NEW AMERICA FOUNDATION
WIRELESS FUTURE PROGRAM

ISSUE BRIEF

Issue Brief # 19 *July 2006*

WHY UNLICENSED USE OF VACANT TV SPECTRUM WILL NOT INTERFERE WITH TELEVISION RECEPTION

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On June 28, the Senate Commerce Committee marked up and adopted comprehensive telecom reform legislation (S. 2686, "The Advanced Telecommunications and Opportunity Reform Act of 2006"). The legislation included a provision (Title VI, "The Wireless Innovation Act of 2006") directing the Federal Communications Commission (FCC) to adopt rules permitting, to the greatest extent feasible, unlicensed access to the unused TV channels in each local TV market for WiFi, local wireless broadband services, and other innovations. This Brief addresses the technical arguments raised by the opponents of this legislation. In summary, the type of worst-case scenarios opponents raise can easily be addressed through the application of new smart radio technology and the conventional FCC rulemaking process.

I. Background: Broadcast to Broadband

On May 13, 2004, the FCC approved a Notice of Proposed Rulemaking (NPRM) proposing to allow a new generation of wireless devices to utilize vacant television channel frequencies in each market. This so-called TV band "white space" consists of frequencies that are allocated for television broadcasting but are not actually in use in a given area.[1] The FCC's proposed rulemaking is pending but currently inactive. Separately, there is proposed legislation in the U.S. Congress that would direct the Commission to complete the proceeding and reallocate unused TV band spectrum for shared, unlicensed access.

The FCC's proposal would promote both spectrum efficiency and wireless broadband deployment. The TV band has been called a "vast wasteland" of underutilized spectrum. After the completion of the DTV transition—and the reallocation of TV channels 52-to-69 for auction and public safety uses—an average of only seven full-power DTV stations will be operating on channels 2-to-51 in the nation's 210 local TV markets. Only 42 MHz of the 294 MHz of prime spectrum allocated to DTV services will actually be utilized on average.[2]

The FCC was clear in this NPRM that any devices certified to operate in the TV white spaces would be required to use new "smart radio" technology that would not interfere with television reception. The National Association of Broadcasters (NAB), the Association for Maximum Service Television (MSTV) and other broadcast industry advocates opposed the FCC's proposal, claiming that unlicensed devices operating on vacant channels in the TV band would cause harmful interference to television broadcasts and other incumbent uses of licensed TV band channels. Simultaneously, in other FCC rulemakings, they have tried to acquire vacant TV spectrum for themselves.[3]

The FCC's proposed rules are intended to make way for technologies that utilize unlicensed spectrum, such as WiFi, to utilize the prime TV band spectrum to offer wireless broadband services. WiFi technology has become very popular at higher frequencies, and has had a positive impact on the growth of broadband services. However, the bands used for WiFi do not have appropriate radio propagation characteristics to serve low population densities, or to penetrate the exterior walls of buildings. Lower-frequency spectrum, such as that used for TV broadcasting, is capable of traveling longer distances at a given power level, and can better penetrate obstacles such as buildings and trees.

Thus, the proposed use of "white space" TV channels could have a particularly great impact on the growth of information services in rural areas. In urban areas, where less "white space" is available, this spectrum would also be

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useful because of the great demand for wireless broadband services and because of the ability of low-frequency TV band spectrum to penetrate trees, buildings and other obstacles.

Unlicensed Devices: 350 Million and Booming

Unlicensed devices have been authorized by the FCC since 1938. A Consumer Electronics Association study quoted by the FCC estimates that there are over 350 million unlicensed devices in the US and that annual hardware sales are in the multibillion dollar range.[4]

All of these devices comply with general rules established by the FCC to ensure that they do not cause interference to licensed systems and federal government systems.[5] Some unlicensed devices operate at very low power so they can coexist with higher-power licensed users in the same band,[6] while others (e.g., WiFi) operate in bands that are largely devoid of licensed users.[7] Before a new model of unlicensed device can be sold, it must be authorized—that is, it must be tested by a third party and shown to comply with technical standards established in FCC rules.[8] The FCC enforces its technical rules for unlicensed devices through both this equipment authorization program and through its statutory jurisdiction over the marketing of devices "capable of emitting radio frequency energy...in a sufficient degree to cause harmful interference to radio communications."[9]

II. "Your Neighbor's Static"

In August 2005, the Association for Maximum Service Television (MSTV), representing broadcast industry interests, released a video on its website claiming to show the interference that would be caused by unlicensed devices operating in the TV band.[10] MSTV did not include any details to show how an independent observer could reproduce its results; it stated simply that the device demonstrated was "an FCC-compliant unlicensed device," and could cause interference to DTV sets at distances up to 78 feet and to analog TV sets up to 452.7 feet, "even through multiple walls." MSTV has claimed that this video is based on laboratory reports prepared by the Canadian government's Communications Research Center (CRC).[11]

The basic phenomenon shown in the video, desensitization interference, is well known and the FCC's FM broadcast rules even address it in the case of homes near an FM transmitter. Consumer-grade TV receivers are more susceptible to this problem than other types of receivers because they are designed both to receive signals over a large tuning range and to receive weak signals. Nevertheless, MSTV's video, for reasons described below, both exaggerates the problem and ignores other solutions to it.

A. What was in the MSTV Video?

The MSTV video entitled "Your Neighbor's Static" provides a non-engineering demonstration of the potential impact of unlicensed devices on digital and analog TV reception. However, the technical details are exceptionally important to determine the relevance of both the methodology used and the potential impact. Unfortunately, many of the details are confusing to a non-technical audience, but they are nonetheless critical to understanding interference. As with any important analysis, the lack or unclear presentation of specific technical details can unfortunately render the analysis and/or demonstration meaningless.

The first technical detail to understand is the characterization of the simulated unlicensed device. Unfortunately, it is never identified in the provided video. In the previous edition of this Issue Brief,[12] we assumed it was a "54-MHz-wide noise generator" (the bandwidth associated with nine contiguous TV channels), based on informal discussions with the MSTV staff. MSTV recently stated in an undated "rebuttal" to the Issue Brief[13] that it was an "18 MHz" (three TV channels-wide) signal based on the findings of the CRC report. MSTV has released another undated "fact sheet"—accompanied by a statement from its consulting engineering firm, Meintel, Sgrignoli, & Wallace (MS&W)—that provides background information explaining the video. Neither the MSTV documents nor the MS&W statement describe in engineering detail the characteristics of the transmission tested, nor do they give a measurement of its spectrum as is common in such experiments. The MS&W statement does say that "the methodology used is identical to the one used by the Communications Research Center of Canada (CRC) for their laboratory evaluation."[14] Since interference is a highly technical issue, a precise description of the demonstration is necessary to 1) verify the results, and 2) validate the relevance of the results.

Neither MSTV nor MS&W ever explicitly specify which two CRC reports they reference. We assume for this discussion that the more recent Feb. 3, 2005 CRC report should be used, since the Nov. 29, 2004 report filed at the FCC deals with a 5.57 MHz bandwidth maximum, a little less than one TV channel. However, the Feb. 3, 2005 CRC report describes the signal as having a nominal bandwidth of 18 MHz or three TV channels, but also says that the "flat portion of the filtered interfering signal, Figure 4, is about three TV channels wide."[15] CRC provides both a plot of the spectrum of the interfering signal, as is customary in such reports, and gives the more usual technical description of the bandwidth: the 3 dB bandwidth (the point at which the power density is 50 percent of the peak) as "30 MHz" or six TV channels wide.[16]

While the FCC proposal has not yet specified a maximum bandwidth for unlicensed devices emitting on the TV band, in all but the most remote areas it is not possible to find a contiguous free spectrum block of four, five or six TV channels. Indeed, if the FCC supports MSTV's position that access to channels immediately adjacent to a licensed TV channel in an area will not be permitted, the type of transmission the CRC tested would need to be even more wide-band (five-to-eight contiguous channels) to result in the sort of desensitization interference MSTV demonstrated.[17]

We have provided a brief analysis of the technical specifications of the MSTV video. Although the specifications are not provided explicitly, we implicitly determined the test waveforms are at least six TV channels wide (a total of 36 MHz). These test cases represent uncharacteristic use of the white spaces, not only because the existence of six contiguous channels is unlikely, but also because such a case could easily be eliminated by establishing a new limit on total transmit power in addition to the limit on power/120 kHz that was proposed in the NPRM. This will be discussed below.

A series of tests that would determine the impact of various bandwidths would provide more relevant engineering information to determine appropriate regulations to prevent harmful interference.

Implementing and Enforcing the Proposed Interference Protections Through the FCC's Equipment Authorization Program

This section reviews the FCC's current Equipment Authorization Program and how it can be used to ensure that equipment authorized under the proposed rules does not cause harmful interference to TV broadcasting reception. Section 302 of the Communications Act of 1934, as amended, and the various rules the FCC has implemented under it, plus the changes we are proposing below, can give the FCC powerful tools to demand and enforce compliance with its goals.

Various parties have raised concerns about what might happen after well-intentioned rules are adopted with respect to compliance of new unlicensed equipment. Several have also mentioned that it would be impossible to recall equipment if the FCC later found it had erred. This section will respond to these two concerns.

Equipment Authorization Today

The FCC, unlike many of its foreign counterparts, has authority under §302 of the Communications Act to both set standards for equipment capable of causing harmful interference to transmitters (47 USC §302a(a)) and to forbid the manufacture, import, sale, or even interstate transportation of equipment that fails to meet its Rules (47 USC §302a(b)). These powers are then implemented in the Commission's Equipment Authorization Program (*See* http://www.fcc.gov/oet/ea), as codified in Subparts I, J, and K of Part 2 of the Commission's Rules (47 CFR §§2.801-1207).

The cognitive radio transmitters envisioned in this rulemaking would be classified as intentional emitters and would be subject to Certification under current procedures. Under Certification procedures, a prototype unit would have to be submitted to a Telecommunications Certification Body (TCB) designated by the Commission (*See* http://www.fcc.gov/oet/ea/procedures.html#sec4) to be tested for compliance with the adopted rules. Traditionally, such testing has reviewed only the emissions of transmitters as it was assumed that the transmitters did not interact with their environment. However, as a result of both the Commission's Cognitive Radio (*See* http://gullfoss2.fcc.gov/cgi-bin/websql/prod/ecfs/comsrch_v2.hts?ws_mode=retrieve_list&id_proceeding=03-108) and 5 GHz U-NII (*See* http://gullfoss2.fcc.gov/cgi-bin/websql/prod/ecfs/comsrch_v2.hts?ws_mode=retrieve_list&id_proceeding=03-122) proceedings, the Commission is now putting into place, independent of Docket 04-186, procedures for testing radios that explicitly interact with their environment.

While the Equipment Authorization Program permits testing and approval of equipment by privately operated TCBs, in practice, the Commission has retained sole authority to approve new types of equipment that raise novel testing issues (*See* http://www.fcc.gov/oet/ea/procedures.html#sec4), and it is expected that this would also apply to the cognitive radios under consideration in this proceeding. Transmitters can only be imported, manufactured, or marketed after this approval is obtained. The Commission has the resources and authority to enforce such requirements.

Post-Approval Options with Today's Technology

With traditional radio technology, a transmitter's functionality was determined at the factory and never changed afterwards. But most radio transmitters in the past 10 years have had microprocessors and significant software controls. The Commission's software-defined radio rules (47 CFR §§2.944,1043) permit the use of software in radios that is added after manufacture subject to security requirements to ensure that the hardware/software combination has been approved to comply with the technical standards of the Commission. For example, the personal computer software industry today uses products like Macrovision's *FLEXnet* (*See* http://www.macrovision.com/products/flexnet_publisher/index.shtml) to control the use of valuable software through features such as expiration dates.

Since the radios under consideration here are expected to be used, in most cases, in conjunction with Internet access, it would not be a significant burden for them to connect to the equipment manufacturer or distributor periodically to update their software just as personal computer users update their software—although in this case the *FLEXnet*-like functionality could reliably enforce the updating. This requirement need not apply to very low-power devices that are not connected to the Internet—such as remote monitoring devices that can be used to track herds of cattle, or to monitor industrial machinery.

B. Preventing Desensitization Interference

The existence of white spaces or unused portions of the TV broadcast spectrum within a region as well as the capacity to locate/detect these white spaces is well established. The appropriate signal levels to prevent receiver desensitization (i.e., interference) are a matter of rigorous engineering analysis.

The signal levels of the test waveforms are important in determining the amount of desensitization of a receiver. By assuming unlicensed devices will transmit at maximum allowed power levels over an unrealistically wide range of contiguous channels, the interference demonstrated in the video exploited a longstanding loophole in FCC Rules that has never caused a problem using real emitters in the field.[18] Today, the UHF TV band is not used only by TV transmitters and wireless microphones. It also has, in select markets and bands, powerful land mobile base stations, mobile transmitters, portable transmitters,[19] and wireless video assistance devices.[20] Some people even live near five-megawatt UHF band transmitters, which are more than a million times stronger than the low-power unlicensed devices proposed here—and the FCC has never found it necessary to address interference to neighbors of such transmitters even though it does so in the case of neighbors of FM transmitters.[21] In the real world, desensitization has not been the problem that might be predicted from laboratory experiments.

By assuming unlicensed devices will transmit at maximum allowed power levels over an unrealistically wide range of contiguous channels, the interference demonstrated in the video exploited a longstanding loophole in FCC Rules that has never caused a problem using real emitters in the field.

The present FCC rules were written two decades ago when test instrumentation was less advanced than it is today so the parameters specified in the rules and measured are the parameters that were easy to measure at that time and which were important for the devices sold *then*. Contemporary test equipment uses microprocessor control and can now measure total power over arbitrarily large bandwidths. Since MSTV's video addressed a special case in which measuring desensitization over wide bandwidths would matter, so the FCC's measurement procedures and emission standards should evolve with the times.

This loophole in the Part 15 unlicensed rules, which would theoretically permit wideband emissions in TV spectrum, could be closed once and for all if the FCC adopts an additional easily-measured total limit on power in the TV bands for out-of-band emissions and applies this limit to all intentional and unintentional emissions.[22] When the FCC adopted in 1979 its limits for personal computer emissions[23] in order prevent interference to TVs, it made an assumption that it wanted to "protect a TV receiver in a residential area receiving a TV signal E_S and located at 10 meters or more from a Class B computer with at least one wall between the computer and the TV receiver."[24] While personal computer speeds are much higher than they were in 1979, today's personal computers still emit power in the TV band comparable to these limits and experience shows that this 10 meter protection goal has been adequate and noncontroversial.

The FCC could eliminate the desensitization concerns raised by MSTV by setting a similar protection distance goal for unlicensed devices and setting a maximum total TV band power limit that the unlicensed device can transfer to a TV receiver at that distance.[25] This would follow the long-standing precedent that has successfully protected TVs from PC interference over the past 25 years. The Equipment Authorization program, described in the sidebar on page 3, can then verify that this limit is met before each equipment model can be sold.

C. Adjacent Channel Issues

MSTV has recently raised the issue of adjacent channel protection, raising the specter that "100 mW unlicensed device can cause interference to adjacent channel DTVs up to 950 meters away!"[26] This problem is easily remedied. MSTV's calculations assume that the unlicensed device is transmitting a DTV-like signal filling the whole adjacent channel. FCC needs to establish some rules for adjacent channel protection as it has in many other radio services. With such rules in place, the proposed unlicensed devices can then readily adjust their signal and its location to meet the adjacent band requirement.

But the issues of non-TV signal use of TV spectrum and adjacent channel protection are not new. The mobile sharing of TV channels 14-to-20 in 13 major markets by public safety radio systems has resulted in protection criterion that are codified in federal regulation (47 CFR 90.307). These factors can be used to compute the extra protection which is needed to decrease unlicensed power in channels adjacent to TV channels, particularly in the parts of the channel closest to channel edge.

Therefore, we agree that interference from devices operating in adjacent channels to TV bands can exist. However, the problem can easily be solved by the FCC with current technology.

D. Waiting for the IEEE 802.22 Standard

The broadcast lobby has also urged the Commission to wait for the Institute of Electrical and Electronics Engineers (IEEE) 802.22 committee to resolve its deliberations on this topic. IEEE 802.22 is a sister committee to the IEEE 802.11

that created the widely used WiFi standard. In the case of WiFi, the 802.11 committee deliberations started several years after the FCC's adoption in 1985 of the basic regulation for these devices.[27] Indeed, the FCC adoption of this rule was very controversial and it is unlikely that a consensus standards group such as 802.11 could have ever reached the 75% majority it requires for action.[28]

IEEE 802.22 has members who are proponents of unlicensed use as well as broadcast interests firmly opposed to it. The 802 consensus rules make it very unlikely that this disparate group will ever reach consensus unless the FCC acts first and lays out specific rules for sharing with broadcast signals so that the role of 802.22 can then follow the successful precedent of 802.11 in developing a specific implementation of the FCC rule. Indeed, like the FCC's Part 15 rules that allow 802.11 WiFi devices to share the unlicensed 2.4 GHz band with hundreds of other devices, the FCC will presumably authorize other innovative devices to operate on the TV white spaces and not limit access to devices meeting a private industry interoperability standard.

E. Spectrum Sensing Issues

MSTV also challenges what can be considered the most promising proposal within the NPRM for avoiding interference with television transmissions: the spectrum-sensing, listen-before-talk (LBT) protocols that the Department of Defense recently accepted and the FCC has recently adopted for unlicensed sharing of the upper 5 GHz bands used (until now) exclusively by military radar (this LBT method is described further in section III below). First, MSTV refers to the 5 GHz LBT system authorized by FCC regulation[29]—and agreed to after testing by the Defense Department—as adequate to protect national security-related radars but *not* TV reception. MSTV asserts that unlicensed devices sharing the 5 GHz band are "only required to detect a strong radar signal" and "only required to detect radar signal 80% of the time."

Compared to military radar, TV is a bullhorn on a stick—extremely easy to detect and avoid.

In fact, military radar is much *harder* to detect than TV signals simply because TV signals are on continuously, microsecond by microsecond, for up to 24 hours a day. Radars are on for about a microsecond and then off for a period usually greater than a millisecond to allow the pulse to go out and return. Radars are designed to elude detection. For example, they generally rotate, so for much of the rotation the signal can't be seen because it is sent in another direction. TV transmitters have a fixed antenna pattern. In short, compared to military radar, TV is a bullhorn on a stick—extremely easy to detect and avoid.

The "80% of the time" quote of MSTV does not have a reference. The relevant FCC rule contains no such number.[30] Perhaps MSTV is referring to a recent FCC test procedure for such devices[31] that requires 80 percent detection, but this is clearly stated as the detection for a small number of radar pulses. Since the radar transmits continuously, 80 percent probability of detection on a small number of pulses translates into near certain detection on a series of pulses over a few seconds. Again, by contrast, TV signals are on continuously, not in a series of isolated pulses, so they are much simpler to detect reliably.

MSTV states in its March 2006 presentation that "(a)fter over two years, no 'sensing' technology studies or proof have been submitted to FCC showing that 'feature detector' or other technology can reliably detect TV signals even at these levels." However, they ignore the February 1, 2005 Reply Comments of Shared Spectrum Company in Docket 04-186 which addressed this exact issue a year before the MSTV presentation.[32]

Nevertheless, the most straightforward way to address this issue is to use system performance goals and not explicit technical attributes. The FCC should just set a verifiable performance goal for LBT detectors as it did in the 5 GHz case and use long-established procedures in its Equipment Authorization Program, described in the sidebar above, to allow only models that meet the goal to be marketed.

III. The FCC Proposal for Unlicensed Sharing of TV Spectrum Without Harmful Interference

The Commission's May 2004 NPRM proposed allowing unlicensed devices to operate on unused TV channels. As the FCC noted in its NPRM, this spectrum would be ideal for unlicensed broadband because it has better radio propagation characteristics than the present WiFi bands and can tolerate higher-power devices without causing interference. These characteristics allow wireless broadband providers to achieve better-quality coverage of larger areas using less infrastructure, significantly reducing the cost of broadband deployment. A study by Intel confirms this, showing that the capital costs of covering a rural area with wireless broadband service in the TV band would be one-fourth those needed to achieve the same coverage using licensed MMDS spectrum in the 2.5 GHz band (which sits adjacent to the current unlicensed "WiFi band" at 2.4 GHz).[33]

The NPRM proposes unlicensed operation under one of three alternative schemes intended to prevent interference to television reception:

I. *"Listen-Before-Talk"* (*LBT*): Sensing the presence of TV signals by the unlicensed device in order to select channels not in use. This concept, also described as dynamic frequency selection (DFS), has already been adopted by the International Telecommunications Union (ITU) and the FCC for sharing of the 5 GHz spectrum between unlicensed systems and military radar as mentioned above.

II. *"Geolocation/Database"*: Location sensing and consultation with broadcast database. In this scheme, an unlicensed device would contain location-sensing technology, such as a Global Positioning System (GPS) receiver. The device would cross-check its own location with an internal database of TV transmitter locations in order to verify that it was a minimum distance from a TV transmitter.

III. *"Local Beacon"*: Reception of a locally transmitted signal that identifies which TV channels may be used in the local area for unlicensed use. In this scheme, low-power local signals, possibly controlled by local broadcasters, would indicate directly which channels were free for use.

The FCC NPRM proposes possible use of any of these methods as acceptable ways of avoiding interference to licensed broadcast users, and recognizes that the final rules might only allow for one or two of these independent alternatives. The remainder of this Issue Brief will discuss basic technical issues that have been raised in the FCC proceeding and then specific points made by the broadcast industry lobby in recent communications with Congress and the FCC.

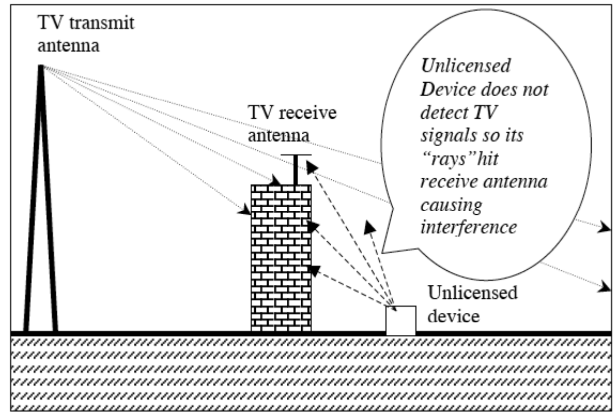
IV. Broadcaster Interference Concerns are Unfounded or Readily Avoidable with Established Technologies

This section will address basic technical issues associated with the three alternatives proposed by the FCC. The proponents of this NPRM, including academics and equipment manufacturers, have shown in their comments that any of the three alternatives may be both effective and practical.

1. Listen-Before-Talk (LBT) Alternative: Avoiding the "Hidden Node" Problem

The broadcast interests have focused much of their concern about the NPRM on alleged vulnerabilities in the *LBT* alternative (Alternative I above), in which unlicensed devices must first "listen" and sense the presence of TV signals in the area before transmitting. They point out, as shown in Figure 1, that an unlicensed device could be in the shadow of a building and be shielded from the TV signals, while a TV antenna at the top of the building might get a good signal.[34] This is known in the technical literature as the "hidden node" problem. Indeed, studies have shown that in both urban and rural areas, where buildings and terrain serve as obstacles to TV signal penetration, there exist many "shadow" spots in which TV signals may be weakened or totally diminished.

Figure 1 - The "Hidden Node" Problem



Therefore, the broadcast interests claim that unlicensed devices using this alternative could miss detecting TV signals due to shadowing, and thus will continue transmitting and cause interference to nearby TV receivers that are receiving adequate signal strength.

The comments of the broadcast industry (and even the FCC's NPRM) assume that the detector part of the unlicensed devices in the *LBT* alternative would be about as sensitive to radio-frequency emissions as are normal TV receivers. But this need not be the case. Research presented at a February 2003 FCC-sponsored seminar demonstrated that a detector optimized for a specific class of signals (e.g., TV signals) can be orders of magnitude more sensitive than a normal receiver.[35] The Commission had previously taken note of this research in its NPRM on cognitive radio,[36] but inexplicably did not address it in this unlicensed NPRM. Similarly, the reply comments of the broadcast community have steadfastly ignored the applicability of this technology, which was mentioned repeatedly by various parties in the comment phase of the FCC rulemaking.[37] In addition, since these radios must merely detect the presence or absence of a TV signal—and not reproduce the picture—the detection sensitivity will be orders of magnitude better than a normal TV set.

It has also been pointed out in the comments that cooperative sensing of TV spectrum by multiple unlicensed devices could, in effect, improve sensitivity of TV signal detection significantly. This would be the case for meshed wireless networks, such as those deployed by cities, counties and college campuses to achieve ubiquitous coverage over wide areas. Such cooperative sensing can be used in conjunction with very sensitive detectors for even more sensitivity gain.[38]

The use of very sensitive receivers could solve the hidden node problem. **The FCC could simply set a sensitivity value for detectors that would give a high confidence that usable TV signals would not be missed**, and then verify in its Equipment Authorization Program that each each model of unlicensed device meets the specified sensitivity level. Equipment can not be manufactured, imported or sold until such a performance verification equipment authorization is complete. (See sidebar on page 3 for more details.)

Broadcast interests have raised the issue that the commercial experience in analogous LBT detection (in the 5 GHz NII rules) does not apply to the TV bands because the signals are different. They are right—detecting DTV signals is *much easier*. The 5 GHz NII Listen-Before-Talk system required by 15.407(h) must detect a wide variety of military radars, many of which have actual parameters that are classified. After the March 2009 DTV transition, there will only be one type of over-the-air TV signal in the U.S., and the proposed LBT detector here need only address that signal format. Furthermore, the radar signals have short pulse widths (typically millionths of a second) followed by relatively long silent periods for the pulse to return to the radar. Then the radar rotates and the signal seen by the unlicensed device will be much weaker for a period that may be up to several seconds.

By contrast, DTV signals are continuously on, transmitting about 20 million bits/sec 24 hours/day in a well-defined format with precise and known frequency and timing control.

2. Geolocation/Database Alternative: Need to Keep FCC Data Up-to-Date

The broadcast interests also raise concerns about a second alternative means to avoid interference with TV reception on nearby channels: geolocation and automated checking against a database of frequency assignments (Alternative II above). Broadcasters have pointed out that geolocation systems such as GPS do not generally work indoors and hence could not reliably determine location.

With respect to the broadcaster claims about the reliability of geolocation technologies, it is important to note that there are advanced GPS technologies used in some cellular telephone systems that actually *do* work indoors.[39] Furthermore, once the DTV transition is complete, it will become technologically feasible to conduct indoor geolocation using multiple DTV signals and/or FM radio signals, instead of the satellite technology used in current GPS systems. Indeed, geolocation could even become a new product for broadcasters. Nevertheless, FCC rules for the geolocation/database option should make it clear that transmission is not permitted unless a valid geolocation signal has been received within a short time period. This will make this option failsafe.

3. Local Beacon Alternative: Control Signal Rules Can Avoid False Positives

With respect to the *Local Beacon* alternative (Alternative III above), it has been recognized that the NPRM did not specifically propose what type of short-range radio signals should be used to broadcast channel availability information. Absent specific rules, a long-range transmitter might indicate availability of a certain channel and be received in an area far away where that channel is not really available. For example, a signal transmitted in the AM broadcast band could have a range of hundreds of miles at night and would be inappropriate for carrying information about which empty TV channels could be used in a given area. The problem could be simply resolved by rules specifying that the radio channel used to convey TV channel availability information must have a range comparable with the geographic validity of the channel availability information.[40]

4. Channel Availability

Some broadcast interests have questioned whether there will be significant channel availability for unlicensed use in major urban areas during the DTV transition. This concern is unwarranted. Even in urban areas, where there are fewer unused channels, there is likely to be substantial channel availability during and after the transition.

Most importantly, there is no doubt that in rural areas—where unlicensed access to the TV band white space would make the most difference for affordable broadband deployment—there *is* spectrum available now and there will be for the foreseeable future. The proponents of this proposal do not seek a guarantee on how much spectrum will be available in a given location at a given time, and are willing to take their risks with the basic FCC proposal and their own analysis.

V. Other Concerns Expressed by Broadcast Interests and the Response from NAF *et al.*

The broadcast industry has vehemently opposed the NPRM with multiple allegations that the proposals would cause serious harm to broadcast reception, cable television (CATV) reception, and to wireless microphones used in broadcast program production.[41] These allegations are addressed in turn below. The order of discussion here follows that of the April 8, 2005 letter sent by a broadcast industry consortium, the Coalition for Spectrum Integrity, to Senate Commerce Committee Chair Ted Stevens (R-AK).[42]

A. DTV Disruption Issue

Broadcasters have claimed that implementation of the proposals would create consumer confusion and delay the DTV transition. There is no evidence for this assertion.

Concerns have also been raised that uncertainty about this rulemaking might cause small local stations to delay making final channel selections and converting to DTV. However, the DTV transition legislation signed by President Bush earlier this year renders this issue moot since it establishes a February, 2009 hard deadline for stations to end analog transmissions and clear TV channels 52-to-69. The broadcast community's statement that unlicensed devices may cause "interference to newly purchased DTV receivers, which may cause consumers to return their new TV sets," similarly lacks a factual basis. Today's DTVs are far more capable of handling and rejecting any potential interference than older analog sets, which are susceptible to a variety of signal impairments that pass through directly to viewers in the form of ghosts, snow, and interference patterns in the video display. To suggest that new DTVs are somehow more susceptible to potential interference than other TVs is questionable logic.

B. Public Safety Interference

The *Geolocation/Database* and *Local Beacon* alternatives in the FCC proposal use local information, such as locations and databases of facilities, in deciding what channel to use. Thus, unlicensed systems using these techniques could readily avoid channels 14-to-20 in the handful of markets in which they are used for public safety. The *LBT* alternative requires more complexity to avoid public safety use of channels 14-to-20 since lower power, intermittent public safety communications are harder to detect than high power, full-time TV broadcasting. However, technology already exists that allows unlicensed devices to detect and avoid military radar—which is a far harder task than detecting public safety communications.

C. Wireless Microphones

Although not generally known, broadcasters and a few other entities are allowed to use vacant TV channels for "low-power auxiliary stations" (e.g., wireless microphones) with nominal licensing under the provisions of federal regulation.[43] While this use is officially licensed, this spectrum has not been auctioned and it bears many similarities to unlicensed use except that it is reserved for a narrow group of eligible users and their devices. These devices are used at studios, but are sometimes used at sports events and other outdoor news events.

Wireless microphone users should be clearly divided into two categories: legal (licensed to users eligible under Part 74[44]) and illegal (ineligible users). It has been estimated that more than 90 percent of wireless microphone users are not eligible for licenses to use the broadcast band although they would be eligible for Part 90 licenses, which would permit wireless microphones in neighboring bands.[45] However, the nearly interference-free co-existence of these devices by many users within the TV whitespaces with little attention to frequency selection is a clear indication of the viability of the unlicensed sharing concept proposed by the NPRM.

There have been concerns raised that the wireless microphones used by broadcasters on vacant TV channels might receive interference from unlicensed devices using the *LBT* alternative. While the FCC minimized this problem in the NPRM,[46] it is a difficult problem to solve in a manner that is transparent to existing users of such wireless microphones because the microphones operate at a lower power, do not necessarily have signal formats enumerated by regulations, and do not have a formal channel plan.

However, it should be noted that there are a diverse number of technologies available to provide wireless microphone services and that the amount of spectrum needed for such services is a fraction of the estimated amount of TV white space spectrum available. For example, broadcast-quality audio could be obtained by using digital microphones interfaced with 3G cellular radios that are capable of carrying arbitrary digital signals.

The provisioning of "safe harbor" spectrum within a portion of the TV band white space is an example of a method by which the FCC could provide ample spectrum for current wireless microphone users pending a transition to more efficient spectrum technology for such users. For example, the Commission could temporarily forbid unlicensed use in a small block of channels where wireless microphones would be protected—as it currently does for certain public safety systems operating among TV channels 14-to-20 in 13 designated metro areas. This block might shrink with time and might also have a later requirement that authorized users must transmit a beacon to indicate their presence to unlicensed devices.[47]

VI. Conclusions

The FCC made a reasonable and important proposal in May 2004 to give devices that meet rigid technical specifications unlicensed access to under-utilized TV band frequencies. The FCC has proposed several alternative means to ensure there would be no harmful interference to television reception or to public safety operations, as required by law. The ability of "smart radio" technologies to avoid interference is well-established, and technology industries have suggested additional improvements. A comprehensive record has been established at the FCC. Legislation that mandates an end to the DTV transition will have the side effect of removing a major uncertainty affecting this proposal. The other concerns about interference raised by the broadcast interests in this proceeding can be easily resolved through normal FCC rulemaking.

Endnotes

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[1] FCC Notice of Proposed Rulemaking in Docket 04-186, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-113A1.pdf

[2] "Measuring TV 'White Space' Available for Unlicensed Wireless Broadband," New America Foundation and Free Press Analysis, January 2006. Available at: http://www.newamerica.net/index.cfm?pg=article&DocID=2713. The share of the Channel 2-to-51 DTV band that will be unused by February 2009, the statutory end of the DTV

transition, ranges from 30-to-40% in congested markets like Trenton, NJ (30%) and Dallas (38%), to 70% or more in smaller markets such as Juneau, Alaska (74%) and Fargo, ND (82%). A separate channel-mapping study by Intel reached similar results.

[3] *See,* e.g., Notice of Proposed Rulemaking, FCC Docket 05-312.

[4] "Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues," OSP Working Paper Series, Federal Communications Commission, http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-234741A1.pdf.

[5] The FCC has agreed with the National Telecommunications and Information Administration (NTIA), which regulates Federal Government use of spectrum pursuant to 47 USC 305, that it will coordinate with NTIA all rule changes that might cause interference to Federal Government radio systems. *See* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-230835A2.pdf

[6] *See* 47 CFR 15.205,209.

[7] *See* 47 CFR 15.247.

[8] For most types of equipment, this authorization is done by a Telecommunications Certification Body accredited by the FCC or a foreign counterpart of the FCC pursuant to a mutual recognition agreement. However, for new classes of equipment, the FCC usually insists on retaining "hands on" control of final approval of new models until there is a consensus with industry on how the testing is to be done and interpreted. *See* http://www.fcc.gov/oet/ea/ - sec0.

[9] 47 USC 302(a),(b) FCC issued $350,000 in fines in 2004 for equipment marketing violations. *See* http://www.fcc.gov/eb/reports/Jan2005.pdf.

[10] Video available at: http://www.tvtechnology.com/dlrf/one.php?id=986.

[11] NAB and MSTV included one such report in their November 30, 2004 filing at FCC. *See* "Laboratory Evaluation of Unlicensed Devices Interference to NTSC and ATSC DTV Systems in the UHF Band," Communications Research Centre Canada, November 29, 2004—included in Comments of NAB and MSTV, Docket 04-186, 11/30/04. http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516883656 http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516883657 http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516883658 (CRC report starts at p. 28 of second file). Broadcast interests have circulated on Capital Hill a second report that appears to be the basis of the video, but this report is not in the record of the FCC rulemaking and hence has not been subject to public comment. *See* Communication Research Centre Canada (CRC), "Laboratory Evaluation of Unlicensed Devices Interference to NTSC and STSC DTV Systems in the UHF Band, Phase II, Report (February 3, 2005), appended to Statement of Robert W. Hubbard, President & CEO, Hubbard Television Group, Before the U.S. Senate Committee on Commerce, Science and Transportation, March 14, 2006 (Appendix A).

[12] Marcus, Michael J., Paul Kolodzy and Andrew Lippman, "Reclaiming the Vast Wasteland: Why Unlicensed Use of the White Space in the TV Bands Will Not Cause Interference to DTV Viewers," New America Foundation, October 2005.

[13] MSTV, "Rebuttal of the New America Foundation Critique of MSTV's "Your Neighbor's Static" Video, undated.

[14] Meintel, Sgrignoli, & Wallace, "Procedure for Unlicensed Device Demonstration," undated.

[15] CRC Phase II Report, p. 7.

[16] *Ibid.* p. 6.

[17] Since MSTV seems to believe that there are few clear channels at all in the country, it is puzzling why they thought an unlicensed system would be able to find a block of five-to-eight contiguous clear channels. Ironically, the very rural areas where it might be possible to find six or more contiguous unused TV channels are precisely those areas that rarely have apartment complexes or similarly congested living arrangements where "interference" couldn't be resolved by neighborly cooperation.

[18] The NPRM proposes protection of adjacent channels in the proposed 15.244(g) and then only limits unlicensed device emissions in other TV channels in 15.244(d), which states "power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power." This type of limit based on a comparision of power in a 100 kHz segment of the emissions to maximum power in any other segment is not adequate to prevent desensitization interference in consumer-grade television receivers. While many unlicensed devices are subject to a peak power limit in §15.37(b), the wording of the proposal implicitly exempts the proposed devices from the peak power limit that would have prevented the effect shown in the video. Desensitization interference can be prevented by adopting either a peak limit, such as in §15.37(b) and §15.517(e), or by limiting total power outside the vacant channels where the fundamental power is.

[19] *See* 47 CFR 90.301-317, 47 CFR 2.106 Footnote NG 66.

[20] *See* 47 CFR 74.870.

[21] *See* 47 CFR 73.318.

[22] TV receivers are uniquely subject to this unltrawideband interference and the ultrawideband rules, §15.501,525 forbid UWB in TV bands. TV receivers have a very wide tuning range to accommodate all channels and try to achieve high sensitivity (which is equivalent to a low "noise figure") using modestly priced components. There is a basic tradeoff between sensitivity and rejection of undesired signals in the same band—and consumer-grade TV receivers, as demonstrated in the video, have a susceptibility to ultrawideband signals which do not occur in real environments outside the laboratory.

[23] *Report and Order*, FCC Docket 20780, 79 FCC 2d 28 (Adopted September 18, 1979). These rules are now codified as 47 CFR 15.109.

[24] *Ibid.* Appendix C. E_S is stated to be the minimum Grade 'A' statistically expected signal strength defined in Part 73 of FCC Rules.

[25] Note that when the FCC selected the 10 meter distance in 1979, it made the following statement:

> "We believe that in most cases interfering radiation from computing devices is **a less valuable** use of spectrum than the radio and television services that would be interfered with. Therefore, we consider it appropriate that our regulations deny to computing devices an interfering use of the spectrum (except where the interference is to other equipment of the computer

> owner). We have made this judgment by comparing the benefits of allowing current uses of spectrum to continue without interference from computing equipment with the costs of denying interfering use of the spectrum to computers" *Ibid*. at para. 67 (Emphasis added)

The unlicensed communications from the proposed transmitters are more valuable than the unintentional and nonfunctional noise emitted by PCs, so the Commission *may* find that a greater risk of interference is justifiable.

[26] Unattributed, undated Powerpoint presentation that "Microsoft Properties" data said was created by Bruce Franca of MSTV on March 29, 2006 and was entitled "Use of Adjacent TV Channels."

[27] 47 CFR 15.247.

[28] Individuals, not organizations, are the voting members of IEEE 802 committees and membership is open-ended with a limitation only on a minimum waiting time before voting and a requirement to pay minimal dues. Thus it is possible for a proponent to try to "stack" the committee.

[29] 47 CFR 15.407. The 5 GHz bands involved here have national security-related military radars and unlicensed devices that are only allowed to use a channel after they determine that no radar is using the channel and then must check regularly for new radar signals and vacate the channel immediately if one appears.

[30] 47 CFR 15.407(h)(2).

[31] Compliance Measurement Procedures for Unlicensed National Information Infrastructure Devices Operating in the 5250-5350 MHz AND 5470-5725 MHz Bands Incorporating Dynamic Frequency Selection**,** contained as Appendix to http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-06-96A1.pdf.

[32] Reply Comments of Shared Spectrum Company, FCC Docket 04-186, February 1, 2005.
http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516982991
http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516982990
http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516982986

[33] Kibria, Masud and Chris Knudsen, "Capital Expenditure Implications of Spectrum Assets in Semi-rural Environments," Intel Corporation, August 23, 2005, p3.

[34] At the frequencies used for TV broadcasting, radio signals do not act like rays of light with clear shadows. But obstacles such as buildings and terrain do result in some shadowing and signal decrease.

[35] The Powerpoint presentation given by Dr. John Betz of MITRE Corp. is available at http://www.fcc.gov/realaudio/presentations/2003/021203/featuredetection.pdf. One illustration of lower threshold for detection versus good reception can be found in tuning an analog TV set with over-the-air reception. One can notice which channels have distant and weak signals by seeing rolling snowy signals that can not be viewed as local signals can.

[36] The Commission had previously taken note of this research in its NPRM on cognitive radio The Commission stated, "there are techniques that can be used to increase the ability of a sensing receiver to reliably detect other signals in a band which rely on the fact that it is not necessary to decode the information in a signal to determine whether a signal is present. … For example, sensing can be made more sensitive by using bandwidths much smaller than a 6 MHz TV channel and/or can look for specific features of the TV signal such as the visual and audio carriers." *Notice of Proposed Rule Making and Order* in ET Docket No. 03-108, 18 FCC Rcd 26859 (2003). At para. 20 and fn. 35. http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-322A1.pdf

[37] *See* Comments of Michael Marcus, Sc.D. http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516482949 and Shared Spectrum Company http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516982986.

[38] Comments of Adaptrum, Docket 04-186, at para. 17-19 http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516482775.

[39] An example is Qualcomm's SnapTrack technology which is used in cellular E-911 systems. *See* http://www.snaptrack.com/impact/index.jsp.

[40] Radio propagation generally has a large random component due to the same reflections that cause "ghosts" in analog TV reception. Therefore, the fix to this problem must state that the statistical confidence limit in the coverage area of the beacon signal must match the validity of the channel availability data to a high confidence limit such as 99%.

[41] Examples of the comments filed by broadcast TV interests are : http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6517610710, http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6517587197, and http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6516983613.

[42] This letter is on file at FCC. *See* http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6517610710.

[43] *See* 47 CFR 74.832(a),(c),(d).

[44] 47 CRR 74.832.

[45] A recent Internet posting by a wireless microphone group stated,

> "And although a lot of people ignore the fact, wireless audio systems actually require a license and are really only supposed to be operated — in the TV band — by broadcasters and media producers…. But according to Stanfill, only about 10 to 15 percent of the systems in use in the United States are properly licensed."
>
> http://mixonline.com/mag/audio_hear_2/index.html.

[46] *See* para. 38 of NPRM.

[47] This beacon might, for example, be the pilot tone which is a part of DTV signals so that the beacon would appear to an LBT detector to be a DTV signal.