SDR for Public Safety

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For a number of years the focus of software defined radio research was on military and commercial applications. For the public safety community, SDR developments were primarily part of the internal research and development activities of land mobile radio vendors. However, several incidents over the past several years have spurred the public safety community to investigate how to leverage evolving SDR and cognitive radio technology to address critical public safety communications challenges.

First and foremost among those challenges is interoperability—the ability of first responders from different agencies to communicate among themselves. Responses to numerous incidents, both small scale local events and large scale regional events, have been complicated by inadequate means for first responder communication due to different and incompatible radio systems. The reasons that interoperability remains a challenge are many, and include both technical and non-technical issues (e.g., governance, policies, procedures, and training). In terms of technical approaches to interoperability, solutions range from gateway products that link existing systems together to new multi-agency regional systems.

Gateway technology ranges from console patches to programmable interconnect devices by which a transmission on one radio system is rebroadcast on one or more other radio systems. While effective in supporting interoperability, such rebroadcasts have several limitations: using a channel for every radio system that is interconnected ties up scarce spectrum resources; channels are sometimes incorrectly or inadvertently linked, causing communications problems; interfacing with repeater-based infrastructure can require tuning of system parameters (which may be difficult during an incident); and capabilities must either be implemented in infrastructure (requiring requisite planning and expense) or deployed to the scene of an incident (i.e., not immediately available).

The alternative of new multi-agency regional systems (particularly trunked systems) provides much more efficient spectrum utilization but typically still pose interoperability challenges (e.g., in the U.S. between federal responders using VHF radios and local responders on an 800 MHz system), and require establishment of governance structures and significant funding. As a result, the search for more effective approaches to interoperability continues.

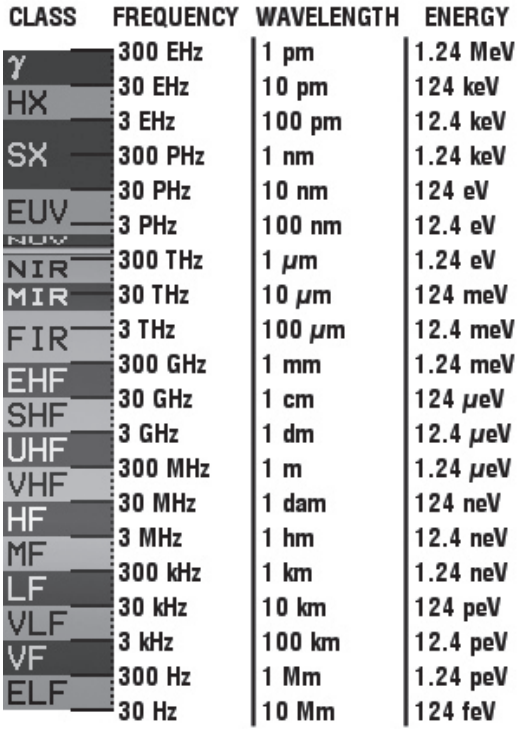
In response, the SDR Forum created a Public Safety Special Interest Group (SIG) in 2004. The purpose of this SIG is to provide a focus within the SDR Forum for activities in which the public safety

community has an interest. Activities include interacting with the public safety community, both users and vendors, to raise awareness of SDR issues, publicizing the activities of the Forum in addressing those issues, and increasing participation of the public safety community in the SDR Forum. This SIG also interacts with other committees and working groups within the Forum to provide the public safety community's inputs into the products developed by the Forum. Organizations participating in the Public Safety SIG include representatives of the National Public Safety Telecommunications Council (NPSTC) SDR Working Group, representatives of public safety land mobile radio (LMR) vendors, software developers, regulators, commercial cellular companies, universities, and contractors supporting the National Institute of Justice's CommTech program along with other federal interoperability programs. This unique organization brings together a diverse set of perspectives on public safety communications to consider how SDR technology could potentially address key issues such as interoperability.

The first major undertaking of the Public Safety SIG was a year-long study on how software defined radio technology can impact public safety, culminating in the release of a report entitled "SDR Technology for Public Safety." This report outlines how SDR technology can enhance interoperability among first responders, and identifies other potential benefits of SDR technology. The key to interoperability is that radio operating parameters such as frequency band, modulation type, and power are controlled by software. Use of reconfigurable software rather than fixed hardware allows a radio to be more flexible and support multiple modes, multiple frequency bands, and multiple functions. This concept of flexible, reconfigurable radios has intriguing possibilities for addressing interoperability challenges. Radios that can be reconfigured to meet the communications requirements of a specific incident could provide a powerful communications tool for public safety first responders.

Although SDR is often perceived as a futuristic technology, the reality is that SDR technology is implemented in most public safety LMR products today. For example, many manufacturers provide options to "flash upgrade" radios—basically reconfiguring the radio with additional or new capabilities. SDR technology is a key component of this capability. Since each capability can often be mapped to a specific protocol, these radios are referred to as multi-protocol radios.

The challenge is that while today's radios use SDR technology to support multiple protocols, and to a limited extent, two bands adjacent in frequency, the real promise for public safety is to utilize SDR to support multi-band and multi-service radios. Multi-band radios could potentially include waveforms that allow the radio to be reconfigured as a VHF, UHF, or 800 MHz radio as needed. For example, a radio could include waveforms to operate on a digital trunked system at 800 MHz, but also includes conventional VHF and UHF capabilities and the ability to be seamlessly reconfigured (possibly via over-the-air reprogramming)



Spectrum diagram, from Wikipedia (http://en.wikipedia.org/wiki/Electromagnetic_spectrum)

among the three bands. For first responders who travel into other jurisdictions and/or provide mutual aid to other agencies, such a radio could be reconfigured to communicate on the other systems, allowing the responder to be interoperable with the other responders of other agencies.

The concept of multiple waveforms supporting multiple land mobile radio (LMR) bands can be extended to applications of SDR in multi-service radios that could be reconfigured to operate on other types of systems as needed, (e.g., commercial cellular systems, or 802.11 systems). Such multi-service capabilities would help realize a "system of systems" concept, in which public safety communications is accomplished using multiple networks and multiple communications protocols. SDR enables devices that could provide significantly greater communications capabilities in a single device than are available today.

The potential benefits of interoperability alone warrant further research and development, but there are additional potential benefits of SDR technology for the public safety community. For example, cognitive capabilities are being researched that could allow networks and radios to adjust operating parameters in response to changes in the RF environment. Cognitive capabilities have the potential for building smart networks that can adjust to dynamic conditions including interference, channel loading, and so on. From a public safety perspective, interest in cognitive applications is focused on leveraging this technology to provide more robust, resilient, and reliable public safety networks. Although cognitive applications do not require SDR technology, the inherent flexibility of SDR technology and the goal of cognitive applications to adjust radio operating parameters make a natural and effective combination.

SDR technology also holds the potential for life cycle cost reductions. Life cycle costs can be reduced by upgrading functions in software without wholesale system hardware changes, and also by facilitating migration to new protocols and standards. For example, a software defined radio base station that could be configured to accommodate multiple waveforms would be useful in gracefully migrating to new protocols without simultaneously requiring new subscriber equipment. Similarly, new subscriber equipment can be procured without requiring hardware retrofits of infrastructure, which may only need a software upgrade to support the new devices.

Although SDR technology is reaching the market today, the real payoff for public safety is still "potential," not yet a reality, and there are a number of key issues that remain to be addressed. These issues range from technical to economic to standards. For examples, technical issues that must be addressed include antennas (particularly for portable radios), front end signal processing, and security. From an economic perspective, there is a need for better cost-benefit models to evaluate the return on investment of SDR. Standards present another challenge—existing standards work in SDR, such as that done by the military on the Joint Tactical Radio System, addresses internal radio software architectures rather than the interface standards such as those specified by Project 25 and TETRA; thus, significant work would be required to leverage the military's standardized architectures for public safety. There are also management and regulatory aspects that must be addressed to expedite the integration of SDR technology into public safety communications systems.

To address these challenges, the Public Safety SIG has initiated several activities:

- Development of a report on "Cognitive Use Case for Public Safety," to articulate the potential

application of cognitive capabilities in public safety networks and define operational requirements for cognitive technology development;
- Development of a cost model that can be used to better quantify the life cycle cost implication of SDR technology;
- Engagement with standards activities such as the TIA Committee TR-8 Mobile and Personal Private Radio Standards to begin consideration of security and other aspects in land mobile radio standards.

SDR technology has quietly been evolving in public safety radio designs as manufacturers find ways to use the technology to increase functionality and reduce costs. While these developments have clearly benefited the public safety community, the technology has matured sufficiently to plot a course for SDR and cognitive radio technology in public safety that results in seamless interoperability, reduced life-cycle cost, and more functional, robust communications capabilities for first responders.

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