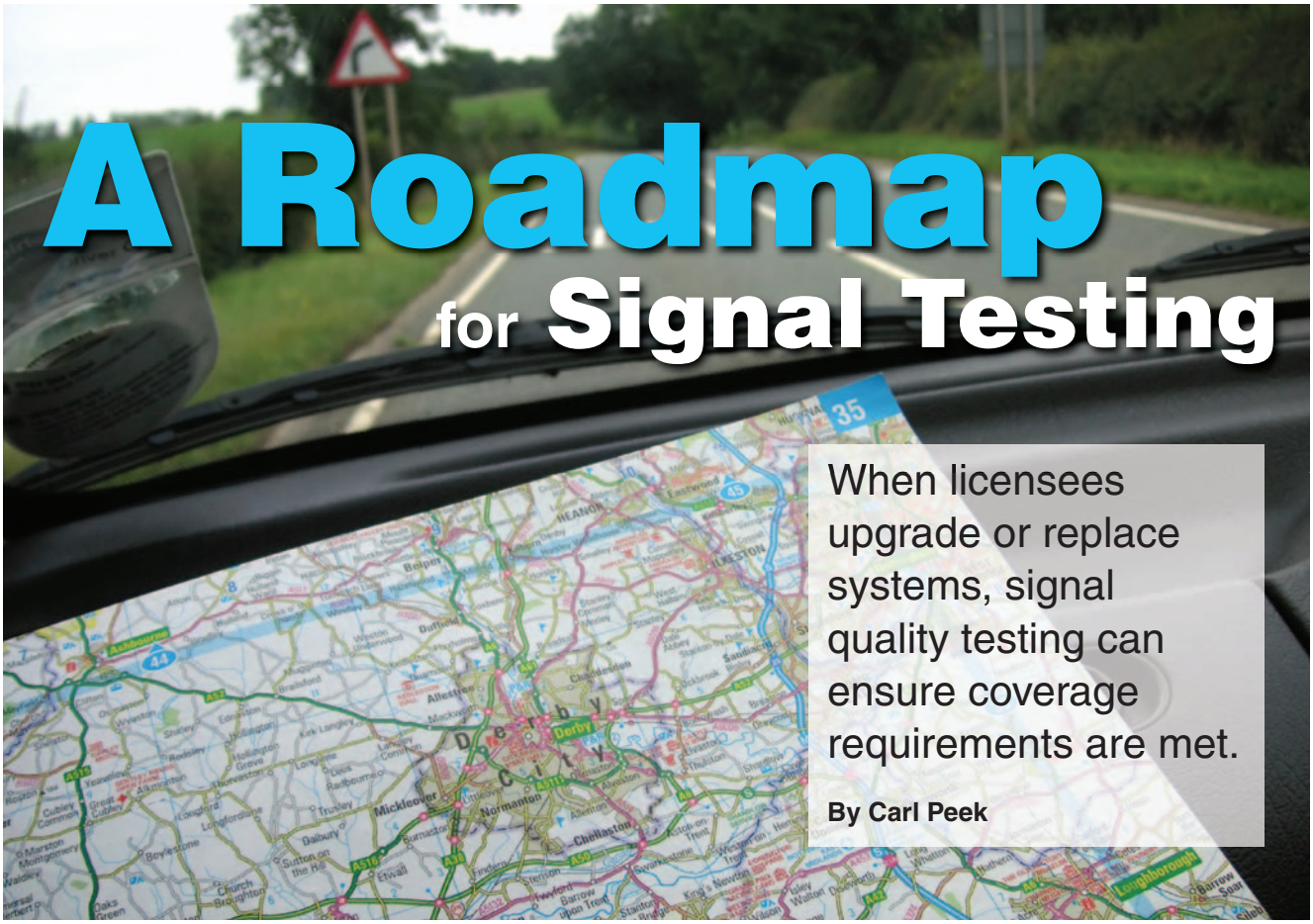


A Roadmap for Signal Testing

When licensees upgrade or replace systems, signal quality testing can ensure coverage requirements are met.

By Carl Peek

Government mandates such as 800 MHz rebanding, VHF and UHF narrowbanding and federal grants for Project 25 (P25) equipment have made coverage testing a required part of the wireless system engineering cycle. In addition, new legislation and policies that codify indoor coverage are emerging. These regulations are motivated by the need to improve spectral efficiency and assure the safety of first responders.

A wireless system may adequately meet the needs of a licensee; however, technology changes and federal or local legislation could require that an existing system be replaced or significantly changed. In these cases, the system designer must:

- Benchmark the coverage of the existing system;
- Specify the new system based on existing coverage performance; and
- Test the new system to meet the coverage specifications.

Most system operators are familiar with the signal strength test for analyzing a wireless system's signal quantity across an area of intended coverage. This has long been the standard for new system compliance tests. However, the ultimate test of a signal is not its quantity, but its quality — the ability to communicate, which can be measured in SINAD for analog and bit error rate (BER) for digital systems.

Drive test packages automate over-the-air measurements while driving or traveling throughout an area of interest. A test system can be set up to combine many types of measurement data with time and location in a measurement database, which can then be analyzed for a variety of purposes.

Testing Signal Quality

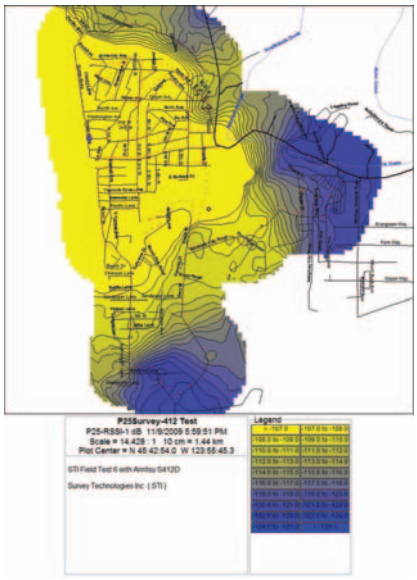
Digital. BER and signal strength measurements combined during drive tests provide wireless engineers with an indication of the quality of the wireless link across a service area tested. Transmitters are usually equipped to create a known bit pattern for tuning and testing performance. These patterns can be transmitted over the RF link and received, decoded and analyzed for accuracy. Some manufacturers' P25 radios have the ability to decode a standard pattern and provide a BER. And some manufacturers of digital radio test sets have developed highly sensitive instruments that can decode BER off the air.

System engineers must determine whether they want a calibrated instrument conducting this analysis or if they are testing a radio's ability to receive and decode the signal around the service area. Both are valid tests. Digital radio test set and subscriber unit solutions are both used for analyzing digital signal quality of wireless systems such as P25 networks.

Drive tests of signal strength and BER concurrently are the best way to measure the performance of a digital voice link. Comparing the two reports on Page 30 shows a small area about one-third of the way from the bottom where a slight drop in signal strength results in a disproportionately large drop in signal quality (BER).

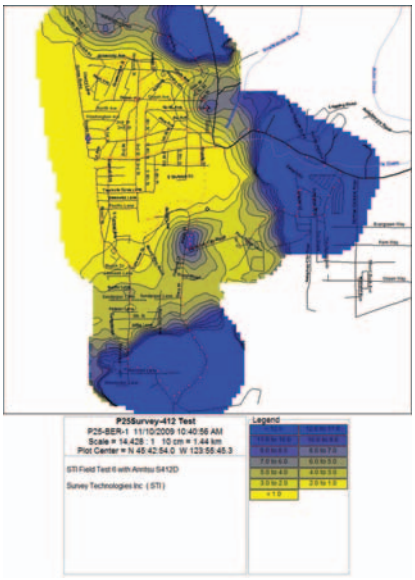
A small hill to the north causes only

Signal Strength Test



Report of the signal strength from a small transmitter using STI Field Test 6.

Signal Quality Test



Bit error rate (BER) result indicating signal quality taken during the same drive test.

a small attenuation in signal strength. However, the signal quality is greatly affected because of distortion of the signal around the edges of the hill.

Analog. Signal quality for analog signals is measured by SINAD. Engineers with analog voice link interests can use a drive test package to make audio SINAD measurements of a two-tone signal being transmitted over a voice link. An engineer's test radio receives the signal, and the test system digitizes the signal across the radio speaker or earpiece.

A fast Fourier transform (FFT) is performed on the audio sample to convert the time sample to a frequency spectrum. The power of the desired two tones (signal) is then compared with the power outside the two tones (noise and distortion). Signal strength along with audio SINAD measurements are the best ways to analyze the performance of an analog voice link.

Distortion. Signal quality measurements such as SINAD or BER will uncover areas of signal distortion or co-channel interference where signal strength is high but quality is reduced, allowing the designer to take action to counteract the effects of the distortion.

Testing System Compliance

Compliance testing is one of the major reasons that system engineers are mandating drive tests. Performance specification and methodology are the most important parts of a new system acceptance plan. A testing methodology including a tile analysis of test results can be used to quantify the coverage of a system.

After data collection, the area of interest can be analyzed statistically using analysis based on rectangular tiles. A verifiable specification statement for a communications system using this quantitative form of analysis might read, "Tile sizes will be 30-second rectangles. After qualifying 80 percent of the tiles in this geographic area with at least 10 measurement samples, at least 95 percent of the qualified tiles must have 100 percent of their measurements above -95 dBm." This allows for an objective standard when writing contracts for system development and compliance testing of that system's performance.

Testing Indoor Coverage

In many urban areas, public spaces such as transit stations, arenas, large shopping centers, schools and government buildings are now required to have specified levels of wireless coverage or performance. This is becoming more common as national, state and municipal governments are increasingly aware of the need for reliable communications in the face of potential disasters.

How are these requirements satisfied? The indoor testing option in some software provides the ability to perform tests where GPS reception is unavailable. The user provides a building plan as a background map and specifies a measurement route on the plan. Measurements are performed while traveling between points on the measurement route. The software then locates the points geographically and uses the recorded measurements to create contour plots.

Testing Uplink

Uplink testing is important for two reasons. First, there is a difference in portable versus site-transmitted power, which means the transmission from the mobile to the site (the uplink) is a weaker link. Second, the uplink and downlink in a voting receiver network architecture use completely different radio links.

For uplink testing, a mobile in a test vehicle transmits to the site; its position and the time of the transmission are recorded in one database. Meanwhile, the test system at the site is measuring signal characteristics, logging measurements and the time of each measurement. After testing is complete, an application can combine these two databases based on time, and contour plots of measurement value over geography can be created.

Synchronous Testing

If intermittent measurements are required, an application such as STI Field Test 6 can be employed to synchronize transmission time and measurement time and combine the databases after the measurements are complete. In cases where a transmitter can't be turned on full time, a synchronized measurement is required. This special technique is enabled by a GPS timer application and an external computer-controlled relay.

The application synchronizes to GPS time of day and controls measurement start and stop times, transmitter on and off time, as well as the total measurement cycle time. A computer controlled relay allows a user to energize a mobile transmitter through a

relay closure.

Hang Time Testing. The computer-controlled relay activates a mobile transmitter, which causes a site transmitter to respond. The measurement is made immediately after the relay deactivates the mobile transmitter and during the hang time of the site transmitter.

Synchronized Testing. The software and hardware activate a site transmitter at the same intervals that the mobile test unit is directed to make measurements by the GPS timer driver extension.

These technology options allow measurements and the test signals to be synchronized to GPS time of day at different locations.

Coverage Prediction

Many propagation software packages have the ability to import and display drive test measurements so that an actual versus predicted analysis of signal strength can be performed. The method of using drive test measurements to calibrate a prediction result is especially useful when planning a wireless system expansion. The existing system's actual signal coverage can be measured and compared with the existing system's predicted coverage. If necessary, the prediction can be adjusted to more accurately reflect existing measured coverage. This increases confidence in projected coverage for system changes or expansion.

A testing methodology including a tile analysis of test results can be used to quantify the coverage of a system.

In this way, models of the existing system are made with planning software, calibrated against drive test measurements and used to plan the system expansion. To assure communications critical to the safety of our first responders, drive test measurements of signal quality, as well as signal strength, are essential steps in system design, construction and validation. ■

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