25 simulcast systems, delay spreads reduce coverage significantly more than their analog simulcast predecessors.

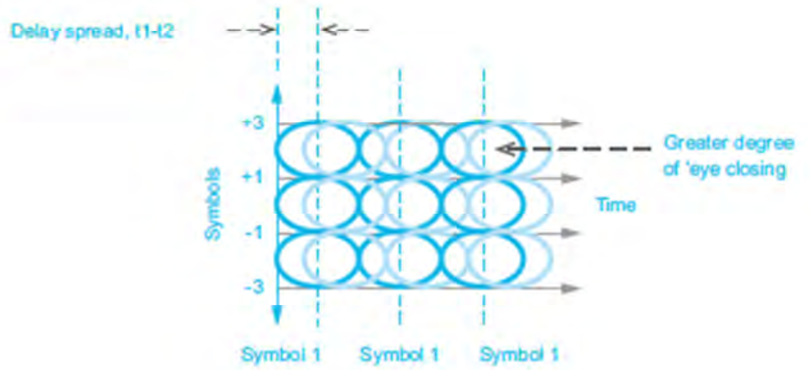
CONSIDERING MODULATION

Analog simulcast uses narrowband FM modulation, where the transmitted signal frequency varies instantaneously, in sync with the applied speech. The delay spread tolerance of narrowband FM is around 60us.

The P25 standard C4FM modulation encodes and transmits the applied speech as one of four 'symbols' - defined states of frequency (600Hz or 1800Hz) either side of the RF carrier frequency. (4800 symbols are transmitted per second.) This occupies a similar bandwidth to analog narrowband FM, fitting neatly into a standard 12.5kHz narrowband channel. Because the information is conveyed within the signal frequency, simple non-linear transmitters (used by analog systems) can be re-used.

The drawback of C4FM is that the maximum delay spread tolerance before the received audio becomes distorted is only 25us, less than half that of analog simulcast. The coverage radius is reduced by a similar amount. So migrating from analog simulcast to a P25 C4FM simulcast system means a lot more sites are required to maintain the same coverage. This is clearly unacceptable.

C4FM EYE DIAGRAM

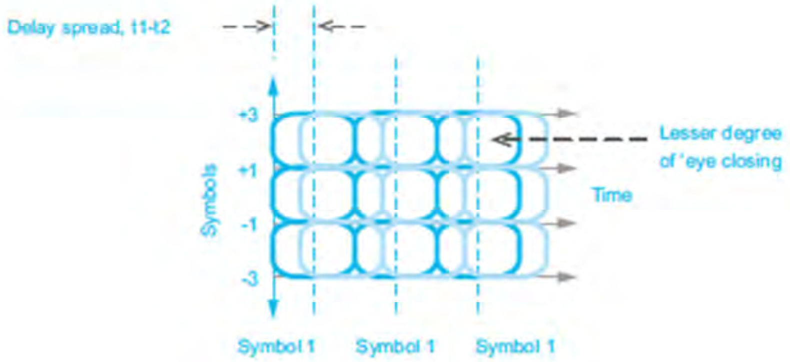


MATCHING ANALOG SIMULCAST COVERAGE

To address this, the P25 standard also includes Linear Simulcast Modulation (LSM) specifically for Simulcast. Applied speech is encoded and transmitted as one of four 'symbols', but the symbols are defined by states of phase, not frequency. Because LSM occupies a far greater bandwidth than C4FM, the LSM signal must be filtered to fit it into a standard 12.5kHz narrowband channel. The filtered LSM signal now contains amplitude as well as phase variations, which must be preserved by the transmitter. More complex linearized transmitters are therefore required.

The advantage is that Phase Shift Keying (PSK) digital modulation methods like LSM have a much greater tolerance to delay spread than Frequency Shift Keying (FSK) digital modulations like C4FM. LSM can withstand delay spreads around 55us before the received audio becomes distorted - similar to the delay spread tolerance of analog FM. In this way, P25 Simulcast using LSM modulation provides coverage that is similar to its analog simulcast predecessor.

LSM EYE DIAGRAM



OTHER RESOURCES

To discover more about the concepts described in this paper, see the following articles published in Tait Connection magazine:

- Comparing FSK and PSK Based Digital Modulations, (Issue 5, page 24)
- Nine Channel Concepts Every Radio System Designer Needs to Understand, (Issue 6, page 27)

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