



Software Defined Radios Help Agencies Communicate

by Joseph Heaps

During Hurricane Katrina in August 2005, winds and floods knocked out virtually every form of communication: landline service, cellular phone service, the Internet, and radio transmission. Even when radio equipment did work, law enforcement officials and emergency crews were unable to communicate with one another because their radio systems were incompatible. This caused confusion and delay and made it nearly impossible for officials to coordinate missions.¹

During emergency situations—whether a natural disaster like Katrina, large transportation accident, or terrorist attack—public safety officials from different agencies (in some cases, different counties and States) must be able to effectively communicate with each other. If they cannot share information quickly, critical time will be wasted and lives could be lost. Unfortunately, police officers, firefighters, and emergency medical personnel cannot always depend

on wireless radio communications during natural disasters, major accidents, or criminal activities because their radio systems are often incompatible.

New technology is emerging that will enable public safety officials to exchange information seamlessly: experts call it “interoperability.” One of the most promising of these technologies is software defined radio (SDR) systems.

SDR is a type of radio that uses software to control a radio’s operating parameters and protocols, allowing the radio to be updated and reconfigured, thus minimizing the need to change existing hardware. SDR can overcome the challenges of incompatible communications systems by allowing radios to be easily updated with new functions, protocols, and standards. Most police radios today cannot be easily reconfigured to implement new capabilities, and as a result, incorporating new communications

AN ANALOGY: HOW DOES SOFTWARE DEFINED RADIO WORK?

The basic concept of software defined radio (SDR) is fairly simple. Think of your home computer. When you want to upgrade some software, you install a new program—you would not look to replace your hardware. SDR works in an analogous way: the user upgrades or reconfigures the radio simply by running new software, thus minimizing changes to the actual radio.

technology into an agency's operations can take decades. SDR technology has the potential to break that cycle by helping to ensure that the investment a department makes today does not lock it into limited solutions for many years. SDR enables new technology to be introduced without replacing the whole system and allows interoperability to be maintained without having to move all users to the new technology at the same time.

The good news is that some elements of SDR technology exist in most public safety radios manufactured today; the bad news is that the full potential of SDR for public safety communications is yet to be realized. Before this can happen, significant technical, operational, and regulatory concerns must be addressed. The National Institute of Justice (NIJ)—through partnerships and research grants—is working to help resolve these issues and accelerate the progress of SDR technology so that public safety officials can communicate effectively with each other and save lives.

Independent Purchasing Yields Incompatible Radios

Traditionally, local police departments and other public safety organizations make independent purchasing decisions for mobile communications devices. With more than 50,000 independent organizations making these decisions—based primarily on local factors—it is not surprising that the field is filled with incompatible communications systems. Further complicating matters, Federal agencies do not generally use the same frequency bands as State and local agencies, making it difficult to coordinate during a major incident.

Significant strides have been made in linking incompatible radio systems to improve first responders' ability to communicate. For example, current technology allows the transmission on one radio system to be rebroadcast on one or more systems. Such rebroadcasts, however, have limitations. Transmitting on a separate channel for every connected radio system is an inefficient use of scarce frequency resources. Channels may also be incorrectly or inadvertently linked, causing communication problems.

Where Does SDR Come In?

SDR technology is increasingly finding its way into public safety products. Some of today's radios use SDR technology to support multiple "protocols," which are the operating rules for communication transmissions. Yet the real future promise of SDR technology is to implement radios that operate:

- On multiple frequency bands.
- Using multiple services, such as two-way radio, cellular, and wireless data.

Multifrequency band radios could include software that controls operating parameters, such as frequency, and allows the radio to be reconfigured, as needed, as one of the three main frequency bands used by public safety officials: (1) very high frequency, or VHF; (2) ultra-high frequency, or UHF; or (3) 800 megahertz (MHz). This approach has been implemented in military radios but has yet to be incorporated in radios used by public safety personnel. The intent in the public safety arena is to allow users to eventually communicate with systems operating on frequency bands

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other than their normal “home” systems—for example, a radio could be developed that includes both an 800-MHz capability used by a city police force and a VHF capability used by sheriffs’ departments in the surrounding counties.

Software could also be developed to further support interoperability by enabling the user to communicate with other responders using both voice and data—such as Wi-Fi and commercial cellular capabilities—and to configure the device to the system needed at a particular moment. These abilities would allow, for example, responders who are called to a scene outside of their coverage area to participate fully in the emergency response.

Saving Taxpayer Dollars

Although the major benefit of SDR technology for public safety is increased interoperability—and how that translates into saving lives—other benefits include potential cost savings over the life of the radio equipment. SDR would allow police departments to easily:

- Upgrade individual pieces of equipment with new features and new communications protocols.
- Upgrade an entire communications system.
- Add new frequencies as they become available.

With respect to upgrading an entire communications system, SDR basestations could communicate via old and new devices until all equipment is upgraded, or equipment could be configured as needed during transition periods. Reprogramming transmitted

over the air from the basestation to radios would reduce the labor and coordination of physically reprogramming radios.

Another significant benefit of SDR is the enhancement of cognitive capabilities. A cognitive radio, for example, can sense its environment and adjust its operating parameters accordingly. Although it does not need to be an SDR, the capability to rapidly adjust operating parameters in real time can be implemented very effectively through software.

Equipment, Security Challenges

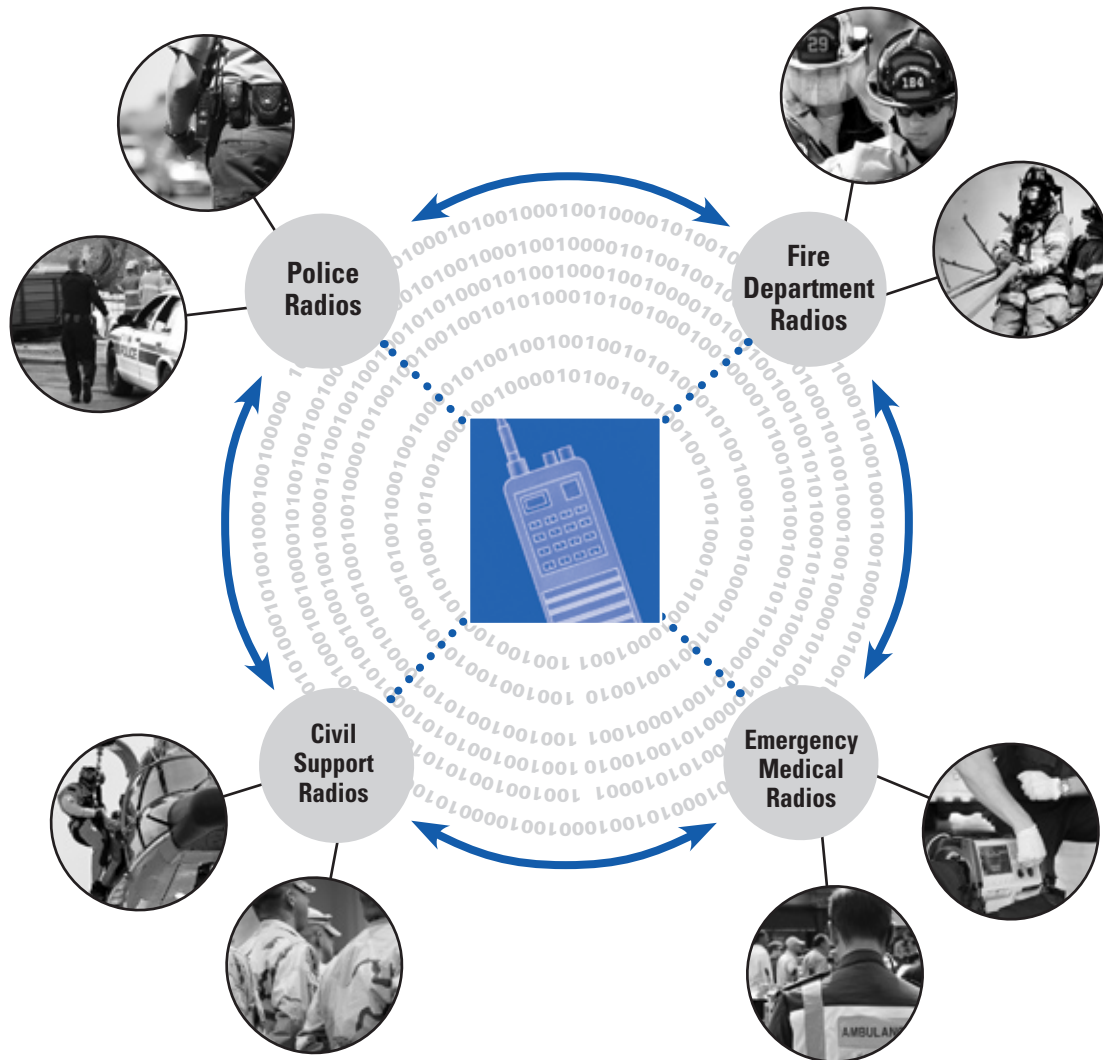
To make SDR technology useful and affordable for law enforcement and other public safety organizations, some key issues must be addressed:

- **Equipment.** Antennas and front-end processing continue to present challenges. Efficient antennas that can simultaneously handle VHF, UHF, and 800-MHz frequencies remain too large for portable use. In addition, development must work toward accommodating different frequency bands. As the frequency range of bands increases, the physics of the antenna present greater design challenges. For example, extending the range to low-band VHF is particularly difficult.

Also, although solutions exist for increasing a radio’s processing, memory, and power, they add weight and reduce the time that a battery remains charged, neither of which is acceptable to public safety agencies. Therefore, additional innovative processing approaches are needed.

- **Security.** Although SDRs are not inherently insecure, the potential impact of viruses or other malicious code is much greater with highly reconfigurable radios, particularly as over-the-air reprogramming occurs. The development of effective security measures will be essential in the deployment of SDR technologies.
- **Standards.** The U.S. Department of Defense has developed SDR standards for all new military radios under the

Software Defined Radio: Connecting Public Safety Officials



Joint Tactical Radio System. Whether these standards (designed to meet military requirements) are suitable for public safety communications remains an open question.

- Understanding the pros and cons.** Cost-benefit analyses are needed so that vendors and public safety organizations have a better understanding of appropriate

price points for SDR. For example, how much extra is reasonable for the purchase of a multiband radio? Can vendors produce equipment at that price point? And it is crucial that such a cost-benefit analysis of SDR consider not only the unit-cost level but, more importantly, the life cycle or advantages of SDR over time.

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Working to Advance SDR Technology

To help address these issues and advance SDR technology for public safety officials, NIJ has implemented a multifaceted strategy.

In 2002, NIJ began to work with the Software Defined Radio Forum, an international consortium of organizations that promote the development and application of public safety radios. Within the SDR Forum, the Public Safety Special Interest Group—chaired since its creation by an NIJ grantee from the National Law Enforcement and Corrections Technology Center–Northeast (NLECTC–NE)—is working on two major initiatives:

- Developing a cost model that will allow vendors and users to identify critical price points for SDR and to perform cost-benefit analyses.

- Identifying opportunities for cognitive technology to improve responders' ability to communicate.

NIJ supports IEEE P1900, a committee that is developing standards for advanced radio concepts and cognitive radio technology.

The Institute is also funding two research and development projects at the Virginia Polytechnic Institute and State University. In the first project, Charles Bostian, Ph.D., and his colleagues are conducting research on cognitive radio for public safety applications. They have developed a prototype radio that is aware of its environment and can identify available frequencies and communicate on them. In the second project, Steve Ellingson, Ph.D., is developing a low-cost prototype multiband radio that will operate in the most common law enforcement radio bands. The architecture of this radio will become "open source"—that is, available to anyone or any company at no cost.

Finally, NIJ is funding three major projects to evaluate SDR technologies in the field:

- Building a prototype software defined, multiband conventional emergency radio that complies with the current standard for public safety radio communications (University of Texas–Dallas).
- Placing multiband military radios in a police department on an experimental basis to evaluate operational issues (NLECTC–NE).
- Developing ergonomically appropriate SDR technology for the public safety community (University of Notre Dame).

About the Author

Joseph Heaps manages the communications technology (CommTech) portfolio at the National Institute of Justice. He has an extensive background in communications technology, including work in the private sector and at the Federal Communications Commission, where he served as a U.S. delegate to two World Radiocommunication Conferences (in 1997 and 2000).

For more information on this work, see www.ojp.usdoj.gov/nij/topics/technology/communication, or contact NLECTC–NE at 888–338–0584.

SDR technology holds significant promise for addressing critical issues in public safety communications, including interoperability, performance enhancement, and life-cycle cost reduction. More work remains to be

done, however, and operational limitations and issues regarding security and standards need to be addressed. As SDR technology evolves, police officers will be able to respond more effectively to emergency situations and save lives.

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Note

1. Warrick, J., "Crisis Communications Remain Flawed," *Washington Post*, December 10, 2005, A06; and Joch, A., "Communications Breakdown," *Federal Computer Week*, December 5, 2005.

Editor's Correction

Forensic Databases: Paint, Shoe Prints, and Beyond

In the last issue of the *NIJ Journal* (October 2007), the article "Forensic Databases: Paint, Shoe Prints, and Beyond" contained inaccuracies on the two databases maintained by the U.S. Secret Service. Here are corrected descriptions of the databases.

Forensic Information System for Handwriting: FISH

Maintained by the U.S. Secret Service, this database enables document examiners to scan and digitize text writings such as threatening correspondence.

How does FISH work? A document examiner scans and digitizes an extended body of handwriting, which is then plotted as arithmetic and geometric values. Searches are made on images in the database, producing a list of probable "hits." The questioned writings, along with the closest hits, are then submitted to the Document Examination Section for confirmation. For more information, see www.secretservice.gov/forensics.shtml.

International Ink Library

The collection—maintained jointly by the U.S. Secret Service and the Internal Revenue Service—includes more than 9,500 inks, dating from the 1920s. Every year, pen and ink manufacturers are asked to submit their new ink formulations, which are chemically tested and added to the reference collection. Open-market purchases of pens and inks ensure that the library is as comprehensive as possible.

How does the library work? Samples are chemically analyzed and compared with library specimens. This may identify the type and brand of writing instrument, which can be used to determine the earliest possible date that a document could have been produced. If the sample matches an ink on file, a notation is made in the database. The U.S. Secret Service generally provides assistance to law enforcement on a case-by-case basis. For more information, contact 202-406-5708.

The revised article and downloadable PDF are available at www.ojp.usdoj.gov/nij/journals/258/forensic-databases.html.