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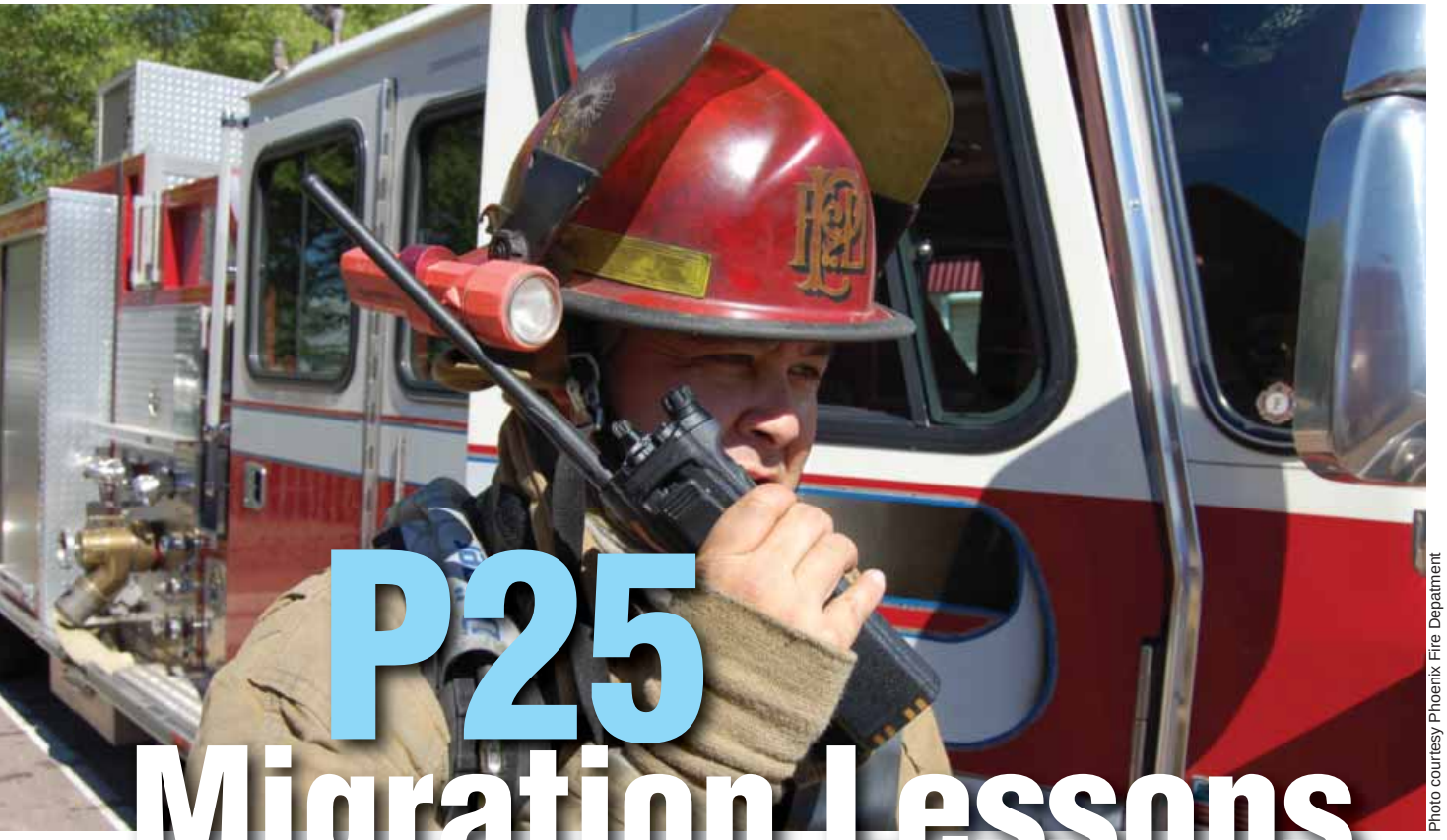

Photo courtesy Phoenix Fire Depatment

P25 Migration Lessons

Audio quality, coverage, maintenance and user experience are some of the features that can change when an organization moves to a digital technology from analog.

By Joe Blaschka Jr.

The conversion from analog systems to Project 25 (P25) digital systems has both positive and negative aspects. The audio quality will change for the better and for the worse. Many times the quality is in the ears of the listener and is hard to quantify. RF coverage that previously was determined largely by signal strength, with the possible exception of simulcast systems, now will also be significantly affected by multipath, resulting in a more complex network to measure and quantify. Changes in maintenance will require new skills for many technicians and engineers. The biggest change is how users experience the radio system's operation. The change in user experience is often the most difficult aspect to deal with. It is better to deal with the challenges before deployment rather than after when they can affect service. Much of this discussion applies to moving to a Digital Mobile Radio (DMR) or NXDN system as well.

Radio Coverage

Love and radio coverage, probably the two most misunderstood things in the universe. Many vendors have used the famous digital versus analog

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voice quality chart shown on Page 24. While there are many cases where this graph holds true, it does not tell the whole story about the complex world of radio coverage. This plot assumes signal level is the only impairment and does not include multipath, which causes delay spread distortion, or mobile flutter, caused by multipath and resulting in momentary signal loss. The effect on the audio quality depends on the degree of multipath and the frequency band. VHF wavelengths are much longer than at 800 MHz, so the areas of signal cancellation at VHF can be larger than at 800 MHz, resulting in a different effect. The difficulty is radio vendors cannot predict where there will be severe multipath issues other than possibly by field experience. This means coverage predictions may not match the actual field experience. The vendors generally have an escape clause about multipath interference, much like they do for other types of interference.

Bidirectional amplifiers (BDAs) can also result in some coverage problems. BDAs were often installed in buildings to support a previous analog system. Coverage at the BDA inside-outside signal boundary has always been a problem because of the signal delay inherent in BDA amplifiers. This often manifested itself in analog systems as an area where audio was distorted but the RF signal could still be heard. In a digital signal, this area usually has a high bit error rate (BER), causing the radio to not decode any signal regardless of the signal level. This can create pockets of "no coverage" in buildings around windows, doors or other RF entry points in the building. BDA systems often will need to be retuned or the coverage modified to move these coverage holes to another location in the building. Sometimes coverage holes can occur outside the building if the BDA system has exceptional coverage outside or at the entrance of tunnels. Regardless, do not be surprised if BDAs within your coverage area may need to be revisited after the conversion to digital.

Lessons Learned: Radio coverage is more difficult to predict with digital signals than with analog, and the digital impairments can be catastrophic. Make sure you have a good understanding of areas that might have high multipath. Be prepared to revisit BDA systems.

Measuring Coverage

Remember the good old days when measuring coverage was just taking out your radio and checking to see if you could "bring up the repeater" or maybe driving around with your service monitor to measure signal strength? Digital radio changes everything. It is all about signal quality and delivered audio quality (DAQ) and less about signal level. Certainly, the signal has to be above the noise threshold, but now the BER has to be less than 5 percent and ideally around 3 percent or better. Even with signal strength of -60 dBm, the radio will not decode if the BER is above 5 percent. We learned long ago that measuring analog simulcast signal strength was not adequate to measure DAQ. Some form of audio testing is required. P25 requires measuring BER with some audio testing as well. There is no "carrier tail" with P25 systems, making it so random coverage testing is also more difficult.

Lessons Learned: Invest in P25 test equipment with the capability to measure signal levels and BER, and log the associated GPS coordinates. Do not assume areas with good signal strength will have good audio quality.

Network Issues

The data technicians say it is all just bits. However, anyone who has deployed a VoIP system knows some bits are fussier than others. Networks supporting regular data connections may not adequately support P25 radio links because of latency and jitter values. A half-second delay in an email is not noticed; it is noticed with P25 audio. Different vendors have different network requirements so understand these prior to deploying a P25 system. Also, many radio service shops and technicians do not have experience with data networks. The wrong setting in a router or switch or cable connection can cause a data storm and bring down a network. Implementing a P25 radio system often requires additional training in network technologies and implementation.

Lessons Learned: Data networks are critical to a P25 system implementation. Be sure to have qualified network support personnel available and understand the vendor's requirements.

Audio Quality

Audio quality is a subjective thing. DAQ is scored as follows:

- DAQ 1: Unusable. Speech present but not understandable.
- DAQ 2: Speech understandable with considerable effort. Requires frequent repetition because of noise/distortion.
- DAQ 3: Speech understandable with slight effort. Requires occasional repetition because of noise/distortion.
- DAQ 3.4: Speech understandable without repetition. Some noise/distortion present.
- DAQ 4: Speech easily understood. Occasional noise/distortion present.
- DAQ 4.5: Speech easily understandable. Rare noise or distortion.
- DAQ 5: Perfect. No distortion or noise discernible.

Different listeners have varying tolerance to distortion or voices with different tonal qualities. One person might grade the same audio as a 3.4 or 4.0, while someone else might give it a 3.0 or lower. This difference can be especially true in public safety where some responders may have varying degrees of hearing impairments. Some users who can pick voice out of considerable static and background noise struggle initially to hear the different sounding audio from a P25 system. The quality and sound of the

voice is also affected by the speaker's tonal qualities, which has a tendency to magnify some tonal aspects of the person's speech. Users generally learn how to listen to the new audio sound after a few months as they adjust to hearing the different-sounding audio.

The vocoding process in digital systems does not tolerate high audio or sound levels. When this occurs, the audio has a tendency to simply go away or become totally unrecognizable. This can occur because of excessively loud talking or loud background noises. The manufacturers have done an excellent job of adding voice processing to manage the audio levels and background noise to keep the vocoder from being overloaded.

P25 radios generally have more audio controls and settings than analog radios. In addition, the radios are usually optimized for accessories such as speaker microphones, ear pieces, Bluetooth headsets and related items from specific manufacturers and for specific applications. As a result, using a Bluetooth headset from a third party may result in unacceptable audio. The same applies to the use of speaker microphones. Accessories are more application specific than in the past, and the settings are more critical. It is critical all accessories be tested in the field and with the radios they are intended to be used with prior to deployment.

Another area to be vigilant is when external analog systems are interconnected to a P25 system through a gateway or similar device. All of the level-setting issues also apply to external analog interfaces as well. An interface to an analog interoperability channel may experience widely varying audio levels because of the levels of the other systems being interconnected. Static and background noise on the analog radio system will be input into the P25 system as well. This can result in distorted audio that does not sound like the original analog input. Careful level setting is required and may require resetting levels in the analog infrastructure as well.

If users have not experienced digital audio before, it is advisable to implement some aspect of a digital system for training, testing and obtaining feedback. This can simply be done using a single P25 repeater for training and radio testing. If the system can be installed and the users placed on it after a few months of training, that is ideal, but that often does not happen as there is pressure to move to the new system as soon as possible.

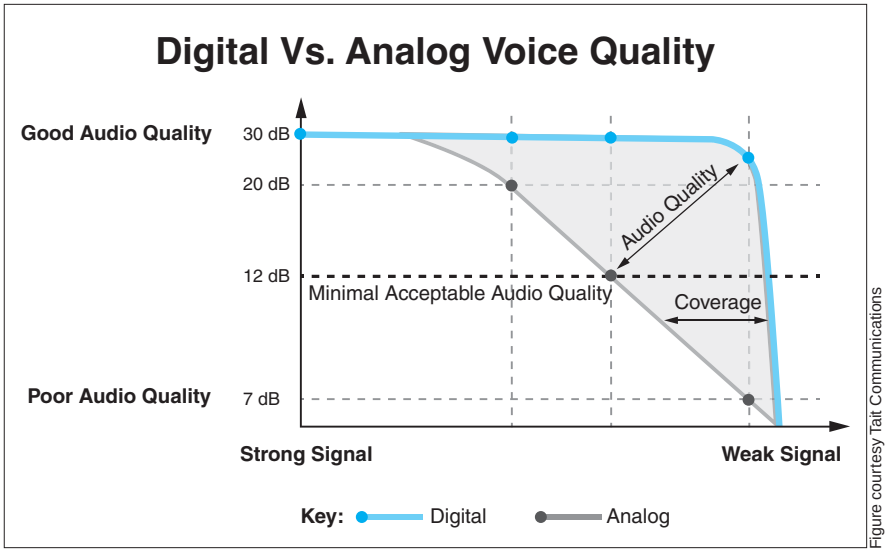

Figure courtesy Tait Communications

Lessons Learned: Audio quality is subjective, and it will be difficult to please everyone. Accessories and radio adjustments have a profound effect on audio quality. Be sure to allow plenty of time for user training and audio-quality acceptance when moving to a new system.

User Experience

User experience, not how the actual system performs from a technical point of view, is what matters. User acceptance of any new system is the primary factor for success. The user experience with a digital radio system is often profoundly different than that of an analog system.

Digital audio quality is different. It is not necessarily better or worse, but it is different. The sound is different, and the impairments are different. This will take some adjustment by the users.

Radio operation cues will change. Many systems provide some type of carrier tail or "repeater hang-time," when the user dekeys so they know they "hit" the repeater. These all go away with a digital system. With a conventional digital system, there is no indication a repeater was keyed. With a trunked system, the traditional talk-permit tone and similar feedback devices are available if they are turned on. There is also little warning about the loss of signal strength. The user has little idea if they are moving to a poor coverage area because there is no static or background noise.

The sudden loss of coverage is a problem. Digital radio signals work fairly well until they can no longer decode the signal. This results in a sudden drop in coverage many users do not like. With an analog system, the coverage loss was more gradual. For example, a portable radio sitting on the chief's desk might be fully quiet in one corner and noisy in the next, but at least it was known when someone was transmitting because the carrier could be heard. With a digital signal, the radio may sound perfect over most of the chief's desk but at that one spot where it falls below an acceptable BER, it will be totally silent. This can happen in a meeting room where some portable radios receive the signal perfectly and others

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receive nothing. This takes some getting used to.

Loss of background noise is a mixed blessing. In most cases, the loss of background noise because of the speech processing is a good thing. Digital voice processing mutes many sounds, such as traffic, music and background crowd noise. However, in other cases, the noise can help understand what is going on at the user's location.

A mixed analog and digital environment can cause users to complain about the analog system. Users who have been operating on a digital P25 system and who have gotten used to the audio often have a lower tolerance for the normal analog radio static and noise. That means the digital radio system might be a success, but now the complaints will be about the old system or neighboring analog system. In the end, it is all about the user experience and how users accept it.

Lessons Learned: Expose users to the changes in the difference between analog and digital as soon as possible. Early exposure, training and user feedback will help tremendously in implementing a successful cutover to the new system.

Maintenance

There is a dramatic change in maintenance when moving to a P25 system. There are few places to make adjustments. The few adjustments necessary are often more critical than in the past. This is a major change for many technicians. In general, there are no deviation adjustments, intersystem level setting updates or channel banks to change. It's just bits. Where there are analog levels, measuring them can be difficult due to the lack of standard interfaces.

This requires the technician to step back and think about how these systems work and where the critical interfaces are. The standard process of dividing the system to find the problem still applies, but the system may be much different and not as intuitive. This is further complicated because almost all of the indicators in these systems must be viewed through a computer laptop screen. Gone are the voting receiver lights, switches to turn off a receiver receiving interference, and lights on the front of the base station indicating when it is transmitting.

Lessons Learned: Maintenance skills learned over years of maintaining analog systems will need to change. The thought process involved with troubleshooting has not changed. The nature of the systems and failure points require additional training and thought.

The biggest lesson is that converting to a digital system is not business as usual. The most successful implementations are by those who realize what those differences are and account for them in the planning of the system, implementation and user training. One does not live long enough to make enough mistakes to learn all this. It is much better to learn from the successes and failures of others. ■

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