From the Chair

by Ralph Haller

The last quarter has been a particularly busy time for NPSTC. Many thanks to the Government of Canada and to Lance Valcour, Canadian Interoperability Technology Interest Group (CITIG), for hosting a very informative and productive Cross Border Interoperability and NPSTC Committee Meeting at their impressive Embassy in Washington, D.C., in May…

D Block Legislation: Will it Be Passed by 9/11?

As September 11 approaches, Congress is under some pressure to pass legislation on the public safety broadband network, which the White House supports. The Dingell-Green Bill, Rockefeller-Hutchison Bill, would give the D Block to public safety, provide funding to build the network.…

NPSTC Opposes Freezing 700 Narrowband Spectrum Proposed in Republican Draft Legislation

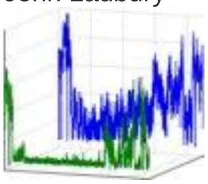
NPSTC urges House to make public safety a priority by reallocating the D Block and providing funding for broadband network as is proposed in Senate Bill S.911…

Intrinsically Safe Issues Still Unresolved

In September 2010, NPSTC learned a new version of the intrinsically safe standard affecting LMR was to go into effect January 1, 2012. FM Approvals intends to replace their current, still safe standard…

Radio-Frequency Measurements to Support Public Safety Wireless Communications in Large Buildings and Structures

by William Young †, Kate Remley †, Christopher L. Holloway †, Galen Koepke, Dennis Camell, and John Ladbury



The public safety community requires dependable wireless communications in buildings that often degrade the radio-frequency channel due to construction materials, architectural features, and large physical dimensions…

GPS TWG Sends Report to FCC: The Controversy Continues

LightSquared is a company that has spectrum in the 1.5 GHz band adjacent to the spectrum used by all GPS receivers… This could radically change and degrade the spectrum environment in which adjacent GPS signals are received…

Protecting Public Safety Communications – Preparing for Coexistence of GPS and 4G Broadband

by Jeff Carlisle, EVP of Regulatory Affairs and

An Alternative to IECGP: Emergency Communication Goals and Activities Funded by FY 2011 Homeland Security Grant Program

Public Policy, LightSquared

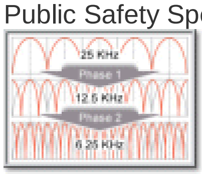
No one in public safety would argue that a basic requirement for first responders is dependable communications… Careful coordination of all spectrum licensees is critical to ensure peaceful coexistence among the competing demands for spectrum…

(HSGP)

Earlier OEC announced that IECGP was defunded in FY 2011… To ensure emergency communication priorities were preserved in FY 2011, OEC worked with FEMA to incorporate emergency communication goals and activities into HSGP…

Narrowbanding: Complying with Two FCC Deadlines

by Mark Rychman, ICMA representative to the Public Safety Spectrum Trust



(Editor's Note: This article first appeared in ICMA's Public Management Magazine. Managers may not be aware of it yet, but another unfunded mandate is waiting just around the corner. The FCC is taking steps to more efficiently allocate the limited airwaves (or spectrum) available.…

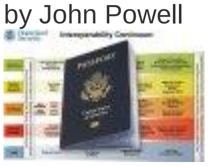
Regulatory Update

by Bette Rinehart, Chair, Editorial Review Working Group

FCC Issues Guidance on Narrowbanding Waiver Requests, FCC Levies $20,000 Fine for Unauthorized Operations, Comment Deadlines Extended for Signal Booster Docket, 800 MHz News, 700 MHz News, and more…

The Roaming Continuum

by John Powell



William K. ("Bill") Jorgensen is the Director of the Williamson County Office of Public Safety in Franklin TN south of Nashville. He is also one of OEC's many COML instructors and one of the driving forces behind the production of (and a star in) the highly successful Tennessee DVD, *Are We Prepared, The Interoperability Continuum*…

Compelling Video on Interoperability and the Value of the Interoperability Continuum

courtesy of the Tennessee Emergency Management Agency (TEMA)

A straight-talking, compelling video that will help the public and its officials understand what interoperability is, and why it is imperative that public safety be able to talk to one another has been developed…

NPSTC Provides Added Public Safety Input to DHS Video Quality in Public Safety (VQiPS) Initiative with New Video Technical Advisory Group (VTAG)

Since We Last Met

NPSTC Filings (VOIPS and 700 MHz, LightSquared, TETRA,…), Canadian "Enabling Interoperability Forum" in September, PSAC Adopts Recommendations…

NPSTC announces the creation of a practitioner advisory group, the Video Technical Advisory Group (VTAG), to provide input to the DHS Video Quality in Public Safety (VQiPS) Initiative on choosing, using, and improving the ways video technologies serve the public safety community…

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The American National Standards Institute (ANSI), International Society of Automation (ISA), and Underwriters Laboratories (UL) are organizations that develop consensus standards through the participation of manufacturers, regulators, and consultants as well as standards certification organizations like FM Approvals.

Radio-Frequency Measurements to Support Public Safety Wireless Communications in Large Buildings and Structures *

by William Young †, Kate Remley †, Christopher L. Holloway †, Galen Koepke, Dennis Camell, and John Ladbury

Abstract

The public safety community requires dependable wireless communications in buildings that often degrade the radio-frequency channel due to construction materials, architectural features, and large physical dimensions. Here we introduce measurements made by the Public Safety Communications Research Program focused on public safety radio frequencies in large buildings and structures.

Studying Radio Communications

Wireless communications technology represents a critical component to the successful and efficient operation of public safety organizations. This article overviews studies and results from the Public Safety Communications Research (PSCR) measurements of radio-frequency (RF) propagation within large buildings and structures. The overall goal of this project is to create a large, public domain data set in the public safety frequency bands, representative of "difficult" responder radio environments.

Figure 1. Three structures used in the RF propagation studies; (a) 60-story office building in Denver, CO, (b) 11-story brick apartment building in Boulder, CO, (c) oil refinery in Commerce City, CO.

Since 2003, PSCR researchers have continued to investigate how well RF waves in a variety of public safety bands penetrate and propagate into large structures such as office buildings, processing facilities, convention centers, and apartment buildings[1]–[3]. Figure 1 shows three of the structures included in the RF propagation measurements. PSCR has collected data on sixteen buildings, providing the public safety community with information largely unavailable to date. In an effort related to these propagation measurements, researchers are testing the performance of wireless technology used in Personal Alert Safety Systems (PASS) and urban search and rescue (US&R) robots[4].

We have collected RF propagation data at narrowband frequencies ranging from 50 MHz to 4.9 GHz, and wideband data covering 100 MHz to 18 GHz. The data and accompanying analysis offer information that can support the public safety community in a variety of efforts, from designing wireless systems, to developing concepts of operations, to establishing standards for wireless communications.

Measuring RF Propagation

The measurement approach used by PSCR falls into two general categories of narrowband and wideband wireless communications. Each method offers unique insights into the RF propagation behavior within the building. The narrowband and wideband data can be thought of as providing macro- and microscopic views of the RF propagation, respectively.

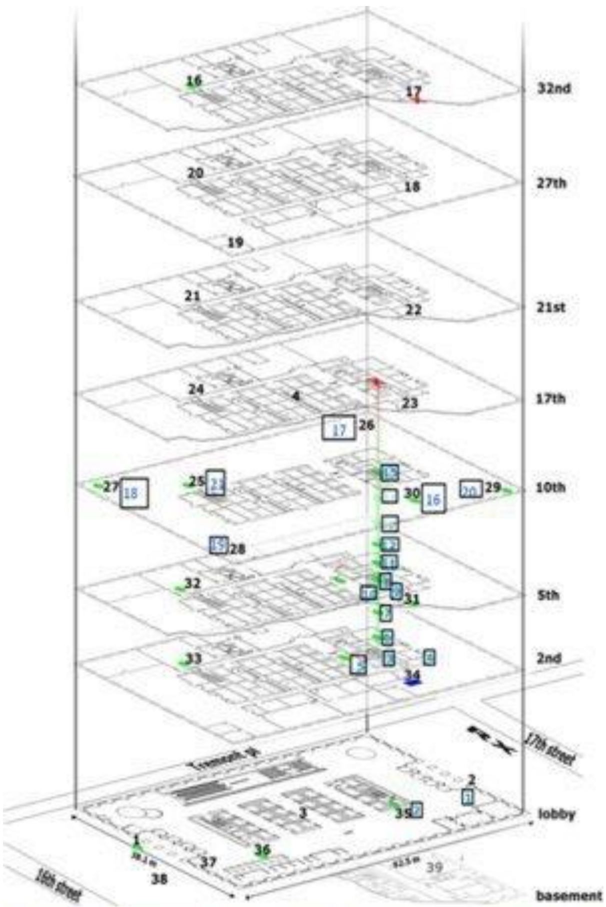

Figure 2. Testing locations for the first 32 floors of the 60-story office building in Denver, CO. The numbers not in boxes indicate key locations in collecting the narrowband data; the boxed numbers are wideband and PASS device testing locations.

The narrowband measurement process simulates public safety personnel moving through the building while communicating with a temporary command center located outside the building. For these measurements, a person carries a mobile radio or transmitter that is continuously emitting an unmodulated signal at or very near a particular public safety frequency, e.g., 160 MHz, 450 MHz, or 750 MHz. At a site outside of the building, the received signal power level is sampled using a spectrum analyzer, along with information about the general location of the mobile radio. For example, in Figure 2 the time is recorded when a mobile transmitter reaches an unboxed number as the transmitter is carried through the building. These data are used to create a "radio mapping" of the building by plotting the received RF signal power versus time. An important consideration in the narrowband collection process is to cover key features of the building such as stairwells and basements where radio communication is often intermittent and weak.

Wideband data support detailed analysis of reflections and scattering within the structure. This is known as a multipath environment. These data are collected over wide frequency bands of widths ranging from 100 MHz to 18 GHz, and support analysis of the time-domain characteristics. Figures of merit such as the root-mean-square (RMS) delay spread may be calculated and used to quantify the period required for multipath reflections to decay below a given threshold level. Generally speaking, the longer the delay-spread, the stronger the multipath effects. Because the collection process for wideband data is time consuming and uses a fiber-optic link, limited numbers of locations are measured in the building. The boxes in Figure 2 show example wideband measurement locations.

As noted above, other concurrent tests capture the performance of a specific wireless technology, such as PASS or US&R robots, at key locations in the same structures. This enables the development of laboratory tests that emulate the same propagation environment. Correlating results from real-world measurements and laboratory tests helps validate the laboratory test in predicting performance in real-world deployments.

Viewing the Collected Data

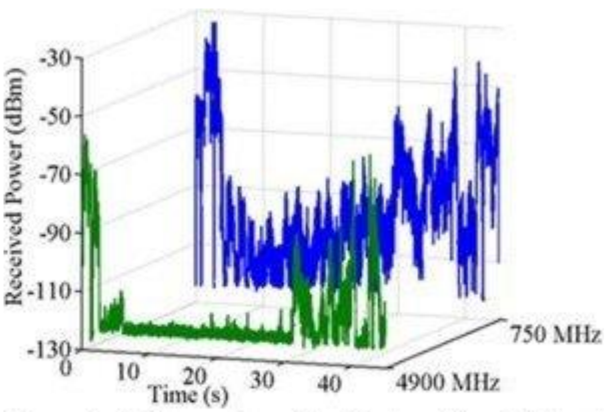

Figure 3. Radio mapping of the 60-story office building at 750 MHz and 4.9 GHz based on measured values collected at one of the receive sites. The other two receive sites show similar measured values.

The collected data are initially viewed in several ways. For example, Figure 3 shows a typical radio mapping for the 60-story building. Notice that a significant portion of the 4.9 GHz signal is below the spectrum analyzer's noise floor of -120 dBm, which demonstrates that the 750 MHz signal penetrates deep into the building better than 4.9 GHz does. The noise floor is the power level where the signal is not of sufficient level to detect.

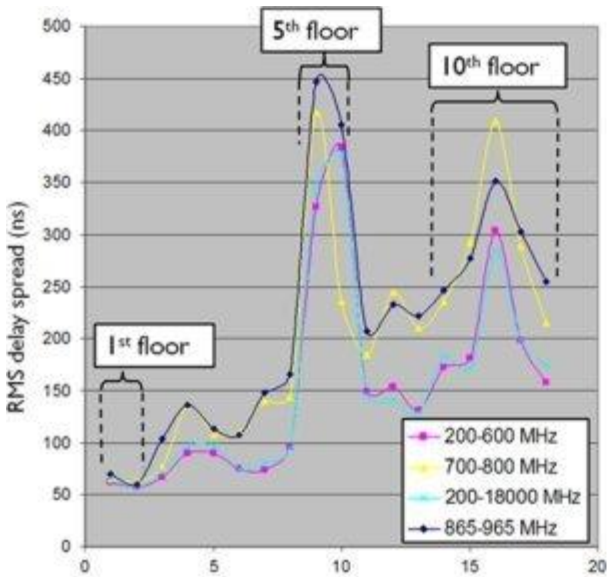

Figure 4. The RMS delay-spread at 18 locations inside the 60-story office building.

From the wideband data, we obtain delay-spread results. Figure 4 shows delay-spread values for the 60-story office building, where the delay-spread actually decreases from the 5th to the 10th floor. This decrease is due to the fact that the 10th floor was a wide-open room with no partitions, while the 5th floor contained many partitions and small offices.

Gaining Insight into Performance

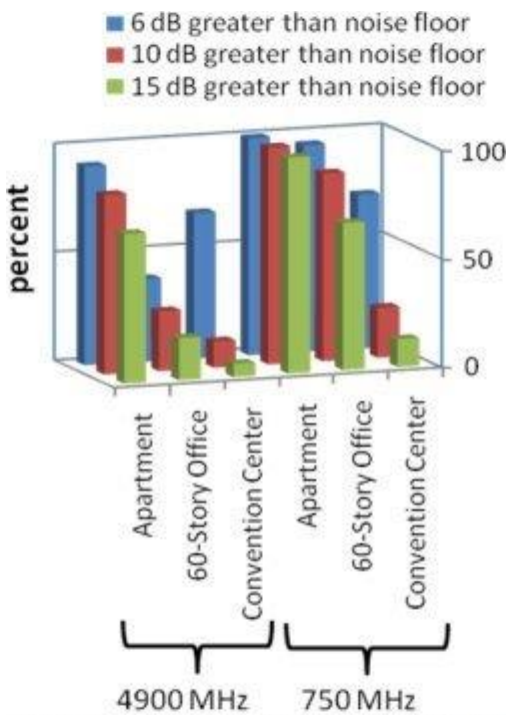

Figure 5. Percentage of received signal that exceeds the noise floor by 6, 10, or 15 dB.

Subsequent analysis of the collected data allows further insight into wireless device performance differences due to frequency and/or building types. For example, the percentage of data greater than the noise floor provides an estimate of coverage percentage within the building. Figure 5 is a comparison of three buildings and two frequencies at three different thresholds above the noise floor. As expected, the percentage coverage is best at 750 MHz for all three buildings. More interesting is the less than 40% coverage for the 60-story office building at 4.9 GHz for all three threshold values that we selected.

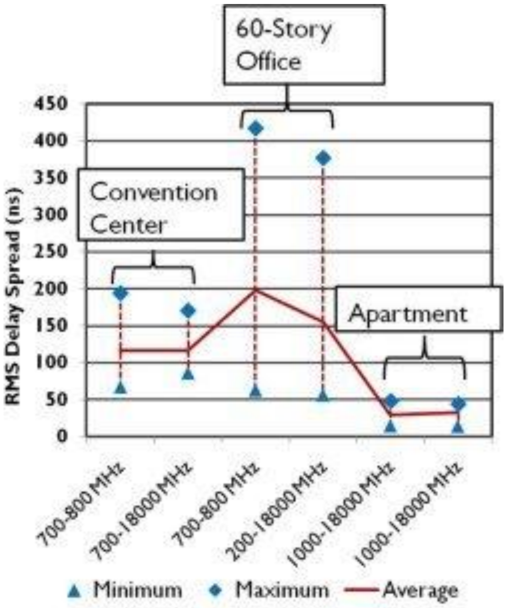

Figure 6. The average, maximum, and minimum delay-spreads measured in three different buildings.

As an example of the time-domain behavior, Figure 6 illustrates the delay-spread behavior for three buildings. The longest delay-spread values occur in the 60-story office building, while the shortest values occur in the apartment building. Thus, the apartment building does not exhibit as strong a multipath environment as either the office building or the conventions center.

Additional Information

This article provides a brief overview of PSCR's activities in radio frequency propagation for the public safety community over the last several years. The example data and interpretations are intended to raise awareness of both the existence of the data as well as the potential value of this extensive data set. For example, radio mapping data can support coverage prediction, the delay-spread data can help with transceiver design guidelines, and both types of data are useful in developing channel models for numerical or simulation-based performance analysis. The reader is encouraged to explore the following website[5], which contains multiple reports based on these data. These reports include a large set of statistics on radio-frequency propagation such as mean RF signal penetration, variability, and delay spread.

References

[1] *W.F. Young, et al., "Radio Wave Signal Propagation Into Large Building Structures Part 1: CW Signal Attenuation and Variability," IEEE Transactions on Antennas and Propagation, Vol. 58, Issue 4, April, 2010, pp 1279-1289.*

[2] *K. A. Remley, et al., "Radio Wave Signal Propagation Into Large Building Structures Part 2: Characterization of Multipath," IEEE Transactions on Antennas and Propagation, Vol. 58, Issue 4, April, 2010, pp 1290-1301.*

[3] *C. L. Holloway, et al., "Attenuation of Radio Wave Signals Coupled Into Twelve Large Building Structures," NIST Technical Note 1545, May 2008.*

[4] *K. A. Remley, et al., "Interference Tests for 900 MHz Frequency-Hopping Public-Safety Wireless Devices," 2011 IEEE Society International Symposium on Electromagnetic Compatibility, Long Beach, CA, August 2011.*

[5] *http://www.nist.gov/pml/electromagnetics/rf_fields/remley_publications.cfm, scroll down to: "Wireless System Measurements for Industry and the Public Safety Sector".*

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