



# TV White Space Position Paper

Fixed TV White Space Solutions for Wireless ISP Network Operators



## Executive Summary

### Opportunity for Fixed TV White Space Solution in the United States

The Federal Communications Commission (FCC) has decided to open spectrum traditionally allocated to broadcast TV to provide broadband access for Americans, especially those in rural areas in the United States. Solutions that use this newly opened spectrum must not interfere with existing users and services in this spectrum. Motorola's TV White Space solution is proven to provide reliable connectivity across the significant bandwidth available in this spectrum for rural wireless service providers while allowing current users of the spectrum to reliably operate their systems.

Motorola is developing solutions for the TV White Space spectrum for both Service Providers as well as municipal state and local government entities. This paper specifically focuses on Motorola's fixed solution for broadband service providers operating networks predominantly in suburban and rural areas. This particular solution provides reliable point to multipoint fixed access to bandwidth that can be used for data transfer, voice and video applications from one fixed Access Point (AP) location to another fixed Subscriber Module (SM) location such as a business or residential structure.

Given the nature of availability of TV White Space spectrum and population density in suburban and rural locations, along with the deployment coverage of Motorola's Canopy® Point to Multipoint broadband access system in the United States, a reliable cost effective fixed system using the TV White Space spectrum would be of immediate and high value to wireless service providers

## The TV White Space Spectrum

In the United States, 408 MHz of spectrum from 54 MHz to 806 MHz (See Figure 1) is allocated for TV. Currently, 108 MHz of that spectrum is being redeveloped for commercial operations through auctions and for public safety applications. The remaining 300 MHz of this prime radio spectrum will remain dedicated for over-the-air TV operations. However, throughout the United States, portions of that 300 MHz resource remain unused. The amount and exact frequency of unused spectrum varies from location to location. These unused segments of spectrum are referred to as TV White Space. The FCC is considering opening these unused TV White Space frequencies for a variety of unlicensed uses. Because there are fewer TV stations located outside top metropolitan areas, larger amounts of unoccupied TV White Space spectrum are available in low population density or rural areas that tend to be underserved with other broadband options such as Digital Subscriber Line (DSL) or cable. This makes this spectrum of particular interest for Wireless ISP operations in rural areas where the population is normally unserved or underserved with broadband access.

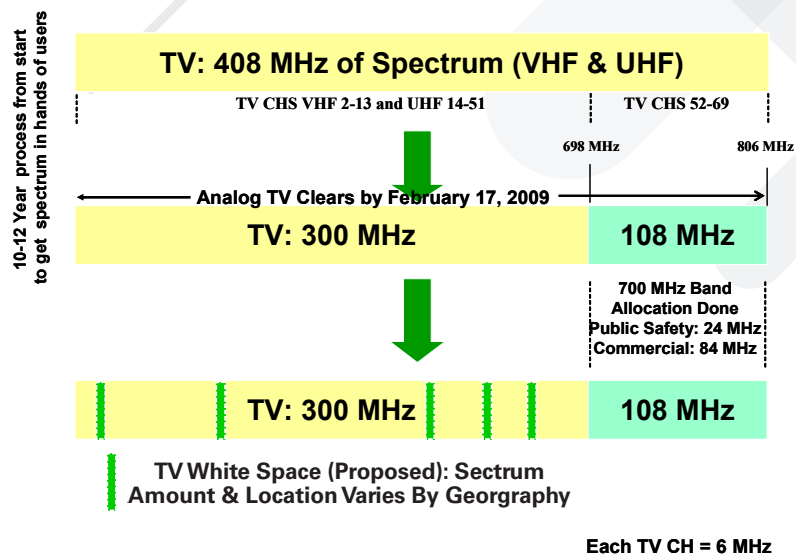


Fig 1 – The TV White Space Spectrum

Each available TV channel provides 6 MHz of spectrum capacity that can be used for broadband connectivity. These channels are shown in Figure 2. This increased spectrum capacity provides the opportunity for new broadband applications to transport video, voice or data services. Following are some likely potential uses:

- **State & Local Government** – Local government and school districts can perform data transfer at a fraction of the cost of leased lines.
- **Service Provider** – A community can be connected to provide Internet access to business and residential subscribers who are currently beyond the reach of DSL services.
- **Enterprises** - A manufacturing plant, transportation hub, a refinery or a power plant could use available TV White Space spectrum to help implement wireless data transfer and/or video surveillance for security of their facilities.

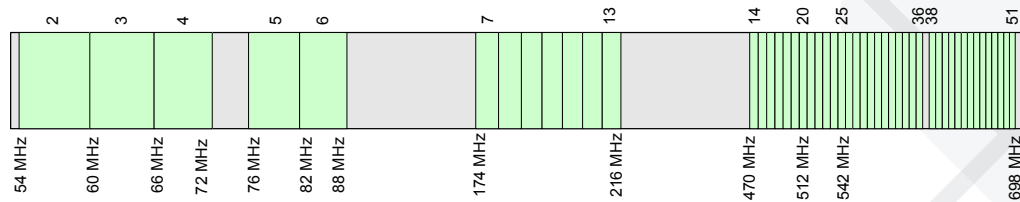


Fig 2 – The TV White Space Channels

These frequency bands are attractive to potential broadband users for the following reasons:

- The availability of a large amount of spectrum that can be used to provide connectivity.
- Propagation qualities that provide for Line of Sight (LOS), Near Line of Sight (nLOS) and Non Line of Sight (NLOS) performance.
- Larger coverage areas due to long range propagation of signal at these frequencies. For example, an AP location that can connect to an SM at a range of 5 miles can provide coverage for a 75 square mile area.

The FCC has decided to support the use of TV White Space as a means to provide broadband connectivity to rural areas in the United States by providing unlicensed access to the unused bands within TV White Space spectrum. These signals must not interfere with broadcast digital TV (DTV) transmissions or other licensed users in these bands. It is estimated that these bands will provide on average ten (10) channels of availability in suburban areas and as many as 25 channels of availability in rural areas. Availability of these channels is driven by the migration to DTV transmission in February 2009. The FCC has recently completed testing with prototype equipment from a number of manufacturers. The testing was intended to collect data to enable the FCC to write rules for use of unlicensed devices in this spectrum.

Currently, the TV White Space spectrum is used by the following applications:

- **Broadcast TV** – Operators that broadcast TV content to a region that use fixed, outdoor signal sources to reach fixed indoor and outdoor antennas at business and residential locations.
- **Low power wireless devices** –Users that broadcast audio content to a local area using nomadic indoor or outdoor microphones or other low power operations related to broadcast and non-broadcast uses. These can be either permanent locations such as a school or house of worship, or a temporary event such as a community event or sporting event.

***“Motorola’s geolocation solution—utilizing GPS location technology with a database of broadcast TV stations’ coverage area to ensure that the device does not interfere with those channels—performed well in all of its tests.***

**- Steve Sharkey, Motorola’s director of spectrum and standards strategy, during an interview with Urgent Communications.**

## The Fixed TV White Space Opportunity for Service Providers

Wireless Internet Service Providers (WISP) in the United States offer cost effective, reliable broadband connectivity to areas where DSL or other wireline or wireless based solutions are not available or not cost effective. Using the unlicensed spectrum at 900 MHz, 2.4 GHz and 5 GHz, these entrepreneurs are able to provide data, voice and video connectivity to municipal, enterprise and residential users in their community. Thousands of WISPs exist in the United States today, purchasing broadband connectivity in bulk and then wirelessly backhauling that connectivity to a distribution network in a previously underserved location. The availability of TV White Space spectrum present an opportunity for these service providers to construct the connectivity needed in suburban and rural locations for the following reasons:

- Additional Connectivity to Existing or New Subscribers – Enables more channels to better serve existing customers or add new customers in capacity constrained areas.
- Additional Applications – More bandwidth enables current customers to add more capabilities to their existing connections. For example, a network operator with connectivity for data transfer will now have sufficient bandwidth for video surveillance of remote areas.
- Data connectivity with broadband performance - Ability to offer services with competitive throughput performance characteristics. Where some subscribers are limited to sharing 4 Mbps of throughput, these subscribers can grow their businesses and provide improved connectivity with 1 to 2 Mbps per subscriber
- Wider Coverage Area – Where current LOS coverage areas are limited to 2 mile range, service providers can now reach areas with LOS, nLOS and NLOS coverage to 5 miles or more.
- Lower Total Cost of Ownership (TCO) – With AP cost structure spread over a larger coverage area, or the opportunity to co-locate TV White Space AP equipment at the same tower locations where other AP equipment is already located, service providers have improved profitability and incentive to grow their networks to reach new locations.
- Simple installation – The “all outdoor” solution is easy to install and does not require the cost of a building or environmentally controlled compartment at the AP tower location
- Network Security - Positive authentication of users to reduce unauthorized non-paying access and protection of over-the-air signal integrity. The signal can be encrypted with 128-bit AES encryption to support applications that require compliance with Health Insurance Portability and Accountability Act (HIPAA) standards.

## Motorola activities in TV White Space

Motorola is a member of the Wireless Innovation Alliance (WIA), which is a coalition of technology innovators, public interest advocates, and higher education organizations that are dedicated to the innovation and the unlimited possibilities of unlicensed and currently unused white space spectrum. WIA and its member organizations believe that with proper development and deployment, innovative TV White Space broadband solutions will enable the delivery of new communication services, particularly wireless broadband, to millions of underserved Americans and business enterprises.

Almost four years ago, the Federal Communications Commission (FCC) began considering rules to allow the use of much-needed and currently vacant spectrum between broadcast channels by unlicensed devices. In January 2008, the FCC greatly advanced its efforts by beginning a second round of testing of developmental devices. The rigorous testing and information gathering process undertaken by the FCC is designed to provide information that will serve as a foundation for rules ensuring protection of television channels while unleashing the benefits of unlicensed TV White Space device use in unused channels within this spectrum. Now that the FCC has decided to adopt the rules and requirements for use of this spectrum, manufacturers can develop commercially available devices and bring a new generation of broadband opportunities to the American public.

*The FCC did a good, comprehensive job on testing, beginning with the lab test and moving to an uncontrolled, real-world environment to identify the factors."*

- Steve Sharkey, Motorola's director of spectrum and standards strategy, during an interview with Urgent Communications.

In August of 2008, Motorola successfully demonstrated the ability to use unlicensed TV White Space devices while protecting digital TV viewing in a wide variety of conditions, including in the presence of strong adjacent channel signals. For more information, refer to the Motorola TV White Space press release at the following link: <http://www.wirelessinnovationalliance.org/>

This geolocation solution is described in the following sections of this paper.

## Motorola's Adaptive Radio Technology for Fixed TV White Space Connectivity

Motorola is developing technology that will meet the FCC protection requirements while protecting licensed incumbent users.

Motorola's solution includes a multi-tiered approach that combines a geo-location database - the primary means of ensuring protection of incumbent licensed users - with added layers of radio frequency sensing and beacon technologies. Motorola has worked closely with the FCC as it develops a comprehensive understanding of TV White Space technology through its testing and rule-making process. The two primary use cases which Motorola is initially investigating are shown in Figure 3.

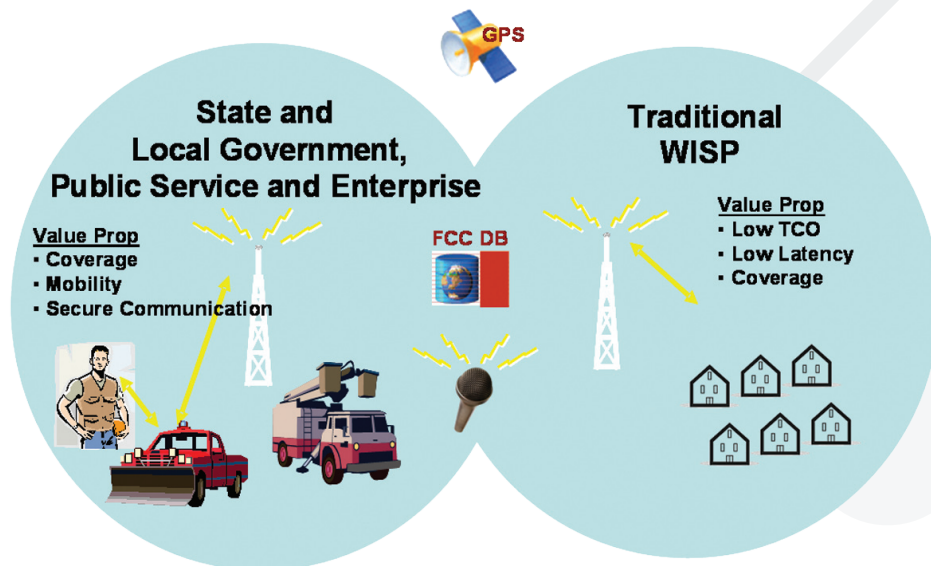


Fig 3 – Motorola's Mobile and Fixed TV White Space Use Cases

This paper focuses on the deployment of fixed solutions for rural connectivity in lower population density areas.

The key to successful use of the TV White Space frequency band is the ability to provide reliable connectivity by avoiding noise and not interfering with broadcast TV or other licensed incumbent users. To maximize signal integrity, Motorola proposes an approach that includes the following capabilities:

- **Geolocation** –The ability to utilize the location of the network and “block out” certain bands within the local operating area that are used by broadcasters and/or licensed users or wireless network operators.
- **Sensing** –The ability to test the environment and identify poor channel conditions in specified bands within the TV White Space spectrum.
- **Beacon Sensing Technology** -The ability to sense a beacon set-up to protect licensed wireless microphones at events and to avoid the frequency where microphones are being used.

## Geolocation

Motorola uses a geo-location database to determine what spectrum is available in a user’s given area. Licensed systems, including land mobile in the 470-512 MHz band and television stations, are listed in the Commission’s database. By knowing its location, querying the database, and being programmed with FCC-set protection requirements, a TV White Space system can determine what channels are available while still protecting licensed or incumbent operations.

DTV station availability varies greatly by location. Where a frequency band may be used in one location, there may be large areas where this frequency is not used and available for use for broadband connectivity. Motorola’s TV White Space solution, with the Adaptive Radio Technology, downloads position, power, and channels of nearby primary users (e.g. DTV) from the FCC database. The Adaptive Radio Technology then ranks available channels per allowable RF power prior to active sensing. This is what was implemented in a demonstration to the FCC in August, 2007. This process is illustrated in Figure 4.

Geolocation databases can also be used to prevent interference at wireless microphones and other protected low-power operations at static events that are planned in advance, such as football games and theater productions. For mobile TV crews reporting from unpredictable news locations, the vehicle can be equipped with a beacon that tells white space devices not to operate on the channels being used. For other unlicensed wireless-microphone uses that are not planned—and as such are not entitled for beacon deployment—“safe harbor” spectrum is an option that has been proposed for FCC consideration to supporting these users. An illustration of information stored in the FCC database that is available to the Adaptive Radio Technology is shown in Figure 5.

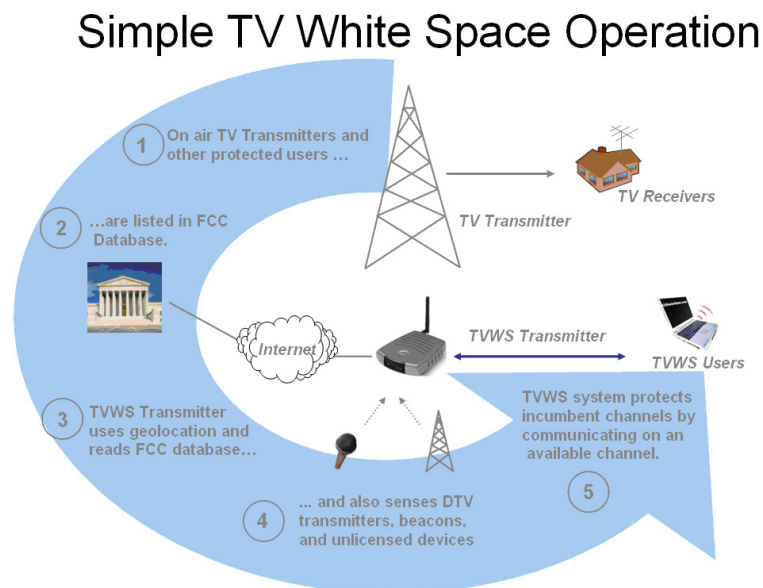


Fig 4 – Illustration of Geolocation Process

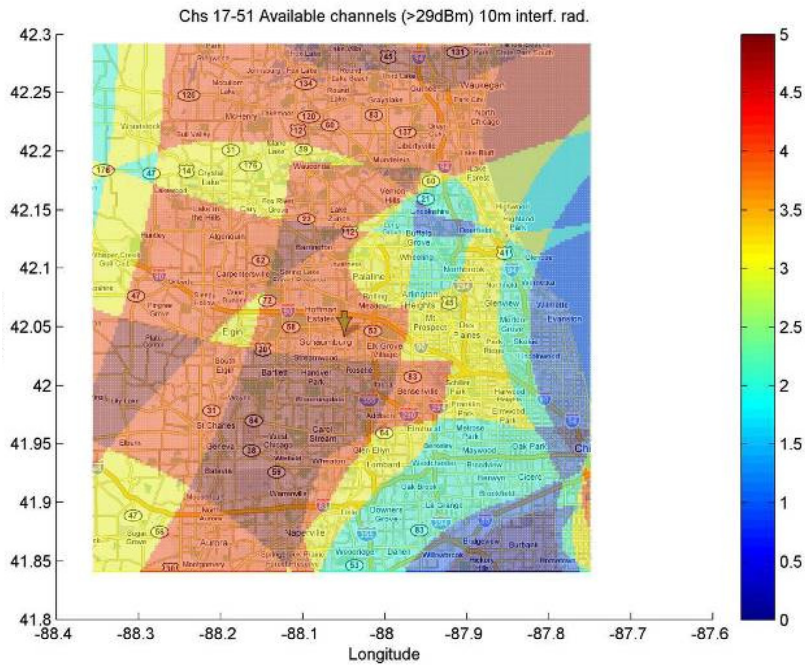


Fig 5 – Illustration of Geolocation Database Information

## Spectrum Sensing

Spectrum sensing complements the geolocation database to assist the network operator in finding the most noise-free channels to use.

Spectrum Sensing provides the ability to sense RF signals or detect a beacon, thereby enhancing compatibility with incumbent operators and facilitating sharing among TV White Space devices. Sensing technology has been widely deployed in many outdoor RF applications for years, and is proven to provide information on the presence of signals and noise in individual bands within a selected spectrum of frequencies. Spectrum sensing reveals activity in frequency bands whether they are used by broadcast TV or other emitters. A sensing spectrum report is shown in Figure 6. Motorola's Adaptive Radio Technology will enable these gaps to be "re-used" while protecting known incumbent users from interference.

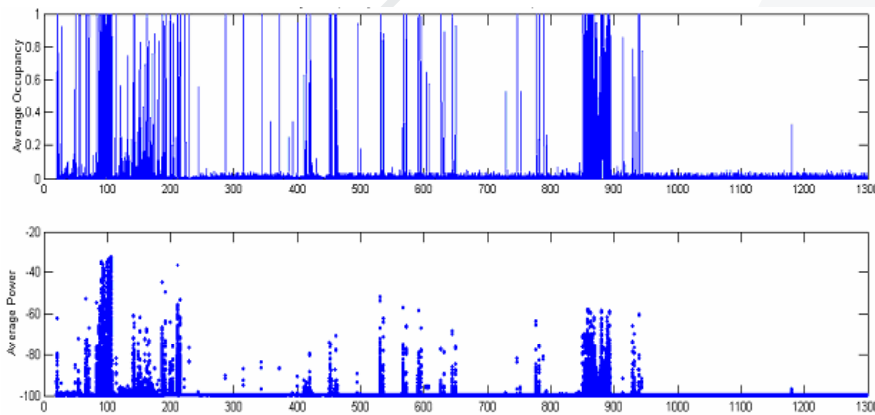


Fig 6 – Snapshot Spectrum Data Results from Sensing

Spectrum sensing measurements illustrate significant gaps and under-utilization of TV band in both time and frequency. These gaps are the “white space” in the spectrum analysis results shown in Figure 6. Additional data on historical activity can assist network operators to improve their deployment decision making. This data can be further processed into information that is immediately useful to network operators. An example of a processed report is shown in Figure 7.

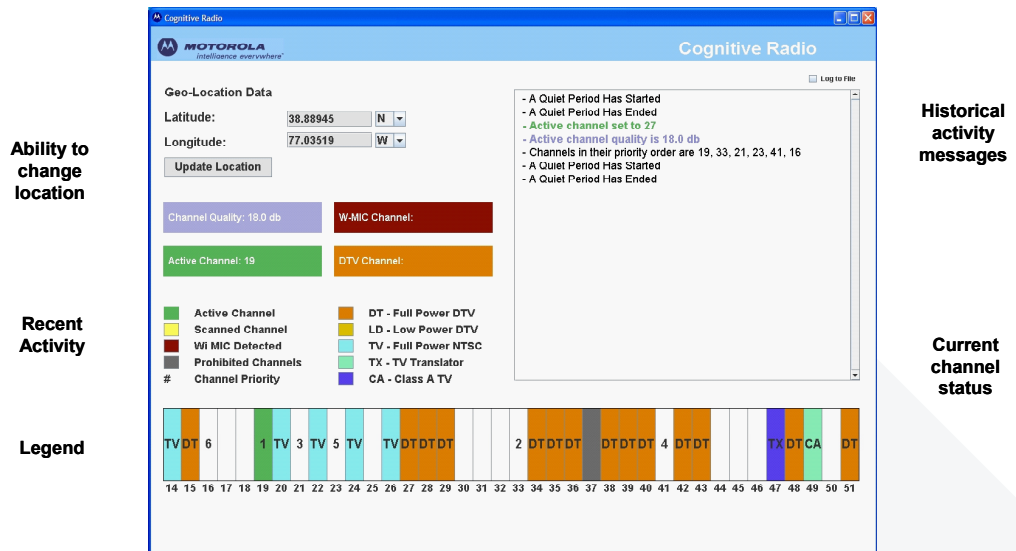


Fig 7 – Illustration of Combined Geolocation Results and Processed Sensing Information

Geolocation and Sensing, when used together in Motorola’s Adaptive Radio Technology, provide protection to incumbent operations while enabling significant new bandwidth to be made available to network operators throughout the United States.

## Summary

Geolocation, augmented with sensing, when used together in Motorola's Adaptive Radio Technology, have been proven in actual field test situations to provide protection to incumbent operations while enabling significant new bandwidth to be made available to network operators throughout the United States. Adding these capabilities to the field proven Canopy system will open new TV White Space bandwidth for use in fixed applications in the United States.

Fixed broadband connectivity in the TV White Space spectrum is an opportunity to expand the size and scope of rural connectivity solutions. In addition, use of the TV White Space spectrum for fixed applications provides an opportunity to cost effectively deploy broadband solutions to enable data transfer, internet browsing, and wireless gaming for operators and video surveillance systems for municipalities or Enterprises that can improve safety/security while improving operational efficiencies





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