and

Integrated Homeland Security, Defense Training and Emergency Relief Communications

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A	Mark Landers	15 July 2011	Initial Template
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1 Introduction

There is possibly no bigger obstacle to small area radio networks than acquiring a frequency that meets the requirements of the network's users. This paper examines the potential of using recently approved unlicensed access to former analog television spectrum in the areas of military training, disaster response and interoperability between friendly foreign militaries and the US military.

2 White Spaces

The Federal Communications Commission (FCC) has recently approved unlicensed access to nearly 300 MHz of VHF and UHF spectrum in the US formerly reserved for broadcast television. While unlicensed, access to this spectrum does require centralized database management.

Unused TV channels between 2 and 52 (except 3- 4 and 36-38) are available for use in areas where they are not used for TV broadcasts or other licensed services. A single 'guardband' channel (6 MHz) adjacent to each active TV channel must remain unused. Unused, non-adjacent channels can be used for wireless networking such as emergency Internet access, video surveillance, military training networks and first-response networks.

The number of available channels depends on the presence of operational TV channels in the area. Availability in and around large cities may be limited. However, availability in rural areas will be much higher.

3 Uses in Military Training

One of the rapidly growing uses of this newly available spectrum is in military training. In this application, exercise participants are fitted with radios that can be dynamically configured to use available white space spectrum. Additional radios can be configured as hubs or base stations, thus creating an IP based data network allowing for exercise information to be collected and exchanged with other local intranets or the Internet. The network can also be connected to exercise control for forwarding critical information to the Observer/Controllers. Finally, the network can be encrypted (to 128 bit with hardware acceleration, higher without acceleration).

Existing technology can cover nearly 3 square miles of area and is small and compact enough to operate for over 24 hours with a 2 lb battery. Assuming total two-way traffic is about 2.425 Mb/s, this allows for 1.724 Mb/s in the Hub to Remote direction (downlink) and 0.701 Mb/s in the Remote to Hub (upstream) direction. Since each white space channel can support 3.125 Mb/s (two-way), a single 6 MHz channels will provide sufficient capacity to support many military training applications. This channel can be either in the VHF or UHF band.

Channel size is configurable and the larger the channel size, the greater the bandwidth. For example, a small, 25 kHz channel can provide a 16 kb/s bandwidth. A large channel, such as 175 kHz can support data rates of

112 kb/s. Channel size can be configured to meet mission requirements. As channel size is increased, range is decreased. See Table 1: Range vs Channel Size Matrix for a comparison of bandwidth, data rate and range of a radio at a given frequency.

Channel Size (kHz)	*Transmit EIRP (dBm)*	*Max Range (km)*
6.25	**30.5**	**60**
12.5	**30.5**	**48**
25	**30.5**	**35**
50	**30.5**	**24**
100	**30.5**	**17**
175	**30.5**	**12**
6,000 (FSK)	**21.5**	**0.8**
6,000 (QPSK)	**21.5**	**0.6**

Table 1: Range vs Channel Size Matrix

Assumptions:

1. Remote antenna has -5 dBi gain (soldier-worn).
2. Hub antenna has 5 dBi gain.
3. 4 W transmit power for all channel sizes except 6 MHz. 0.5 W for 6 Mhz.
4. All links include 20 dB of obstruction loss plus 20 dB fade margin.

4 Uses in Emergency Operations

The tremendous potential of white space radio networks will see increasing application in emergency operations. In the United States, as white spaces networks see increasing use in US Army and National Guard training, white space capable assets will be readily available to these organizations for use in disaster response. By equipping state and local civilian first responders with similar equipment, they will be able to coordinate disaster responses with military units.

Foreign militaries are often called upon to provide disaster response and emergency support. Not only could foreign militaries benefit immensely from the training utility of white space radio networks, but they can reap additional benefits by utilizing the rapid setup and channel selection features of these systems. Further, if the US military provides assistance to local military and civilian disaster responders, the use of such networks provides immediate frequency deconfliction and interoperability.

5 The Agility Military Radio (AMR)

One White Space Radio that is currently being used in the United States for Military training and commercial fixed infrastructure is the KTS Wireless Agility Military Radio (AMR). Its capabilities are described in the following section.

The AMR includes 5 models that support frequencies from 150 to 950 MHz. It will be approved as a fixed TV band Device (TVBD) under Part 15, Subpart H of the FCC Rules as well as an unlicensed radio for the 900 MHz band. A wide variety of applications are supported including Tactical Engagement Simulation Systems (TESS), in Force-On-Force, Force-On-Target, Training and Land Navigation. The radio may be used to create Point-to-Point (PTP), Point-to-Mulitipoint (PTM) or Simplex (one-way) networks with support for any type of Serial and IP traffic including voice over IP and low-resolution video. The Hub radios in an AMR network can operate with an omni-directional, sector or narrow beam directional antenna depending on the coverage requirements. The AMR will be approved to operate with the FCC-approved database server provided by Spectrum Bridge, Inc (SBI) using an optional client provided in the AMR software.

Features:

- Agile RF Modules
    - 150 to 220 MHz
    - 220 to 320 MHz
    - 320 to 470 MHz
    - 470 to 700 MHz
    - 900 to 950 MHz
- Data Rates from 4 to 112 kb/s
- 6.25 to 175 kHz Channel Size
- Extensive power management for long battery life
- 911 Emergency button support
- 3-axis orientation reporting
- Optional wireless link encryption
- Up to 37 dBm RF transmit power
- Automatic Transmit Power Control (ATPC)
- FCC Part 15 and 90 compliant*
- Serial, Ethernet and USB User Ports

- Operates in the recently allocated “White Space” spectrum*
- ETSI Compliant*

The Ethernet port functions as a bridge for IP subnets via the wireless link. The advanced Media Access Controller (MAC) supports contention, polled and reserved access for minimizing delay and maximizing upstream throughput. Secure local network management is provided through an embedded web server. Remote management is supported over-the-air with the Agility Telemetry Element Manager.

Specifications:

- Electrical
- RF Module frequency bands (factory selectable)
    - A 150 to 220 MHz
    - B 220 to 320 MHz
    - C 320 to 470 MHz
    - D* 470 to 700 MHz
    - E 900 to 950 MHz
- RF Transmit Power 23 to 37 dBm with ATPC
- Noise Figure 4 dB
- Spurious & Harmonic Emissions FCC Part 15 & 90 compliant*
- Data Rates 4 to 112 kb/s
- Modulation FSK, SOQPSK
- Channel Bandwidth 6.25 to 175 kHz
- Frequency Selection 6.25 kHz steps
- Selectivity >80 dB
- Operating mode Half-duplex or simplex
- User Ports Serial, Ethernet and USB

Mechanical:

- Dimensions 3.2” x 5.5” x 1.6”
- Enclosure material AL Extrusion, Waterproof
- Weight (w/o mount) 1.5 lb

- Mounting Universal Mount (DIN, Wall, Pole)
- Connectors
- Antenna SMA (F)
- User Ports and Power 2, LEMO

Environmental:

- Operating Temperature Range -30 to 600 C
- Water and Dust IP 675

Power:

- Input Voltage 9-15 VDC
- Current 0.5A (RX), 2 A (TX), 0.1 A (Idle)

(Specifications subject to change without notice)

* FCC and ETSI approval pending

Of note is the fact that the AMR is a highly capable, dynamically tunable radio that can operate not only in the white spaces but has the capability (depending on the RF card selected) to operate in military and government only restricted bands. The AMR also allows for network customization, as required, to support the specific mission.

The AMR's ability to dynamically change bandwidths and frequencies to be used in the white spaces make these radios a highly capable support to training and disaster relief efforts, as well as for use in permanent infrastructure applications.

6 Scenario

In order to understand the flexibility of white spaces radio networks, consider an example of a large earthquake in a populated, coastal environment, outside of the United States. The national government responds to the disaster by deploying units of the military to provide emergency response, rescue and local security. Equipped with white space radio network equipment for military training, the responding units are able to rapidly setup a radio network using a single unused 6 MHz television channel, perhaps one that has become available to recent upgrades to digital TV.

The single channel is broken down into 39 separate 175 kHz sub-channels. Each sub-channel is spaced out geographically in the disaster zone to prevent interference between them, using mobile or transportable towers. This allows the disaster response units to provide coverage to track over 1500 users in each of the 39 separate sub-channels. In addition, the tower mounted radio allows each sub-channel to connect to a local

command intranet and/or the Internet. If additional television channels are available, additional networks can be setup for voice communications, mobile situational awareness, command nets, or so on.

Finally, in this scenario, the United States offers assistance in the form of an amphibious unit that can operate offshore. Marine units and other US disaster response units that have train with similar white space radio network systems are able to provide disaster assistance, without spectrum conflicts or other types of radio interference. In some cases, US units will be able to interoperate with local emergency response and host military units.

7 Conclusion

The utility and flexibility provided by a white spaces radio network provides solutions in the domains of military training, homeland security and disaster preparedness and response. Further, white spaces radio network systems allow tremendous advantages in interoperability between regular US military unit, US National Guard units, foreign military units and emergency responders, reducing resource conflicts and interference in training environments and disaster locations.

All data based on KTS Wireless AMR for Military Applications.