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Photo courtesy Adcomm Engineering

Narrowbanding Simulcast Networks

The challenges and benefits of simulcast for analog and P25 systems

By Ed O'Connor, Joe Blaschka Jr. and John Thompson

As the Jan. 1, 2013 narrowbanding deadline approaches, two fundamental paths being evaluated by public-safety entities around the country are to stay analog and migrate to 12.5 kilohertz or to put in a new digital 12.5-kilohertz Project 25 (P25) system. Because of increased user coverage expectations, multitransmitter systems are being specified and installed.

Simulcast is the contraction of the words simultaneous and broadcast and refers to transmitting the exact same modulation on the exact same frequency from multiple geographically distributed and overlapping transmitters at the exact same time. Simulcast is spectrally efficient, can provide excellent coverage, and is operationally simpler than using multiple channels or zones.

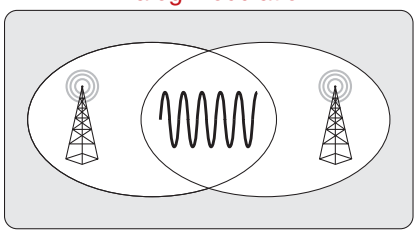
Finances may play a role in the analog/digital technology selection decision. When narrowbanding an existing analog system, a large percentage of the portables and mobiles purchased during the past decade are already narrowband capable. So staying analog requires a municipality to upgrade only the infrastructure, usually representing a lower initial cost of compliance. Converting to P25 requires making a wholesale change of infrastructure and all field units; but P25 provides digital interoperability and may qualify for partial grant funding. The following recaps decisions that two municipalities made — one chose analog and the other digital — and then provides a thumbnail of the simulcast technology employed implementing each system.

New York Analog Simulcast System

For years, rural Broome County, N.Y., wanted to consolidate the dispatch of five of its fire departments to facilitate mutual aid. Volunteers in Broome County serve an 85-square-mile area in the western part of the county. The topography is hilly; north-south ridges and valleys intersect in a T with east-west terrain. Broome County had a primary dispatch site serving four of the departments, but a second site was operated for just one of the fire departments. The channels were both low- and high-band VHF analog, operating on 25-kilohertz channels. The county's microwave system linked the two repeater sites, along with four additional satellite receivers, to dispatch.

With the FCC's narrowbanding mandate looming, it was an ideal time to both narrowband the system and

Analog Modulation



To transport simulcast analog audio to the transmitter sites, use identical paths. T1 microwave, telco T1, IP microwave or RF linked systems are all acceptable transport methods.

simplify operations. Coverage from the primary site had holes. Adding the second site remedied the holes, but two different channels meant an unworkable dispatch situation and missed calls. Using one repeater pair at both sites on the same frequency introduced large areas of overlapping coverage with destructive interference. Sequential paging of multiple departments from two sites took forever and tied up dispatch. An additional concern, which complicated matters, was that with the reduced signal-to-noise-ratio on 12.5-kilohertz analog channels, coverage was potentially going to shrink and create more operational complications. County officials viewed simulcasting the channel to be the only viable solution.

As part of their initial investigation, Broome County officials considered upgrading the fire channel to P25, but because of the high potential cost, it wasn't a viable solution. An upgrade to a new P25 system is planned as part of the county's five-year budget outlook, but officials are hoping a grant will fund the majority of the system. Even if much of the initial investment is paid, there is a concern about the annual maintenance fee.

Tri County Communications of Binghamton, N.Y., the local Motorola Service Shop (MSS), proposed an analog upgrade to simulcast that addressed all the county's needs. The design included a Raytheon JPS Communications digital signal processor (DSP) voter, which collects audio from six receiver sites and forwards the best signal. This selected receive audio, as well as dispatch audio, passes through a narrowband booster limiter designed by Keriza Systems, which keeps audio levels constant. Spectracom GPS master oscillators provide accurate reference signals to keep transmitter carriers and continuous tone controlled squelch system (CTCSS) synchronized so communications in the overlap area are understandable. Timing and audio equipment by Convex automatically adjusts the audio launch time and keeps the levels the same. Tri County had spare base stations and microwave/multiplexing gear, so the whole system was staged in its shop with all the gear for two repeater sites and the microwave connection. All wiring and polarities were verified before deploying to the sites. Staging the system allowed technicians to work with the timing in the convenience of the shop. Staging the entire setup saved time, because when the equipment was deployed to the field, little overlap timing adjustment was needed.

The five fire chiefs are pleased with the seamless simulcast coverage that their new channel provides — and their system is narrowband compliant two years ahead of the 2013 deadline. There have not been any complaints about the system coverage; the two-site dispatch channel reaches the needed volunteers, telling them when to switch to the correct simplex operations channels.

Analog Simulcast Parameters

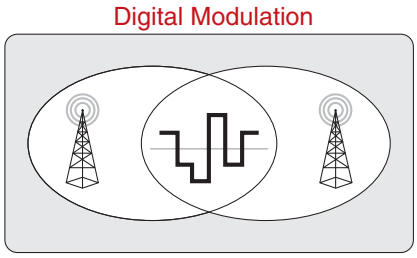
To simulcast voice, or tone and voice paging, one must control the potential interference of the two or more sources. The overlap zone, or non-capture area, is where the relative signal strength of the two or the highest signals is within 15 dB for a 12.5-kilohertz channel. In this area, we attempt to "trick" a receiver into thinking it's only receiving one signal. For seamless communications in the overlap, the carrier center frequency must be within 1 hertz from all sites; recovered audio and recovered CTCSS must be within 0.2 dB; and audio must be aligned within 70 microseconds.

To transport simulcast audio to the transmitter sites, identical paths should be used. T1 microwave, telco T1, IP microwave or RF linked systems are all acceptable transport methods. RT phone lines make simulcast difficult because they may not be identical and can change frequency response characteristics based on temperature variations. Identical base stations of the same type and vintage should be used. This analog technology is fairly well known, but the P25 implementation requires more discussion.

P25 Simulcast in Washington

The Benton County, Wash., radio system was an analog 800 MHz Motorola SmartNet system operating with five sites to cover an area of about 1,800 square miles. The county contains the Hanford Nuclear Reservation and is north of the Umatilla Chemical Depot, an Army facility that houses chemical weapons. The county radio system was originally built with Chemical Stockpile Emergency Preparedness Program (CSEPP) funds and served the county well for about 15 years. The 800 MHz system was used for day-to-day public-safety, public-service and utility communications, and it was designed using omnidirectional antennas to provide signals in the populated areas from two or three sites.

Because the system was nearing the end of its useful life, it was updated to a Motorola P25 digital trunked system using the same sites. For trunked systems, there is no choice but to upgrade



The conversion from analog to digital, whether trunked or conventional, will likely not be as simple as taking out an analog system and dropping in a digital system, especially if simulcast is involved.

to a digital system. Essentially, all new trunked systems being manufactured are digital. However, because the P25 modulation format has less simulcast overlap delay tolerance, the new design used highly directional antennas to minimize the radio signal overlap areas. This resulted in lower overall signal levels in much of the populated areas with some apparent reduction in coverage. An agreement between the Department of Energy and local Native American tribes caused the relocation of one of the main high sites, resulting in additional loss of coverage. The overall system coverage is still being evaluated.

The conversion from analog to digital, whether trunked or conventional, will likely not be as simple as taking out an analog system and dropping in a digital system, especially if simulcast is involved. Digital isn't bad; it's just different. Different design factors need to be considered, as well as the operational setup. Mobile and portable programming can be complicated because of the large number of settings available. Simulcast overlap that is acceptable in analog systems isn't acceptable in P25 systems. With analog, simulcast distortion may result in fuzzy audio or slightly distorted audio, but in digital, simulcast distortion can result in complete loss of audio. There is no graceful degradation, which needs to be considered when planning the overall design.

P25 Simulcast Parameters

All the parameters important in analog simulcast are still important in digital simulcast, but the names change a little. Carriers at each site must be precisely matched. Symbols — the four-level character corresponding to a pair of bits — must be aligned. And transmit levels must be exactly the same for all base stations on a particular channel.

A characteristic of digital signals is that even with a number of unreadable symbols, the audio produced is just as good as an uncorrupted stream. On the other hand, when a significant number of symbols can't be decoded, there is no audio — only silence. Digital provides excellent audio longer, but at the fringe; analog will let you know something is happening, whereas digital is just silent.

Digital systems typically use an IP backbone for connectivity. The packets are time stamped and carry the 9,600-baud payload (12,000 for P25 Phase 2 trunking control channel). Allowable distances between digital sites are smaller than possible in analog simulcast systems. A modulation technique called linear modulation allows for greater distances than simple C4FM, but allowable intersite distances are still less than half the distance between analog sites. P25 Phase 2 uses a Constant Envelope Quadrature Phase Shift Keying (CQPSK) modulation.

Analog simulcast systems can be designed and integrated by radio dealers, OEMS and end users. Analog systems can be pieced together over time. P25 simulcast systems are more involved and are installed by an OEM or a dealer who has emulated the OEM's design using exactly the same hardware and software. Looking down the road, P25 systems with capability to migrate to P25 Phase 2 will meet 6.25-kilohertz channel capacity.

While public safety has adopted P25 as its digital standard for interoperability, other digital technologies that are appearing in North America include: Digital Mobile Radio (DMR), NXDN, OpenSky and TETRA. Some of these alternate technologies are already capable of a 6.25-kilohertz channel equivalent. About half of these alternate technologies can be simulcast (same frequency from multiple sites), while others are oriented to different frequencies from multiple sites.

Deciding whether to stay analog or make the jump to a digital P25 system is a major decision in which many factors should be considered. Economics can play a role, but the existing proven simulcast technology will support either path selected. ■

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