After 22 years of political high jinks and good ol' American corporatocracy, the promise of a versatile, interoperable, spectrum-efficient, digital public-safety radio standard is still largely unrealized.

The Great APCO Project 25 Boondoggle

By Kirk A. Kleinschmidt NT0Z

On April 4, 2008, two Ohio firefighters were killed in a house fire when their radio calls were allegedly never received by fellow firefighters on the scene. According to a comprehensive post-incident investigation, which included a detailed review of the radio call logs, problems with the digital radio system were listed among key contributing factors.

On April 21, 2010, a Charleston, South Carolina, deputy was frantically radioing for help as he wrestled with a drug-fueled suspect, whom he had already Tazed, outside a local drug store. According to an article in the Charleston *Post and Courier*, fellow officers trying to help the besieged deputy heard only honks, whistles, beeps and distorted garble from their digital radios. The newspaper further reports that the county's new $17.5 million radio system, which already needs a $12 million "upgrade" just to make it functional, has experienced numerous communication failures "that have placed police, firefighters and civilians in jeopardy."

These reports are only the smallest tip of the iceberg. Similar problems with digital, trunked public-safety radio systems plague users from coast to coast. Despite the fact that only a small percentage of the problems with these complex systems are ever likely reported by the national news media, the list of recent local headlines is startling.

Charlotte, North Carolina: "Police Radio Blackout Hits Charlotte for Second Time in One Week."

Philadelphia, Pennsylvania: "Philadelphia's Digital Trunked Radio System Fails for the 15th Time in Three Years."

Milwaukee, Wisconsin: "MPD's Digital Radio System Down..."

Palm Beach, Florida: "Palm Beach County First Responders Lose Frequencies for More Than 45 Minutes."

There are dozens more, with new stories being added almost every day.

The rocky transition to trunked, digital public-safety radio systems is the common thread that runs through these stories, but it's the Association of Public-safety Communications Officials' Project 25 (known as APCO P25) – a set of standards aimed at defining the lion's share of present and future digital radio systems – that's really in the crossfire. The U.S. House Energy and Commerce Committee became so concerned that it recently called on the Federal Communications Commission to weigh in on the issue.

On July 20, 2010, at the request of Committee Chair Henry Waxman, FCC Chairman Julius Genachowski submitted a letter that made some surprisingly pointed and straightforward observations on the problems with trunked P25 digital radio systems and their likely obsolescence.

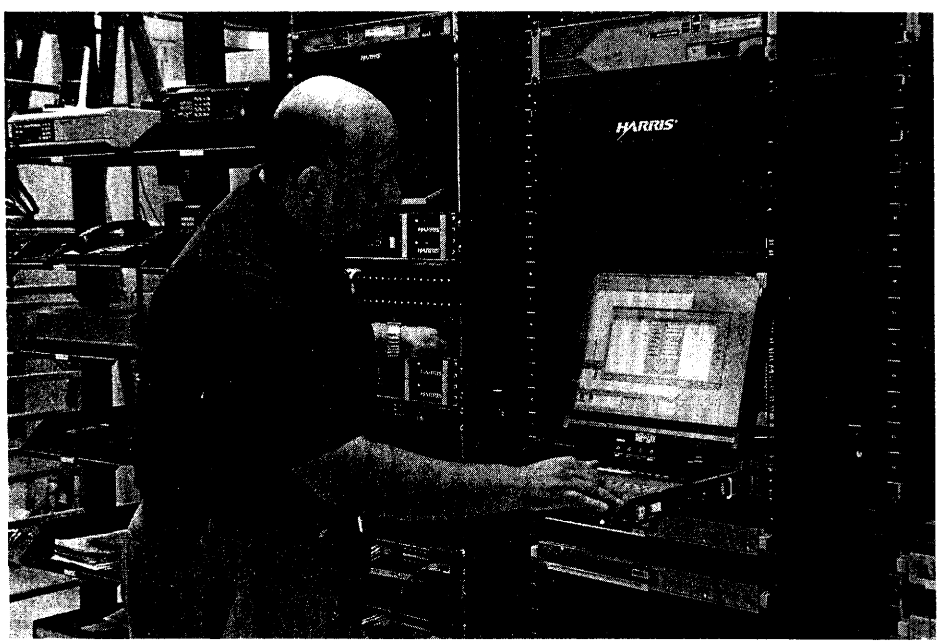
Among other things, Genachowski noted that, "proprietary solutions and market dominance play an important role in the problems with interoperability, innovation, cost and competition" in the market for public-safety communications systems; that after 20 years in the making, P25 systems rely on proprietary solutions that lack the benefit of market competition based on truly open standards; that "the current structure of the public safety equipment market may hinder efforts to achieve interoperability for a broadband public safety network" (a technology that could, and some say should, replace P25 technology altogether); and that public safety applications and services should be based on open, global standards.

In his letter, Genachowski cites a June 9, 2010, *Washington Post* article that placed Motorola's share of the public-safety radio systems market at 80%. Other manufacturers with significantly smaller market shares include Harris, Thales, EADS, Kenwood and RELM Wireless. So when the FCC Chairman's letter refers to "proprietary solutions," "market dominance," "lack of open standards," etc, it's reasonable to read between the lines and assume that the chairman is referring to Motorola and its lion's share of the action.

In fact, Motorola has been at the center of the public safety radio market since one-way AM radios were first installed in police vehicles in 1936. John Muench, a Motorola director of business development, says the company was present at the start of the P25 effort and is a key industry player when it comes to shaping P25 standards and moving them forward. "Motorola has shipped more than 1.75 million hand-held and mobile P25 radios to date," says Muench, and more than 75% of the US population is covered by Project 25 radio technology."

It's important to understand that the challenges and issues faced by P25 and other trunked, digital radio systems are vast, multifaceted and extremely complex. Some of the issues are related to the P25 standards and the standards-setting process, while others have to do with vendors, manufacturers, planning (or lack thereof) by customers and served agencies, user training (or lack thereof), technology and even the laws of physics.

Frustrating and expensive as they are, these aren't simple, cookie-cutter issues, and this article



A technician configures the "back office" central server components of a Harris P25 trunked radio system. Minus a radio or two in the background, it's difficult to tell this setup apart from a typical computer server. (Courtesy: Harris Corporation)

can only address a fraction of the overall factors. If you explore the links in the resources below, however, you will begin to see a much bigger picture. Be prepared to spend hours doing so.

APCO Project 25 in a Nutshell

Project 25 was initiated in 1989, but gained considerable momentum in the post-911 debacle summed up with the question, "Why can't federal, state and local public-safety workers talk to one another on the radio?" The standards, aimed at creating digital public-safety radio systems that are interoperable, backward-compatible with existing analog systems, and spectrum-efficient, are produced by a joint effort of APCO, various federal agencies, numerous equipment manufacturers and the Telecommunications Industry Association (TIA), which publishes the P25 standards.

But P25 is far from "all inclusive." It's a sprawling collection of multiple standards (in six main groups) that govern how P25 radios and radio systems function. P25-compliant systems are being deployed in three main phases.

Phase 1 is where the bulk of existing P25 systems operate on 12.5 kHz-wide channels (digital and legacy/analog). Most Phase 1 standards have been finalized and ratified. Phase 2 hardware adds additional digital modulation technologies to enable advanced features and a much narrower 6.25 kHz-wide channel spacing. Some Phase 2 standards have not yet been finalized. Phase 3 standards will address the public-safety use of high-speed data using wireless broadband networks and will be coordinated in conjunction with an international effort called Project MESA (Mobility for Emergency and Safety Applications). Phase 3 standards are undergoing significant development.

Problems with P25 and Digital Radio Systems

There are fundamental differences between the operational characteristics of analog and digital radio systems – just ask anyone who receives their TV signals off-air. During the recent transition to digital TV broadcasting in the U.S., countless thousands of viewers noticed that they couldn't receive digital signals from stations that were previously watchable in analog, that multipath distortion was the new watchword of the day, and that digital signals were simply there or they weren't. There was no "fringe reception zone" where signals were noisy and degraded, but watchable.

Whether we're talking about P25 or any digital radio system, trunked or otherwise, the physics of digital radio are unavoidable. If a firefighter is stuck in the basement of a building, his chances of making a successful radio call under less-than-optimum conditions are almost certainly better with an analog radio (or a P25 radio switched to analog mode). Many fire companies have come to the same conclusion and are now requiring firefighters to use analog communications at fire scenes, saving the digital radio systems for dispatch and other wide-area connections.

Value engineering:

Technology issues aside, one of the main reasons digital trunked radio systems "fail" is because they're often scaled back to the point where customers can initially afford them. The systems are so expensive – often tens of millions of dollars each – they're frequently "value engineered" to the degree that there isn't sufficient infrastructure to provide adequate coverage.

If a customer needs, say, 37 towers to provide solid coverage system-wide, but can only secure funding for an initial 19-tower system, the whole project is probably doomed from the start. High-power vehicle radios may work fine with fewer towers, but because of "value engineering," in-building communications become problematic, especially with lower-power, handheld radios, and there will be dead spots, even in some outdoor locations. Many systems suffer from these issues.

Inexperienced buyers:

When a customer, say a county, moves to implement a P25 system, administrators are faced with technical and operational challenges they're often unprepared for. They usually lack the necessary technical expertise and must rely on vendors, consultants and manufacturers for just about everything. For many local county-level technical specialists, a P25 digital radio system is the biggest, most complex project they've ever tackled, and it's often technically way over their heads. In reviewing existing "failed" installations, it's clear that some customers had difficulty securing even simple project components such as the rights to necessary tower sites.

Poorly defined functionality:

Many customers – and way too many vendors – don't fully understand or can't precisely define required system and operational features during the planning stage and, because of that, their resulting radio systems may have expensive and unnecessary features, may lack critical functionality or capacity, or simply "don't work the way they should." And when you combine confused customers with overzealous vendors, a

TRACKING INTEROPERABILITY FUNDING

By Ken Reitz KS4ZR

Nearly $1 billion in the form of federal matching grants were made available to state and local governments in 2007 to upgrade their public safety communications. The grants were a result of the 9/11 Act (Implementing Recommendations of the 9/11 Commission Act of 2007). The legislation directed the National Telecommunications and Information Administration (NTIA), the same agency in charge of the DTV transition of 2009, to administer the grants in consultation with the Department of Homeland Security (DHS). Grants were administered through the Public Safety Interoperable Communications Grant Program known as PSIC and required states and territories to fund 20% of the total requested amount.

Recipients of PSIC grants could use their funds for a wide assortment of projects not confined to radios or towers and had until September 30, 2010 to complete their projects, though limited extensions were granted. So, where did the money go? You can find out what programs your state and county had planned to do and the budgets they received through PSIC grants by going to this web site:
www.ntia.doc.gov/psic/awardsmap.html.

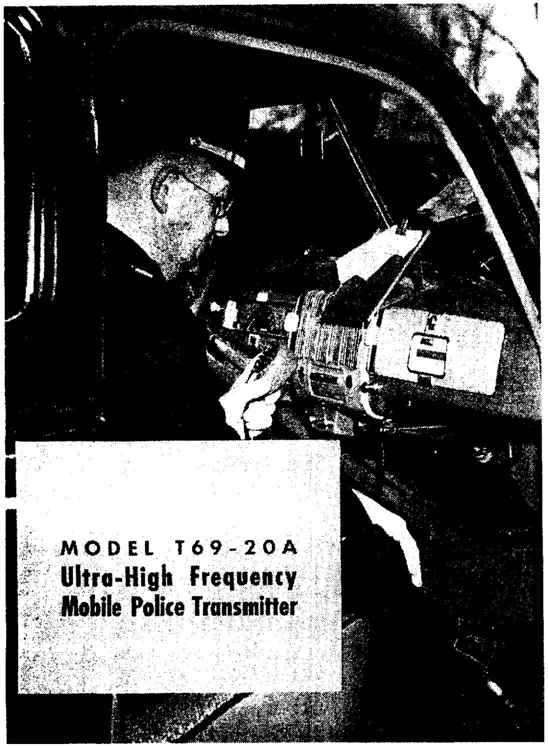
The data are complete through September 2008 and examine the status of all state and local enforcement agency preparedness. PSIC awards had a requirement that states and territories (which also qualified for such grants) have an approved Statewide Communications Interoperability Plan (SCIP) and approved Investment Justifications (IJs) prior to release of funds. According to NTIA, all 56 states and territories have SCIP through DHS's Office of Emergency Communications.

What the PSIC awards map doesn't tell is whether or not the installed systems actually work or that taxpayers are getting their money's worth or that these incredibly expensive projects are being properly managed. For that, most Americans have to rely on their local press. But, local information about a particular system may look like an isolated incident. There should be a clearinghouse of information nationwide that could provide a library of such information.

Luckily, there is. That place is a blog written by Daryl Jones, an entrepreneur in the telecommunications field whose work deals with developing advanced technology for public safety, including issues with Project 25 radio systems.

The site **http://blog.tcomeng.com** tracks mainstream media reports on problems associated with digital trunked radio systems across the U.S. You can read the actual newspaper articles that Jones has archived dating back to 2002. Headlines such as this one from September 21, 2010 in *The Oregonian,* "Oregon Emergency Radio System Running Late and $107 million Over Budget," ought to be enough to cause local governments to be humiliated, politicians ashamed and taxpayers ready to revolt.

Daryl Jones also has a running series he calls "The Appearance of Impropriety," in which problems stemming from poor project management to possible outright fraud are documented.



In 1939, the T69-20A UHF mobile transmitter was the first of its type made by Motorola. Crystal-controlled on a single frequency, it put out 10 W of AM between 30 and 40 MHz. (Courtesy: Motorola)

kaleidoscope of "failed" systems, cost overruns and the appearance of general mismanagement ensues.

Operational costs:

Many buyers simply don't plan for ongoing support and maintenance costs and are completely unprepared for apparently hidden costs, such as potentially huge fees for software licensing and other unforeseen or poorly explained expenses. P25 systems are complex, computerized, requiring expert setup with constant tweaking by highly skilled technicians, none of which come cheap (and none of which are likely to already be on county staff).

It's a big computer! P25 systems are essentially big, highly centralized, networked computers. When the server crashes or the power goes out, all communications can instantly fail until the system is restored, unlike mission-critical business computers where servers have redundant backup hardware that can seamlessly "fail over" when one goes down (and are backed by emergency power systems).

Because of ever-pressing cost concerns, many digital radio systems lack redundancy and are vulnerable to power and hardware failures. To avoid those issues, Motorola, Harris and EADS all offer expensive options for redundancy. Even so, in some cases the components that are needed to automatically switch from main to standby systems have caused catastrophic failures. In addition, most systems will revert to site-trunking or "Failsoft" modes if the central controller fails.

Remember, digital radios aren't really radios in the traditional sense – they're computers. P25 manufacturers actually call their digital radios *terminals*, as in computer terminals, because that's exactly what they are. A trunked P25 radio system is a lot like a computer network with a central file server and a bunch of remote client computers, which, in this case, are digital radios (digital radio computers). As such, they are subject to similar problems.

Vocoder problems:

One of P25's core technologies is its vocoder hardware and software that converts speech audio into digital data (and back again), with the goal of saving precious RF bandwidth. Under ideal conditions the P25 vocoder, essentially mid-90s technology, works well enough, but many users find its performance in noisy field conditions completely unacceptable. The problem is that there's no real provision in the P25 standards for using an improved vocoder, because switching core technologies in mid-stream would play greater havoc with interoperability, a major benchmark of P25 in the first place.

Transit time:

Because a trunked P25 digital radio system is essentially a string of networked computers and terminals, audio signals can take a long time to transit the system. When a user presses his PTT switch and speaks into his radio, his voice may take two to five seconds to be heard as speech on the receiving end of the link.

Key-up time:

Gone are the days when a user can simply mash the PTT switch and start talking. Trunked P25 systems are highly centralized, and before a user can speak, the central server has to find an open channel, reserve that channel for the intended users, communicate the channel information to the respective radios, validate encryption keys as necessary, etc, which can sometimes take several seconds. No matter how desperate your situation, if you start talking before the system has provisioned your connection, nobody will hear you!

Loosely-defined standards:

P25 standards aren't fully documented and set in stone. There's plenty of wiggle room for vendors and manufacturers to interpret a standard's "exact meaning" and add "enhancements" that differentiate their products from those of competing manufacturers. These enhancements can indeed add value, but they can also "lock" customers into single-sourced hardware and upgrades, as the "enhanced" hardware, which meets the published P25 spec to the letter, still can't be manufactured by anyone else. A major goal of P25 was to have digital radio systems that could interoperate with each other without regard to manufacturer. And, we still don't have that.

Moving targets:

Most P25 standards beyond Phase 1aren't fully ratified and are under active development, making full compliance difficult or impossible.

Open standards that aren't:

Articles, papers and material from P25 participants over the years promote the concepts of "openness" and "open standards," but P25 standards aren't exactly open in the usual sense. When you get down to brass tacks, the P25 standards-setting process is in fact, vendor driven, with Motorola doing much of the driving. In fact, Motorola, with its roughly 80% share of the public-safety radio market, owns a lot of the

The XG-100M, Harris' newest P25 mobile radio, part of the company's Unity line, incorporates leading-edge, noise-reduction technology. (Courtesy: Harris Corporation)

intellectual property (IP) at the core of P25.

There are processes and practices in place for other P25 participants to license and use this IP in a non-prejudicial manner (one company can't get a better "deal" than another), but there's no provision to allow someone to develop a truly "open-source" implementation of a P25 trunking controller, for example.

So, P25 standards are open in a certain sense, but not open in every sense. Linux, for example, the open-source software that runs most of the Internet, contains IP that's freely licensed and contributed by its developers, but it's truly open in the sense that anyone can produce, publish or manufacture hardware and software based on it, at no cost, without risk of running afoul of someone's IP lawyers.

Cost:

With infrastructure costs soaring into the millions per system, you'd think manufacturers might give away the actual radios as incentives! Until that day, hand-held and mobile P25 trunked radios typically sell for between $3000 and $6000 each, more if you add features such as encryption or dual-band operation.

Obsolescence issues:

Customers may expect more service life from P25 systems than will be provided by manufacturers, not because the hardware will wear out or break down, but because the vendor or manufacturer may simply decide that its hardware or software is obsolete, potentially forcing an expensive and unexpected upgrade. If your P25 trunked system uses features provided by only one manufacturer, meaning that nobody else can provide the required hardware or software to keep your existing system working, that manufacturer may suddenly declare that your system's software is no longer supported and they've decided that you need to replace it with the company's new line of hardware and software, complete with multimillion dollar price tags.

Security vulnerabilities:

Every radio system has certain basic vulnerabilities. If you cut the coax at the base of a tower, for example, that node is off the air. P25 systems have these vulnerabilities, too, but because P25 is essentially a distributed computer system, it can also be attacked as a computer.

Matthew Blaze, a computer security expert and professor at the University of Pennsylvania, wrote a paper, with the help of students and partial funding by a grant from the National Science

Foundation, titled "Security Weaknesses in the APCO Project 25 Two-Way Radio System." In the paper, published November 18, 2010 through the Department of Computer and Information Science at the University of Pennsylvania, Blaze and his team highlighted multiple P25 vulnerabilities, including active traffic analysis attacks, selective jamming attacks, and even distributed denial of service (DDOS) attacks similar to those used on the Internet.

An average shoplifter isn't likely to escape justice by exploiting P25 security flaws, but because P25 systems are widely used by federal, state and military agencies, P25 security is a legitimate issue when it comes to organized crime and terrorists.

A Look to the Future

In the near future, the date January 1, 2013 stands out. On that day, all public-safety radios in the U.S. that operate between 50 and 512 MHz may only transmit signals with a maximum bandwidth of 12.5 kHz (down from the current 25 kHz standard). That includes business radios, taxi cabs, public safety, you name it.

Since 1997, to be sold in the U.S., public-safety radio equipment has had to accommodate 25 kHz or 12.5 kHz transmission bandwidths. Despite the suggestions of some over-eager independent sales firms, the 2013 "narrowband mandate" does not require digital radios: 12.5 kHz narrowband analog FM works just fine and is fully compliant. If you have equipment that was purchased in 1997 or thereafter, you don't even have to buy new gear to comply with the new standard. You simply have to reprogram your existing radios (which can still be quite a process if your system supports hundreds or thousands of users).

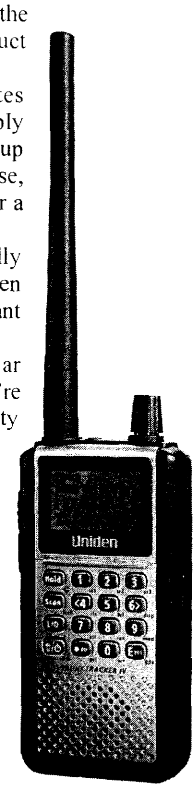
Longer-term, over the next two to five years, P25 faces competition from broadband IP network technology that transports digital communications: voice, video, images and data (much like the Internet does now). Whether these IP networks will be common carrier (such as a cell phone company) or private, may depend on who controls the spectrum and who can build the system most economically. Ultimately we may see some of both.

It's ironic that, because the P25 standards process has dragged on for so long and the systems use technology that many see as outdated, P25 digital radio systems may be functionally obsolete before they're seen as actually functional and reliable. That's no consolation for a customer who is $50 million "upside down" in a new P25 trunked system. In the big picture, the expert advice for potential P25 customers should be *caveat emptor*, "Let the buyer beware."

SCANNING P25 DIGITAL SYSTEMS

Scanning enthusiasts have had a roller coaster ride over the past decade or so with regard to successfully scanning P25 and other digital trunked radio systems, but the current crop of P25-capable scanning receivers is making it easier than ever before. Not all of the success has been driven purely by improvements in radio technology. In many ways, up-to-date databases of frequencies and talk groups provided by RadioReference (**www.radioreference.com**) and others have made a big difference in an average user's ability to successfully receive trunked radio communications, P25 and otherwise.

"The FCC," says Paul Opitz, a Senior Product Manager at Uniden, which manufactures several P25-capable scanning radios for its own brand and others, "really only coordinates frequencies, emission types and transmission bandwidths, and doesn't get involved with talk groups and other details that are often crucial to scanner listeners. Until the RadioReference database achieved its present level of maturity, a product such as our HomePatrol-1 receiver was practically impossible."



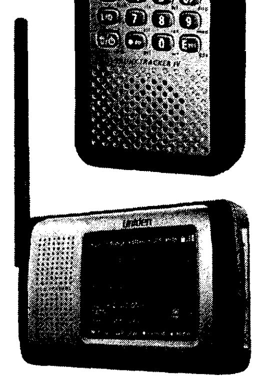
The HomePatrol-1(see review in October 2010 *MT*) incorporates licensed data from the RadioReference database, allowing users to simply enter their location information (ZIP code or GPS) and let the radio set up frequencies and talk groups for local radio systems based on the database, eliminating or greatly reducing the need to ferret out the information for a specific location and program the radio manually.

The HP-1 is the first receiver Opitz has worked on that was specifically targeted for consumers' ease of use. The rest, he says, have feature sets driven mostly by the needs of professional users who, surprisingly, buy a significant number of P25-capable scanners.

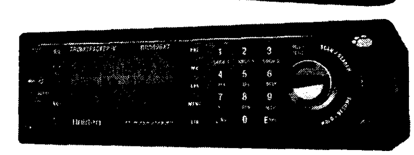
"When federal and state agencies send personnel into unfamiliar jurisdictions," says Opitz, despite the promise of P25 standards, "they're not set up to automatically interoperate with local and state public safety agencies everywhere they go. To at least monitor most trunked, digital communications, the 'three letter agencies' could send along a pile of $10,000 service monitors, or they could send along a bunch of $500 P25 scanners, which do pretty much the same thing at a fraction of the cost."

A similar situation exists on a more local level. Police and public-safety helicopters, for example, are frequently loaned out to other jurisdictions. And if a helicopter is following a police chase across four counties, the airborne personnel won't automatically have radio communications with every municipality, county and agency they could encounter. By incorporating a P25 scanner, as many do, they have a fighting chance of knowing what's heading their way.

According to Opitz, not many police officers listen to scanners while off duty, but plenty of firefighters and first responders do. "That's why a lot of the features in our P25 scanners are based on input from professional users. There are an awful lot of Uniden scanners being used in the field on a daily basis."



Encryption and a smattering of proprietary digital radio systems can make reception challenging for enthusiasts and professionals alike. Most federal P25 systems are encrypted, as are a handful of big-city systems (many of which are being replaced and updated with newer, more "standard" P25 systems). The forums at **www.radioreference.com** contain a treasure trove of information about scanning specific systems. You can also find discussions about the societal and governmental issues surrounding encryption and the impact of closed public-safety radio systems on the public's "right to know."



- Kirk Kleinschmidt NT0Z
Photo Credits: Uniden

READING LIST AND RESOURCES

http://apcointl.org – The APCO International main web site.

http://blog.tcomeng.com – A web blog by Daryl Jones, a veteran public-safety radio technology consultant, that contains links to hundreds of articles and resources on P25, problems with digital radio systems, mainstream media hits, interoperability issues, technology and government, and more.

www.dvsinc.com/prj25.htm – DVSI develops P25 vocoder technologies.

www.openp25.org – The web home of an open-source P25-compliant switch and trunking controller project.

http://openp25.org/wp-content/uploads/2008/03/p25trainingguide.pdf – An online copy of P25 Radio Systems Training Guide by Pete Lunness of Daniels Electronics (Canada, **www.danelec.com**).

www.project25.org – The Project 25 Interest Group web site.

www.radioreference.com – a radio communication database that lists public-safety frequencies, specific information about trunked radio systems nationwide, and plenty of informative forums on these topics and more.

http://tiaonline.org – The Telecommunications Industry Association main site.

About the author: Kirk Kleinschmidt NT0Z is a regular contributor to MT and writes the On the Ham Bands column, also found in this issue. His last feature, "MT's Guide to Buying a Transceiver," was part of the November 2010 MT Radio Buyer's Guide.

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