PUBLIC SAFETY WINS
WIRELESS INTEROPERABILITY NATIONAL STRATEGY

Technical Solutions

Software Defined Radio

THIS ANALYSIS OF SOFTWARE DEFINED RADIO HIGHLIGHTS THE FOLLOWING

- Introduction
- Technical background
- Technical description and conceptual drawing
- Appropriate uses
- Advantages and disadvantages
- Costs
- Spectrum requirements
- Management issues
- Security and standards issues
- Additional information

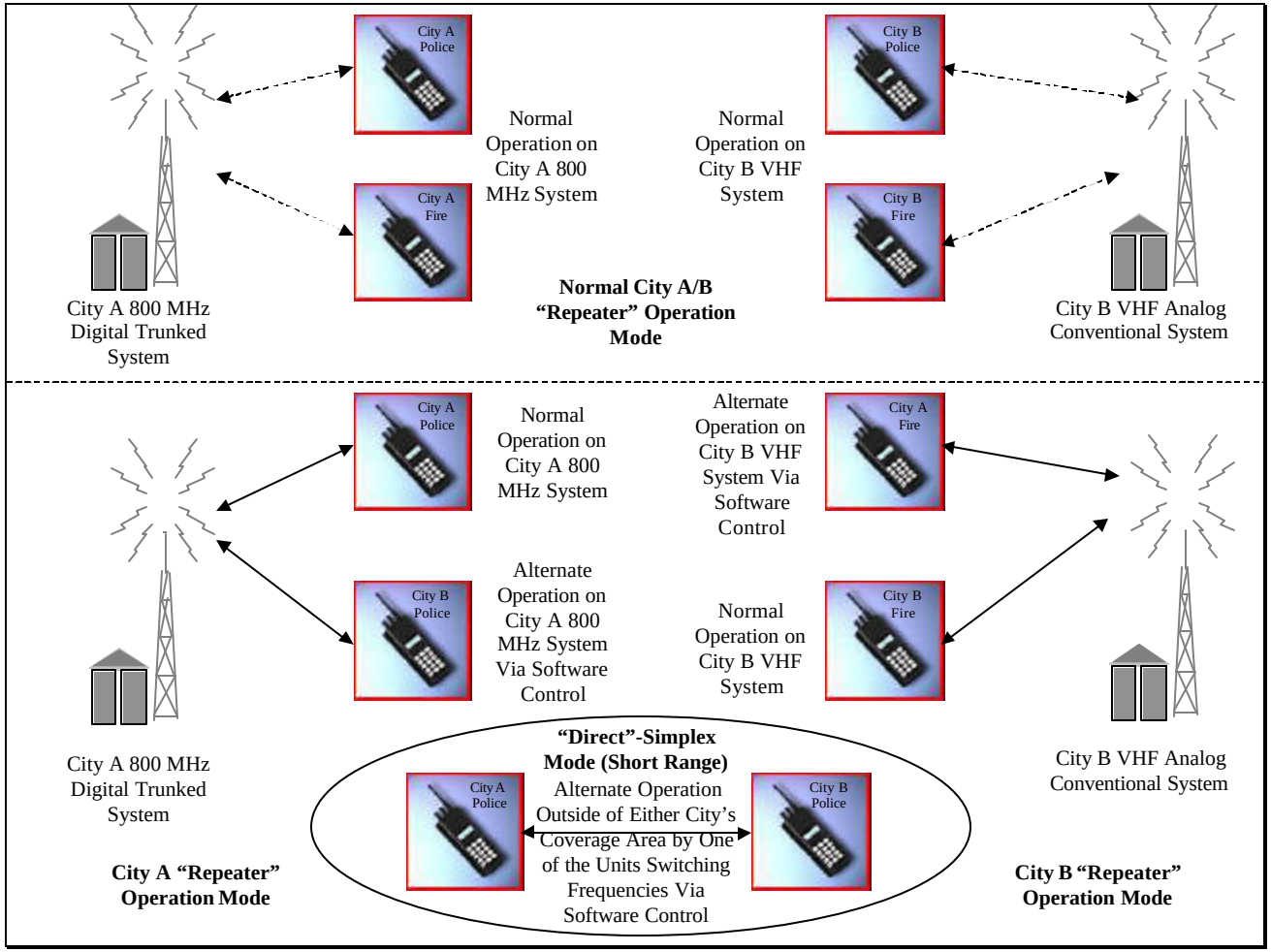
RECENT ADVANCES IN TECHNOLOGY HAVE ENABLED SOFTWARE DEFINED RADIO TECHNOLOGY TO MOVE FROM CONCEPT TO REALITY

- The development of software defined radio technology began within the Department of Defense's (DoD) SPEAKeasy research program in 1992
  - The objectives of the program were to consolidate a family of discrete military radios into a single technology platform
- Today, the majority of software defined radio research is performed within the DoD's Joint Tactical Radio System (JTRS) program
  - The mission of the JTRS program is to develop a family of tactical software radios, all built on a common, open software communications architecture
- Software defined radio technology is still in the early stages of development and implementation in the military community and is not yet suitable for use by the public safety community
- However, the public safety community should attempt to leverage lessons learned from the military applications of software defined radio technology in an effort to develop devices that will increase interoperability and enhance the ability of public safety agencies to achieve their missions
- Public safety agencies at all levels of government involved in homeland defense are expected to turn their attention to software defined radio-based systems to overcome interoperability challenges in times of crisis (e.g., natural disasters, terrorist attacks)

CURRENT SOFTWARE DEFINED RADIO RESEARCH FOCUSES ON DEVELOPING DEVICES CAPABLE OF OPERATING IN MULTIPLE RADIO ENVIRONMENTS

- Software defined radio technology can perform the following control functions within the software domain without requiring the user to make any hardware alterations—
  - Numerous modulation techniques
  - Wideband or narrowband operation
  - Communications security functions
- Software defined radio technology is designed to be software upgradeable to accommodate evolving standards over a broad frequency range
- Software defined radio devices are envisioned to interoperate with existing and evolving land mobile radio (LMR) systems by switching operating modes
- These devices will also be capable of operating in multiple public safety frequency bands using multiple technologies, thereby providing interoperable communications between disparate radio systems
  - If systems use different frequencies, all users desiring interoperability may switch to a common frequency band to achieve unit-to-unit communications
  - If all users desiring interoperability are outside their system's coverage area, they can download or use preprogrammed system parameters to communicate on the serving system
  - If systems use different frequencies and operate in different modes, users who are outside their home system coverage area need only switch to the frequency band necessary for interoperability with the desired units in the desired system

THE DRAWING BELOW ILLUSTRATES THE FUNCTIONAL CONCEPT OF SOFTWARE DEFINED RADIO



ONCE COMMERCIALLY AVAILABLE, SOFTWARE DEFINED RADIO TECHNOLOGY COULD PROVIDE MANY INTEROPERABILITY BENEFITS FOR THE PUBLIC SAFETY COMMUNITY

- Software defined radio has been widely recognized as a promising technology to achieve multiband, multimode radio operation without using additional hardware (i.e., one device with one transmitter)
- When available for the public safety community, software defined radio devices will be a viable solution for public safety agencies that require interoperability and use—
  - Different frequency bands (for either trunked or conventional communications)
  - Proprietary trunked systems from different manufacturers
  - Proprietary trunked systems from the same manufacturer, and the newer system is not backward compatible with the older system
  - Different operational modes (e.g., digital versus analog)
  - Different technologies (e.g., trunked versus conventional)

THE SOFTWARE DEFINED RADIO SOLUTION HAS SEVERAL ADVANTAGES

- It is interoperable across disparate radio networks, frequency bands, and technologies
- Agencies need not change, reprogram, or add infrastructure on any of the backbone radio systems involved in the interoperability scenario
- No dispatcher intervention is required to set up and remove the interoperability link
- Outside agencies can join the interoperability talk group(s) or channel(s) by simply selecting the correct switch positions on their subscriber units
- Software defined radio technology could potentially—
  - Provide international connectivity, especially for federal use and search and rescue operations
  - Offer advanced features and capabilities (e.g., data communications with multiple wireless data protocols)
  - Provide services tailored to a user's needs
  - Provide integrated voice and data (IV&D) information over the same channel
- Additional wireline leased circuits are not needed, thus avoiding potential leased circuit failure, audio path distortion, or transmission of external energy (such as lightning) into communications shelters

THE SOFTWARE DEFINED RADIO SOLUTION ALSO HAS SEVERAL DISADVANTAGES

- Software defined radios are still under development and are currently unavailable for use in the public safety arena
- Software defined radio technology could potentially—
  - Create interference that could impact the integrity of existing radio systems
  - Reduce the reliability of operation due to software issues requiring actions such as “rebooting”
  - Hinder the current effort to establish open standards with existing proprietary systems
  - Introduce vulnerability due to unauthorized access to the software-based device
- The Federal Communications Commission has not yet fully addressed spectrum management issues along with how to control who can have access to what frequencies
- LMR equipment vendors have neither invested substantial resources nor given formal timelines for the development of software defined radios
- Currently, the radio frequency front end is implemented by analog circuitry, which often leads to bulky design, multiple antennas or lower gain, and architecture complexity
- Use of software defined radios requires participating agencies to establish agreements or Memoranda of Understanding (MOU) in advance
- Generally software defined radios will require higher power consumption that similar hardware based radios and thus have shorter battery life
- Additional modes of operation could lead to increased operational complexities to the user

THE SOFTWARE DEFINED RADIO SOLUTION PRESENTS SEVERAL COST CONSIDERATIONS

- The software defined radio solution requires significant initial investment including—
  - Acquiring the subscriber units
  - Programming the units for all desired radio systems
  - Creating all of the initial logic and programs required for the desired modes of operation
  - Creating all required interlocal agreements or MOUs
- If an open software defined radio standard is established, it would eventually create more competition in the LMR marketplace and possibly drive down LMR equipment prices
- Over time, the cost of software enabled technologies should decrease, thereby reducing the initial investment to acquire software defined radios
- After the initial investment, the ongoing or recurring costs may be relatively modest
  - As new interoperability needs are identified and new capabilities are developed, programming efforts may require outside vendor support
  - Maintenance costs for software defined radios may be higher than equivalent hardware based radios as a dynamic software environment requires more diligence on forward and backward compatibility issues
  - As new systems are identified with which interoperability is required, interlocal agreements or MOUs will have to be updated, or new ones created
  - Personnel costs are minimized because this type of interoperability does not require dispatcher setup

THE SOFTWARE DEFINED RADIO SOLUTION REQUIRES NO ADDITIONAL SPECTRUM

- This solution typically uses previously licensed spectrum
- In theory, using software defined radios allows all accessible spectrum to be utilized and thus could enable the spectrum to be better leveraged

THE SOFTWARE DEFINED RADIO SOLUTION REQUIRES MINIMAL TO MODERATE MANAGEMENT BY THE PUBLIC SAFETY AGENCIES INVOLVED

- Detailed MOUs or interlocal agreements are critical to ensuring that all agencies understand their roles in the partnership
- System procedures should be established to prevent unauthorized use of certain frequencies or functionality
- Training is necessary to ensure users are cognizant of the spectrum, technology, and modes of operation required for interoperable communications
- The system manager of each system on which software defined radios will operate must identify and manage those units and coordinate with those that may require access at some point in time
- Although this interoperability solution is relatively simple to implement, formal interoperability procedures should be developed to ensure that users follow established procedures on each other's systems
- Dispatchers are not required to initiate the interoperability link

SOFTWARE DEFINED RADIO TECHNOLOGY PRESENTS SEVERAL SECURITY AND STANDARDS CONSIDERATIONS

- The ability to reconfigure a radio by software download could make software defined radio devices very susceptible to malicious attacks
- Authentication processes have been proposed to ensure that the software application being downloaded is appropriate for the device
- Manufacturers must find a way to inhibit access to certain bands (e.g., some Federal Government and military bands)
- Software defined radio devices are expected to operate with incompatible technologies
- It is projected that a standards process will be established for software defined radio technology

SOFTWARE DEFINED RADIO SUBSCRIBER EQUIPMENT MUST MEET SPECIFIC REQUIREMENTS TO BE CONSIDERED A VIABLE SOLUTION FOR THE PUBLIC SAFETY COMMUNITY

- Software defined radio subscriber equipment must—
  - Allow users to communicate outside of their regularly designated radio system
  - Communicate with legacy, conventional, proprietary trunked, as well as Project 25 conventional and trunked systems
  - Operate in public safety frequency bands
  - Operate in simplex mode or unit-to-unit direct communications without accessing system infrastructure
  - Have the ability to establish temporary, deployable communications infrastructure
  - Support common encryption algorithms
  - Provide IV&D capability and be compliant with Project 25 data requirements
- Local operational requirements surveys will determine specific geographic coverage areas. However, in general—
  - Portable coverage (via handheld device) will be required in metropolitan, border, campus, and designated buildings
  - Mobile coverage (via vehicle installed devices) will be required in interstate, rural, and tribal reservation areas