ASSOCIATION FOR **MAXIMUM SERVICE TELEVISION, INC.**

P.O. Box 9897
4100 Wisconsin Avenue, NW
Washington, DC 20016

Tel (202) 966-1956
Fax (202) 966-9617

October 14, 2008

**VIA ELECTRONIC FILING**

Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

RE: Authorized Ex Parte Communications: Unlicensed Operation in the TV Broadcast Bands (ET Dockets No. 04-186 and 02-380)

Dear Ms. Dortch:

On Friday, October 10, 2008, David L. Donovan, president of the Association for Maximum Service Television ("MSTV") and Victor Tawil, MSTV's senior vice president, met with Julius Knapp, Alan Stillwell and Robert Weller of the Office of Engineering and Technology. The purpose of the visit was to discuss a proposal by Google regarding use of the first adjacent channel by white space devices ("WSDs") in the TV broadcast band.

At the outset, we applaud Google's recognition that sensing is not a viable means to prevent interference to over-the-air broadcast television, cable television, and wireless microphones. Unfortunately, Google's unscientific attempt to enact a variable power regime to govern operating on the first adjacent channel will cause significant interference to over-the-air television and cable viewing.

The concept underpinning the proposal is not new. It is based on an earlier proposal submitted by the White Spaces Coalition ("Coalition") in 2007. The Coalition plan envisioned using signal strength to allow unlicensed devices to increase power as the devices moved closer to a broadcast tower. The problems with the Coalition plan were explained fully by MSTV at that time.[1]

Google's proposal substitutes geolocation for sensing to control the power levels of unlicensed devices operating on a first adjacent channel. It employs a predictive methodology based on location, as determined by GPS, to control the power levels of these devices. WSDs operating on first adjacent channels would be allowed to increase

[1] *Ex Parte Letter, Baseline Protections Needed to Protect DTV Viewers,* submitted by the Association for Maximum Service Television, Inc. and the National Association of Broadcasters, in OET Docket Nos. 04-186 and 02-380, April 20, 2007 at 2.

power significantly as the device moves closer to a broadcast tower and exceed the FCC's proposed first adjacent channel D/U ratio by more than 10 dB.

We noted that Google's approach significantly increases interference to both broadcast and cable digital television reception. Earlier proposals used this variable power approach for personal and portable devices with 100 milliwatt power levels. Google's proposal envisions expanding this approach for high powered, fixed unlicensed devices that may operate up to 4 watts. This approach has not been examined, much less tested by the FCC. Moreover, Google provides no specific data, methodology or assumptions it would employ. In addition, instead of analyzing multiple adjacent channels, as the earlier proposal by the Coalition, the Google proposal merely increases the probability for error by reducing the number of channels examined to only one channel.

Operating such devices on the first adjacent channel will cause interference to digital television sets and government subsidized digital to analog converter boxers. Analyzing data reported by the FCC last year clearly demonstrated that WSD devices operating at 100 milliwatts on the first adjacent channel would cause interference in 84% of a TV station's service area. Allowing higher power fixed devices (up to 4 watts) would cause significantly more interference to consumers' digital television viewing. Indeed, the fixed unlicensed approach outlined by IEEE 802.22 does not allow fixed unlicensed devices to operate on the first adjacent channel. .

The problem with Google's approach is fundamental to signal propagation. Any predictive methodology presumes, wrongly, that broadcast signals remain uniformly constant throughout the service area. It assumes there are no variations in propagation, as well as consistent flat terrain with no buildings or obstructions. It assumes that consumers living near a broadcast tower will use an outdoor antenna that is 30 feet off the ground. In fact, OET's own DTV receiver report states that "the signal level at the TV's RF input can easily vary over a 26-dB range simply by changing from an indoor antenna to an outdoor, mast-mounted antenna."[2]

Such assumptions are wholly inappropriate to predict interference inside a station's contour. Indeed, signal strength can vary significantly from one house to another and even room to room in the same structure. We provided the Office of Engineering and Technology with copies of an analysis presented previously by the New America Foundation, which demonstrated significant differences in signal strength at locations only one or two miles apart in Los Angeles. Moreover, NAF presented data showing a difference in signal strength of 15 dB to 20 dB at the same residence.[3] Simply stated, data submitted in the record by white spaces proponents, documents that one cannot adopt a "one size" predetermined methodology that can govern the power levels of

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[2] OET Report, FCC/OET 07-TR-1003, Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006 dated March 30, 2007 at 2-7.

[3] Sturza, Mark and Farzad Ghazvinian, *Can Cognitive Radio Technology Operating in the TV White Spaces Completely Protect Licensed TV Broadcasting,* New America Foundation, January 2007 at 35, 36, 44 and 53.

unlicensed devices operating on the adjacent channel. Any attempt to do so will underestimate TV broadcast signals strengths and cause harmful interference.

In high-density urban and metro areas, most consumers rely on indoor antennas. The broadcast signal strength at the indoor antenna will be significantly less than that predicted by Google's methodology. As a result, a WSD using Google's geographic model will significantly overestimate the strength of the broadcast signal and WSDs operating on the first adjacent channel will operate at power levels that ***will*** interfere with TV reception.

We observed that Google's plan would impose significant hardship on consumers living in high-density, urban areas. In other words, it would cause significant problems for low income, minority and elderly consumers who generally live in apartments, condominiums and higher density environments. These viewers not only depend heavily on over-the-air television, but also in many cases rely on indoor antennas in urban areas. In addition, the predictive model approach envisioned by Google would result in significant interference in markets where signals vary considerably due to terrain or buildings.

MSTV has already documented the parameters under which the Commission can both authorize WSDs that rely on geolocation technology *and* protect reception of DTV signals, wireless microphones and cable services.[4] These parameters are based on sound engineering principles and the results of the FCC's own tests in 2007 and 2008. Google's untested variable power concept, however, is fatally flawed, and does not form a basis on which to adopt rules authorizing WSDs in the public's digital broadcast spectrum.

A copy of the attached MSTV power point was submitted for the record. Copies of MSTV's Ex Parte letter dated April 20, 2007, and the New America Foundation's data, attached hereto, were presented to OET as well.

Sincerely,

David L. Donovan
President

CC: The Honorable Kevin Martin
The Honorable Michael Copps
The Honorable Jonathan Adelstein
The Honorable Deborah Tate
The Honorable Robert McDowell
Mr. Julius Knapp
Mr. Alan Stillwell
Mr. Robert Weller

[4] *See, e.g.,* MSTV, Notice of Ex Parte Communications, ET docket Nos. 04-186, 02-380 (Oct, 1, 2008).

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# White Spaces

*Response to Google Ex-parte filed on October 9, 2008*

October 11, 2008

# Google Adjacent Channel Proposal

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- Use a database and a predictive propagation model to identify what adjacent channels need to be protected
- Determine the field strength level of the TV stations based on a predictive model at the location of the WSD and use a predetermined D/U ratio to compute the power of WSD
- WSD device could operate up to +36 dBm (4 watts) WITHIN a TV adjacent channel contour

# Google Illustration

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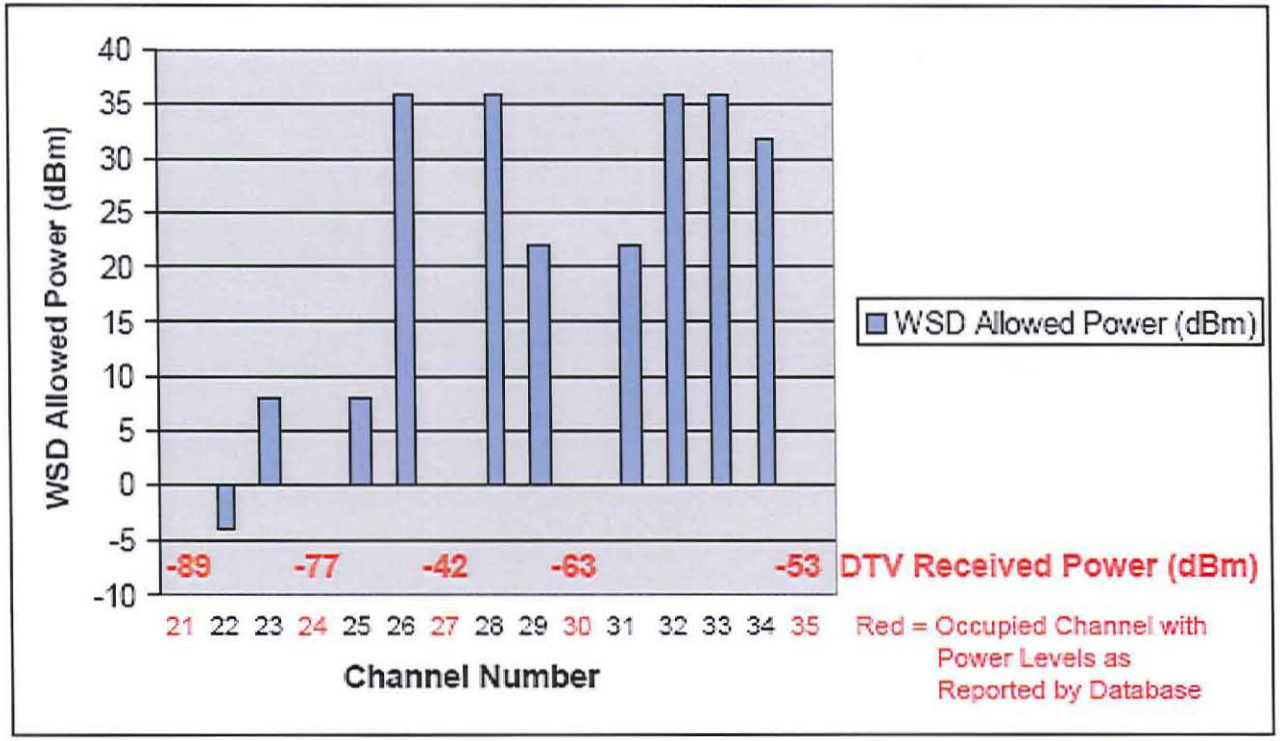
# Adjacent Channel: Proposed Rules



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# MSTV Response

- Google proposal is rehash of earlier submission where Google is substituting predictive modeling instead of sensing to operate on adjacent channel of TV station
- In April 20, 2007 filing, MSTV rebutted earlier proposal using actual *measured data* submitted by NAF (handouts)
- New proposal is deliberate attempt by Google to allow high power devices on the adjacent channel and is not supported by science and data
- Result will be interference to TV reception and wireless microphones

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# NAF TV Field data

- Measurements made by NAF in January 2007 in Los Angeles at three separate residences within approximately one mile of each other, and approximately 25 miles from all the DTV stations in Los Angeles
- NAF data showed that reception of DTV signals on the same channel varied within a residence by as much as 15 dB, and by 20 dB and more between the three residences (see attached NAF data)

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# Bottom line

- The Google proposal is not supported by the science and their own measurement data
- The proposal will cause significant interference to TV reception and wireless microphones in the heart of broadcasters' service areas

# Comparison of Predictive Modeling vs. Measurements

| Channel 32<br><br>Residence 1 | NAF TV Measurements* | Longley-Rice Prediction | Tirem Prediction |
|---|---|---|---|
| Bedroom # 1 | -74.8 dBm | -23.2 dBm | - 21.0 dBm |
| Bedroom # 5 | - 92.1 dBm | -23.2 dBm | - 21.0 dBm |
| Kitchen | -84.5 dBm | -23.2 dBm | - 21.0 dBm |

* Note that the NAF measurements were DTV pilot measurement and should be lower by 11 dB to account for the full 6 MHz signal

# Comparison of Predictive Modeling vs. Measurements

| Channel 32<br><br>Bedroom 1 | NAF TV Measurements* | Longley-Rice Prediction | Tirem Prediction |
|---|---|---|---|
| Residence # 1 | -74.5 dBm | -23.2 dBm | - 21.0 dBm |
| Residence # 2 | -67.1 dBm | -23.4 dBm | - 21.2 dBm |
| Residence # 3 | -86. 9 dBm | -23.5 dBm | - 21.3 dBm |

* Note that the NAF measurements were DTV pilot measurement and should be lower by 11 dB to account for the full 6 MHz signal

COVINGTON & BURLING LLP

1201 PENNSYLVANIA AVENUE NW
WASHINGTON, DC 20004-2401
TEL 202.662.6000
FAX 202.662.6291
WWW.COV.COM

WASHINGTON
NEW YORK
SAN FRANCISCO
LONDON
BRUSSELS

April 20, 2007

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

**Re: Baseline Protections Needed to Protect DTV Viewers;**
**Ex Parte Filing of MSTV and NAB in ET Docket Nos. 04-186 and 02-380**

Dear Ms. Dortch:

As the Commission is aware, over the next few years the country will be completing a transition to digital television ("DTV"). In preparation for this transition, consumers, broadcasters and the government will continue to spend billions of dollars on new digital equipment. Further, as the digital television world unfolds, new opportunities are emerging for over-the-air television services. The DTV transition, as well as these technological developments, will be seriously jeopardized if TV band devices are allowed to operate in the television spectrum without being accompanied by proper protections to prevent interference with existing services in the band.

As the Association for Maximum Service Television, Inc. and the National Association of Broadcasters ("MSTV/NAB") have consistently demonstrated, the following baseline protections are necessary in order to ensure that harmful interference to TV viewers and other licensed operations does not occur: (1) the development of appropriate out-of-band emission limits, as the current Part 15.209 limits are insufficient to prevent interference; (2) only authorizing fixed TV band devices to operate; personal/portable should not be permitted; (3) utilizing proper interference avoidance mechanisms, including a geolocation method, as sensing alone will be inadequate to prevent interference caused by TV band devices; and (4) ensuring that all TV band devices operate outside the protected contour on both co- and adjacent channels.

On March 28, 2007, the White Spaces Coalition[1] ("Coalition") filed an *ex parte* letter styled as a response to the comments and related technical documentation of MSTV and NAB. While the Coalition made a variety of claims, nothing in its letter altered the

[1] The White Spaces Coalition includes Dell, Earthlink, Google, HP, Intel, Microsoft, and Philips.

record before the Commission, which clearly demonstrates the need for the protections discussed above. MSTV submits this letter to address the claims made by the Coalition and once again demonstrate the protections that are necessary in order to prevent interference to existing services as well as to ensure a successful DTV transition.

**The Coalition's So-Called "Interference Eliminating Capabilities" Will Not Protect Viewers.**

The Coalition chastises MSTV and NAB for not addressing certain specific "interference eliminating capabilities" purportedly contained in the Coalition's so-called unlicensed development platform. It is not clear from either the Coalition's comments or replies whether it is actually proposing that these factors be made mandatory.[2] Nevertheless, since the factors the Coalition alludes to were not submitted until their reply comments, we will take this opportunity to directly and specifically address these so-called "interference eliminating capabilities," which will do little to protect the public's television service from harmful interference.

The first three factors concern the use of Transmission Power Control ("TPC"). The Coalition has proposed a minimum 25 dB dynamic range for TPC; the use of a power adjustment algorithm; and the restriction that the device will transmit at the minimum power required for reliable communication. While MSTV/NAB support greater TPC dynamic range, TPC does not change the ultimate interference potential of a device.[3] The Coalition suggests a power adjustment algorithm is intended to minimize interference on adjacent channels by using low power where the DTV signals are low and higher power where the adjacent DTV signals are high or are not being used. A simple review of this proposed algorithm, however, shows that it clearly will not protect TV viewers.

To illustrate this point, we will use measurement data supplied by NAF with regard to the signal variability within a residence to show that this algorithm is ineffective. NAF submitted measured data with regard to actual DTV signal levels at 3 residences in the Los Angeles area.

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[2] For example, in its comments, the Coalition proposes that the FCC adopt a transmitter power control (TPC) range of 20 dB but only notes that its proposed device will have a TPC range of 25 dB. In addition, the other "interference eliminating capabilities" are attributed to its so-called unlicensed development platform without a suggestion that these requirements be included in the FCC rules. In fact, in its comments, the Coalition specifically states that "the Commission should not impose additional restrictions on personal/portable operations" and requests that the Commission make clear that certain proposed requirements, such as the mandatory control signal not apply to personal/portable devices.

[3] If the device is trying to communicate over its full distance range it will transmit at full power. If the device's transmission is 'blocked" by walls or people moving in the path of the transmission, the device will transmit at full or higher power. Interference to nearby viewers is not a consideration for TPC. This fact has been long recognized by the FCC and all interference analysis and all FCC compliance testing of devices employing TPC are required to be done at full power.

Let's assume that an unlicensed device is located in bedroom 2 of residence 1 and that the TV band device correctly determines that TV channel 34 is available for use. Under the proposed algorithm, channels ±1, ±2, and ± 3 would be scanned to determine the level of TPC applied. For signal levels above -65 dBm, the device can operate at 20 dBm or the Coalition's maximum proposed power of 100 mW.

The NAF data for residence 1 shows that bedroom 2 receives the following DTV signal levels[4]:

| DTV Channel No. | 31 | 32 | 33 | *34* | 35 | 36 | 37 |
|---|---|---|---|---|---|---|---|
| Signal Level in dBm | -64 | -63 | X | X | -62 | -64 | X |

X= vacant TV channel

Therefore, based on the values in the above Table, the unlicensed device under the Coalition's algorithm can operate at 100 mW. However, several other rooms in this same residence receive much lower (up to 15 dB lower) but usable DTV signal levels on these channels. For example, the second floor living room and kitchen receive DTV signals on the adjacent TV channel 35 at - 78 and -77 dBm levels, respectively.[5] DTV reception at these levels could clearly be interfered with by a device operating in the same home at 100 mW on the adjacent channel. This is not based on some theoretical model but on *actual measured* data placed in the record of this proceeding by NAF.

Clearly, if the so-called "interference eliminating" algorithm can't work in a single family home, it will be ineffective to prevent interference to nearby neighbors. One can easily imagine this same situation occurring in an apartment, condominium or town home environment.[6] As hoping that unlicensed personal/portable devices are always located in the "right" room is not a solution,[7] the Coalition's algorithm clearly doesn't prevent interference given actual measured signal variation in the field.

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[4] The NAF study actually measured DTV pilot signal levels which is 11 dB less than the actual energy in the full 6 MHz DTV signal. The values in the chart and the paragraph were adjusted by 11 dB to show the actual received DTV signal levels seen by a DTV receiver or an unlicensed device.

[5] Similarly, on TV channel 36, the second floor kitchen receives a DTV signal at the -78 dBm level and the first floor bedroom 5 receives a DTV signal at the -79 dBm level. Recent FCC test data shows that DTV receivers susceptibility to second adjacent interference can be the same or even worse than from first adjacent operations.

[6] Another example of the invalidity of the Coalition's algorithm is that an unlicensed device in bedroom 5 on the third floor could operate at 100 mW while the same device in the same home's kitchen on the second floor would be limited to less than 1 mW. Further, the higher height of unlicensed operation on the third floor would also suggest that this device would be more of an interference threat to DTV operation on lower floors.

[7] To protect a -83 dBm signal the FCC has proposed a D/U ratio of about -26 dB for adjacent channel operation. This means that the undesired signal can not exceed -57 dBm. The Coalition's algorithm at -83 dBm permits operation at +2 dBm. At 10 meters, a +2 dBm device would emit approximately -50 dBm, a signal 7 dB higher than permitted.

The final factor cited by the Coalition is a transmission mask. In its reply comments, the Coalition notes that its development platform device will comply with a spectrum mask that attenuates out-of-band energy by 55 dB. The mask would require that the out-of-band energy levels from 100 mW or 20 dBm device be attenuated by 55 dB to the -35 dBm level (+20 dBm – 55 dB = -35 dBm). At 10 meters, this -35 dBm level would be attenuated by another 48 dB by propagation loss over this distance so that the permitted level at 10 meters from the device would be -83 dBm. This is the same level as the minimum receivable DTV signal. Since this "out-of-band" energy can be on any channel it can occur on channels being used for DTV reception. While this approach is a slight improvement over 15.209, an unlicensed device complying with this mask could still interfere with DTV receivers 10 or 20 or more meters away.

The Coalition claims that this mask is designed to eliminate interference and "meet or exceed the ATSC standards." One assumes that this last phrase is consistent with the Coalition's position in its reply comments that the "varying interference rejection" capabilities of DTV receivers should not impose a burden on unlicensed device operation particularly if such receivers do not fully meet ATSC specifications. In other words, despite its claims to protect TV viewers, the Coalition would protect only those viewers that have TV receivers that meet voluntary ATSC receiver specifications and that do not "burden" unlicensed device operation.[8] As the Coalition should know, such a position will leave millions of viewers in the dark.

**The MSTV/NAB Test Data, And That of Others, Show That Personal/Portable Devices Are Incompatible With Over-the-Air Viewing.**

The Coalition acknowledges that MSTV/NAB have submitted many pages of test data to support their position that unlicensed portable and personal devices operating in the white spaces would pose a threat to broadcasters. However, the Coalition states that MSTV/NAB test data is irrelevant because it did not take into account certain parameters proposed by the Coalition in its reply comments.

In fact, the Coalition has not taken or submitted any test data to support its positions and all of the test data, including data from unlicensed proponents such as NAF, support MSTV and NAB's technical positions.

To begin, a significant portion of the test and measurement data submitted by MSTV and NAB characterizes the interference susceptibility of today's DTV receivers. This data is far from irrelevant, as suggested by the Coalition. Rather, it is absolutely essential data needed for the development of technically sound rules and regulations to protect DTV

[8] It should be noted that the FCC's recent testing of some of the best performing DTV receivers indicated that "(n)o receiver appeared to fully achieve the ATSC recommended guidelines for interference rejection performance." MSTV also notes that the language and spirit of Part 15 unlicensed operation places the responsibility of avoiding interference on the Part 15 operator and manufacturer and not on the authorized licensed service.

viewers and permit non-interference fixed broadband operations. These measurements show that operation on both co- and adjacent channels must be avoided within a TV station's contour. Measurement data submitted by the University of Kansas supports the MSTV and NAB test results. The MSTV/NAB receiver tests and measurements also reveal that multiple interference sources and operation on other channels, such as the second adjacent channel and image frequencies, are also a concern. *Recently released FCC DTV receiver test data confirm and further validate the MSTV/NAB tests and findings.*[9] For example, the FCC tests show similar DTV receiver performance for adjacent channel operation. The FCC study also shows interference problems on other channels, such as N+7, consistent with MSTV/NAB data and findings. Finally, the FCC study included extensive testing with regard to multiple interference sources and confirms MSTV/NAB finding that TV receivers can have worse performance when multiple interfering signals are present.

**Devices Operating at the Out-of-Band Emission Limits of Section 15.209 Will Do Great Harm to the Public's Television Service.**

In its letter, the Coalition appears to fault MSTV and NAB for their focus on the inadequacies of the current out-of-band limits for intentional radiators set forth in Section 15.209 of the FCC's rules. It also asserts that because unintentional radiators such as florescent lights, air conditioners, electric blankets, and battery chargers operate safely in the TV band, somehow TV band devices operating at the limits of Section 15.209 will not harm television reception, notwithstanding evidence to the contrary.

MSTV and NAB are rightly focused on the inadequacy of the Section 15.209 out-of-band emission limits because these limits will *not* protect TV viewers. This issue has been fully explained in both our comments and replies and has been confirmed in extensive testing performed by the Canadian Research Center.[10]

Moreover, to the extent that the Coalition believes that there are now "billions" of devices that produce wideband signals at the 15.109 or 15.209 similar to those that would be produced by an unlicensed white spaces device, we urge the Coalition to produce such devices. We know of no fluorescent light, air conditioner, electric blanket, or battery charger that would have such a spectrum signature. However, we can guarantee if it does, it will certainly interfere with DTV reception since the 15.209 level is actually a higher signal level than the DTV signal at the protected contour.[11]

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[9] See OET Report, FCC/OET 07-TR-1003, *Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006*, by Stephen R. Martin, Technical Research Branch, Laboratory Division, dated March 30, 2007.

[10] Other commenting parties, such as Motorola and IEEE 802, have also identified the fact that the Section 15.209 limits provide inadequate protection to TV reception.

[11] The Section 15.209 level of 200 microvolts per meter at 3 meters is equivalent to 46 dBu. The DTV protected contour level is 41 dBu.

The Coalition takes issue and calls "incredible" MSTV/NAB's statement that NAF has admitted that the Section 15.209 protection limits are inadequate. NAF clearly states that "the above requirements in the proposed §15.707 (that specifies the Section 15.209 limit) are inadequate" on page 23 of its document entitled, Technical Comments of the New America Foundation. While we do not dispute that NAF also raised concerns about how this limit was measured, they clearly stated that the requirement itself was inadequate.[12]

**TV Band Devices Must Be Kept Out of the Contour of Adjacent Channel Stations.**

Although included in the letter under the section concerning "Out-of-Band Emissions," the Coalition takes issue with MSTV/NAB's comment that "NAF funded testing of DTV receivers by the University of Kansas shows that TV band device operation on either co-channel or adjacent channels within a TV station's contour would result in interference to TV viewers, again confirming NAB's and MSTV's previous analysis and tests."

The Coalition, however, fails to provide any data or analysis to refute the above statement or MSTV/NAB's previous analysis or tests. Nor is any analysis or data provided to rebut MSTV/NAB's analysis of NAF's University of Kansas study. The Coalition's sole response is to merely say this is not so and to quote some general language from the University of Kansas report that states that *if properly implemented* some secondary operation in the TV band is possible – a generic point not disputed by MSTV or NAB.[13] Adjacent channel operation *within* a station's contour, however, is incompatible with over-the-air reception.

**Comprehensive Analysis Confirms That By Itself, Spectrum Sensing Will Fail to Prevent TV Band Devices From Operating On Occupied Television Channels.**

The Coalition incorrectly claims that MSTV/NAB's sensing and interference analyses are unrealistic, as for sensing purposes MSTV/NAB have assumed that the unlicensed device would have its detector "underground" but its transmitting antenna would be "hundreds of feet in the air."

In fact, a 100 mW device will have a significant interference range whether it is outside, located within a house on the ground floor, or in an apartment on the 20th floor. Most cellular telephones operate with similar powers and can communicate to cell towers miles away. The interference ranges of these white spaces devices are similarly in the range of miles – not merely the same home or next door as suggested by the Coalition and others. Simply put, if an unlicensed device fails to correctly "sense" an occupied co- or adjacent channel, it will cause significant and debilitating interference over a very wide area.

In an unsuccessful attempt to demonstrate that such sensing mishaps will not occur, the Coalition points to the fact that they propose sensing at 30 dB below the minimum usable

[12] NAF has recently filed a letter that MSTV will address in a separate filing.

[13] MSTV and NAB have consistently supported the use of the band for secondary fixed operations to provide new broadband services for the American public.

DTV signal level. What they fail to point out is the fact that there may be considerable physical differences between the receiving systems employed. For example, a TV viewer may be using a high gain antenna of up to 10 dB. The TV antenna may also be located outside on the roof where it has a 7 dB height advantage. The white spaces device may be located indoors or may be subject to a hidden node problem where signal attenuation of the TV signal may be 15 dB or more.[14] The 30 dB margin suggested by the Coalition is clearly not sufficient to deal with these situations that don't involve "the detector underground and the transmitting antenna hundreds of feet in the air."

While the Coalition has claimed that it supports a robust technical debate on this issue, its response to MSTV/NAB suggest that it wants this debate to be devoid of facts, measurements and data. We urge the Commission to see past the Coalition's rhetoric and give attention to the technical analysis and data in the record – all of which suggests that personal/portable devices will cause interference and should not be permitted.

Respectfully submitted,

/s/ Marsha J. MacBride

Marsha J. MacBride
Jane E. Mago
Kelly Williams
NATIONAL ASSOCIATION OF BROADCASTERS
1771 N Street, NW
Washington, DC 20036

/s/ David L. Donovan

David L. Donovan
Victor Tawil
Bruce Franca
ASSOCIATION FOR MAXIMUM SERVICE TELEVISION, INC.
P.O. Box 9897
4100 Wisconsin Avenue, NW
Washington, D.C. 20016

Jonathan D. Blake
Matthew S. DelNero
Jodi M. Steiger*
COVINGTON & BURLING LLP
1201 Pennsylvania Avenue, N.W.
Washington, DC 20004-2401

*Its Attorneys*

* Admitted only in Virginia; not admitted in the District of Columbia, and supervised by principals of the firm.

[14] NAF submitted data showed differences in TV signal strength within the same home of 20 dB or more and between homes within 1 mile of each of 30 dB or more.

NEW AMERICA FOUNDATION

WIRELESS FUTURE PROGRAM

WORKING PAPER

*Working Paper #16* *January 2007*

# *White Spaces Engineering Study:* CAN COGNITIVE RADIO TECHNOLOGY OPERATING IN THE TV WHITE SPACES COMPLETELY PROTECT LICENSED TV BROADCASTING?

By Mark A. Sturza and Farzad Ghazvinian*

### *Policy Background*

*In 2004, the FCC proposed to allow unlicensed wireless devices to utilize vacant television channel frequencies in each market, a rulemaking that is currently in its final stages. The FCC discussed three methods (control signals, position determination, and cognitive radio with dynamic frequency selection) to ensure that unlicensed TV band devices operate only on vacant channels without harmful interference to broadcast TV service. Of these methods, cognitive radio has spurred the most debate. The cognitive radio method uses spectrum sensing and dynamic frequency selection (DFS) to identify and avoid occupied TV channels. This method has been approved by the Defense Department for unlicensed devices to share spectrum with military radar in the upper 5 GHz band. Potential service providers and equipment manufacturers embrace it because it does not require external infrastructure. However, TV broadcasters oppose it because they do not understand it and fear it will result in harmful interference. This report answers the following question that is central to the FCC's current rulemaking: can unlicensed TV-band devices using cognitive radio techniques completely protect licensed broadcast TV services?*

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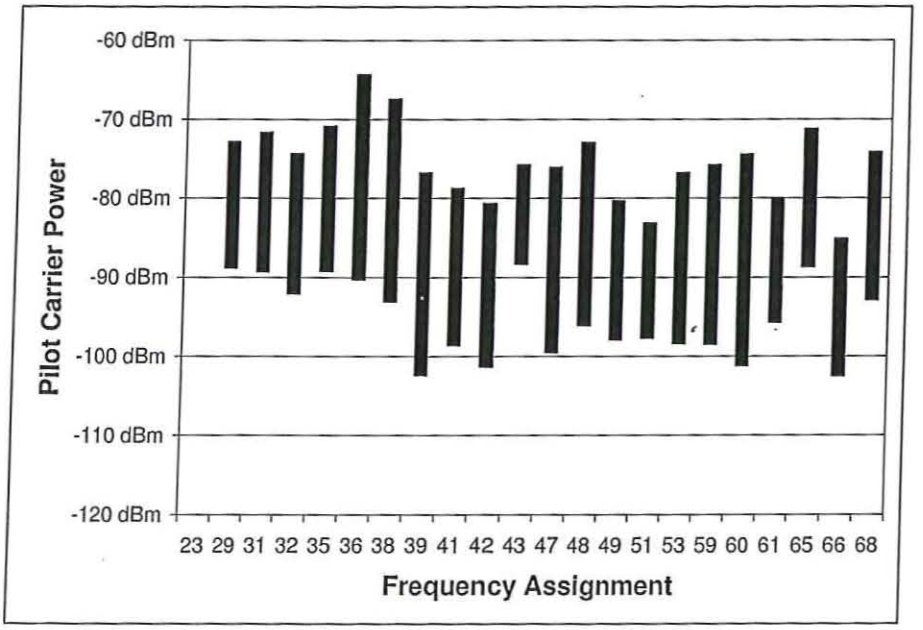
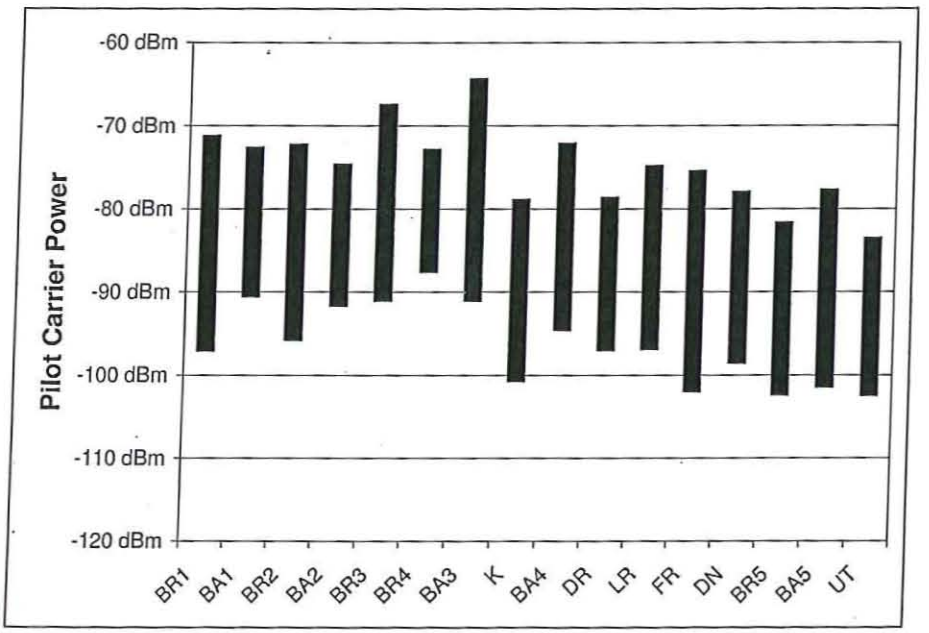
**Mark A. Sturza (mark@3CSysCo.com) is president of 3C Systems Company. Dr. Farzad Ghazvinian (farzad@ghazvinian.com) is an independent consultant. Full bios are included at the end of this study.*

Thanks to Microsoft Corporation for funding this study and report.




• Figure 39 – Residence 1 Pilot Carrier Power Variance By Frequency Channel

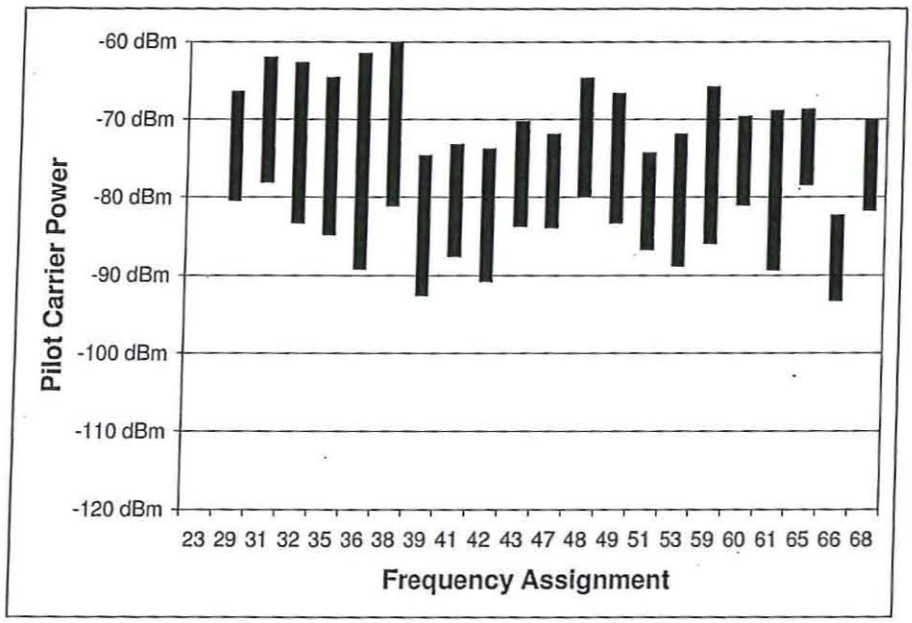



• Figure 40 – Residence 1 Pilot Carrier Power Variance By Room

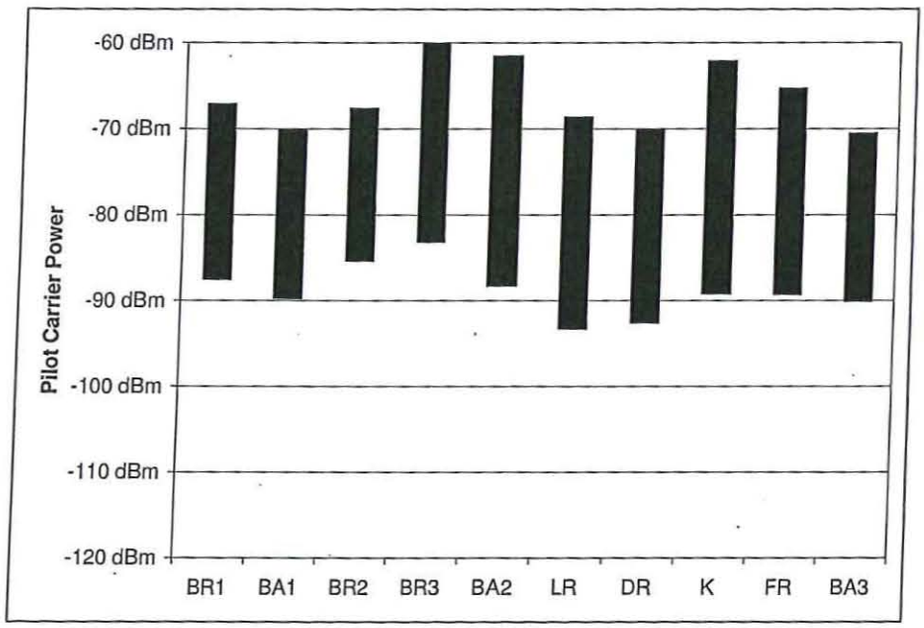
• Table 14 – Residence 1 Raw Pilot Carrier Measurements (dBm)

| | 3rd Floor | | | | | | | 2nd Floor | | | | | | 1st Floor | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency Assignment | BR1 | BA1 | BR2 | BA2 | BR3 | BR4 | BA3 | K | BA4 | DR | LR | FR | DN | BR5 | BA5 | UT |
| 23 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 29 | -78.9 | -74.9 | -84.4 | -79.9 | -78.4 | -72.8 | -75.9 | -85.1 | -76.6 | -78.7 | -78.2 | -83.5 | -86.6 | -86.4 | -88.8 | -83.5 |
| 31 | -73.0 | -72.6 | -75.0 | -77.4 | -71.6 | -74.2 | -74.5 | -85.5 | -86.8 | -78.6 | -82.5 | -75.4 | -77.9 | -85.5 | -77.7 | -89.3 |
| 32 | -74.8 | -82.2 | -74.3 | -83.4 | -80.8 | -74.9 | -75.6 | -84.5 | -81.7 | -80.7 | -79.6 | -85.3 | -79.7 | -92.1 | -81.9 | -90.0 |
| 35 | -81.3 | -82.7 | -73.2 | -75.7 | -74.9 | -80.3 | -70.8 | -87.7 | -77.5 | -81.9 | -89.2 | -85.4 | -87.4 | -81.6 | -86.7 | -87.2 |
| 36 | -75.2 | -82.5 | -75.0 | -79.0 | -79.1 | -74.4 | -64.3 | -89.4 | -74.5 | -84.3 | -84.1 | -81.4 | -84.0 | -90.3 | -89.6 | -88.6 |
| 38 | -77.5 | -80.0 | -72.2 | -74.6 | -67.4 | -84.9 | -69.0 | -78.8 | -72.1 | -83.5 | -77.6 | -79.0 | -88.9 | -88.1 | -81.9 | -93.1 |
| 39 | -81.8 | -87.6 | -76.7 | -90.9 | -77.1 | -84.1 | -81.1 | -100.5 | -84.4 | -96.8 | -96.9 | -98.5 | -94.1 | -102.4 | -98.5 | -101.3 |
| 41 | -88.2 | -85.5 | -80.6 | -78.7 | -82.3 | -86.9 | -86.0 | -94.3 | -87.8 | -85.4 | -88.8 | -89.4 | -98.6 | -90.4 | -90.1 | -96.1 |
| 42 | -97.1 | -89.1 | -83.2 | -86.2 | -80.6 | -82.5 | -84.7 | -86.2 | -88.5 | -85.6 | -87.6 | -94.4 | -90.1 | -101.3 | -90.9 | -97.8 |
| 43 | -82.2 | -84.1 | -75.7 | -80.5 | -76.4 | -79.7 | -83.8 | -86.0 | -82.0 | -84.9 | -86.9 | -85.4 | -85.6 | -86.6 | -88.3 | -85.2 |
| 47 | -81.3 | -85.9 | -76.0 | -82.5 | -81.5 | -82.2 | -85.6 | -96.9 | -85.2 | -87.1 | -91.1 | -84.7 | -92.4 | -93.0 | -96.3 | -99.5 |
| 48 | -83.8 | -86.4 | -76.4 | -87.4 | -72.9 | -85.5 | -80.4 | -90.6 | -90.1 | -89.9 | -88.0 | -90.7 | -96.1 | -89.9 | -89.8 | -91.9 |
| 49 | -89.3 | -90.6 | -83.1 | -83.1 | -80.3 | -86.4 | -88.0 | -87.5 | -83.5 | -88.0 | -87.7 | -90.3 | -97.9 | -85.8 | -91.3 | -97.5 |
| 51 | -85.0 | -83.1 | -85.0 | -91.7 | -91.1 | -87.6 | -91.1 | -93.1 | -88.6 | -90.3 | -85.6 | -95.0 | -97.7 | -93.0 | -89.2 | -96.6 |
| 53 | -83.2 | -83.0 | -82.5 | -83.5 | -76.7 | -84.6 | -79.8 | -86.0 | -93.3 | -84.4 | -84.2 | -93.0 | -98.4 | -96.1 | -91.2 | -96.1 |
| 59 | -87.7 | -85.3 | -78.8 | -84.5 | -75.7 | -76.6 | -83.0 | -94.6 | -94.6 | -85.7 | -87.7 | -84.7 | -97.5 | -93.9 | -91.0 | -98.5 |
| 60 | -77.5 | -83.8 | -84.6 | -80.1 | -86.9 | -74.4 | -77.4 | -85.6 | -93.1 | -83.9 | -81.6 | -82.2 | -83.1 | -92.6 | -88.8 | -101.2 |
| 61 | -79.9 | -84.7 | -81.0 | -89.2 | -85.2 | -81.0 | -83.1 | -92.0 | -84.5 | -93.7 | -85.0 | -84.1 | -87.5 | -89.3 | -88.0 | -95.7 |
| 65 | -71.2 | -79.4 | -77.1 | -75.3 | -76.4 | -80.1 | -78.1 | -84.8 | -79.8 | -82.2 | -74.8 | -87.1 | -88.7 | -88.1 | -84.0 | -85.4 |
| 66 | -93.3 | -88.7 | -95.8 | -85.1 | -90.3 | -85.6 | -87.8 | -100.8 | -90.8 | -97.0 | -91.6 | -102.0 | -98.2 | -99.3 | -101.5 | -102.5 |
| 68 | -80.9 | -84.2 | -74.1 | -75.3 | -79.9 | -74.2 | -80.3 | -83.9 | -88.8 | -83.1 | -82.3 | -82.7 | -92.9 | -92.2 | -86.4 | -92.6 |

The raw pilot carrier power measurements are shown in Table 15. They range from -93.3 dBm to -58.0 dBm. Figure 65 shows the variation by frequency channel and Figure 66 shows the variation by room. The average variation across rooms for a given frequency channel was 16.3 dB. The DTV signal spectrums captured in residence 2 are shown in Figure 67 through Figure 88. Many of the figures show the frequency selective fading characteristic of the WSSUS channels simulation results presented in Section 4.2.




• **Figure 65 – Residence 2 Pilot Carrier Power Variation By Frequency Assignment**

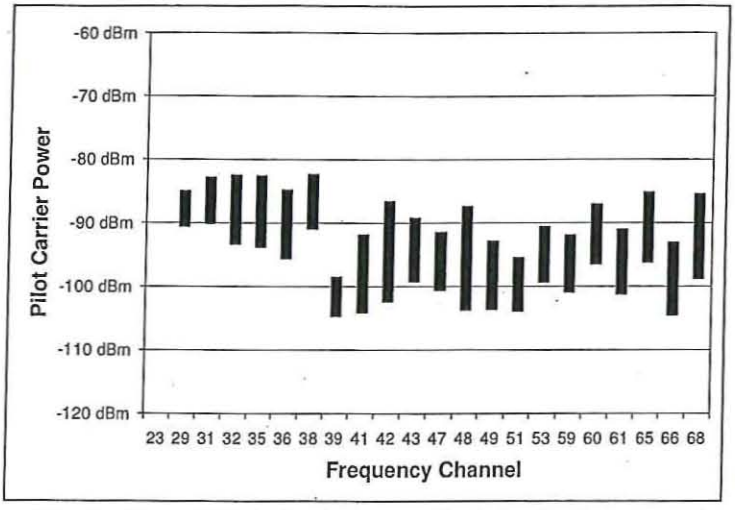



• **Figure 66 – Residence 2 Pilot Carrier Power Variation By Room**

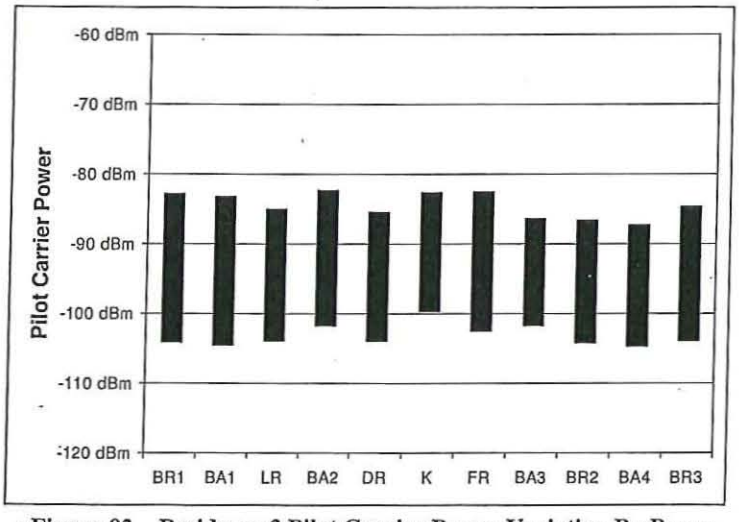
• Table 15 – Residence 2 Raw Pilot Carrier Power Measurements (dBm)

| Frequency Assignment | BR1 | BA1 | BR2 | BR3 | BA2 | LR | DR | K | FR | BA3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 29 | -77.9 | -79.2 | -68.1 | -66.4 | -67.0 | -74.5 | -75.9 | -70.6 | -75.6 | -80.4 |
| 31 | -68.2 | -72.4 | -67.6 | -67.4 | -62.0 | -78.1 | -70.0 | -63.0 | -71.4 | -74.2 |
| 32 | -67.1 | -70.6 | -78.2 | -83.2 | -62.7 | -83.3 | -70.5 | -67.6 | -75.5 | -74.4 |
| 35 | -68.4 | -84.8 | -72.7 | -66.7 | -64.6 | -79.4 | -73.7 | -71.2 | -70.2 | -76.6 |
| 36 | -67.6 | -79.5 | -69.4 | -62.0 | -61.5 | -82.1 | -74.9 | -89.2 | -76.0 | -74.1 |
| 38 | -68.0 | -81.1 | -68.1 | -58.0 | -69.3 | -68.6 | -74.4 | -62.1 | -65.3 | -70.5 |
| 39 | -84.2 | -89.8 | -83.1 | -78.7 | -88.3 | -85.1 | -92.6 | -74.6 | -86.2 | -90.1 |
| 41 | -79.9 | -85.5 | -80.5 | -73.2 | -76.3 | -85.7 | -80.5 | -77.7 | -87.6 | -86.7 |
| 42 | -78.0 | -89.7 | -81.0 | -73.8 | -76.6 | -90.8 | -82.1 | -74.4 | -79.6 | -83.6 |
| 43 | -78.2 | -81.7 | -76.3 | -70.5 | -70.2 | -83.7 | -76.5 | -72.3 | -78.3 | -75.2 |
| 47 | -78.2 | -83.9 | -82.1 | -71.9 | -78.0 | -82.4 | -76.2 | -77.8 | -81.4 | -81.4 |
| 48 | -74.6 | -77.2 | -78.7 | -64.7 | -73.8 | -79.8 | -77.9 | -77.0 | -78.7 | -72.0 |
| 49 | -79.8 | -77.7 | -77.8 | -66.7 | -83.3 | -80.1 | -74.2 | -75.4 | -78.4 | -76.2 |
| 51 | -82.3 | -83.6 | -85.4 | -74.3 | -80.3 | -86.7 | -83.0 | -79.2 | -85.9 | -80.3 |
| 53 | -87.6 | -88.8 | -84.8 | -71.9 | -77.5 | -83.1 | -80.9 | -79.7 | -84.7 | -80.1 |
| 59 | -81.5 | -85.9 | -79.9 | -65.8 | -76.3 | -81.2 | -80.9 | -70.2 | -75.0 | -78.2 |
| 60 | -79.3 | -75.7 | -76.0 | -74.4 | -79.8 | -73.8 | -79.1 | -69.6 | -81.0 | -75.5 |
| 61 | -80.1 | -77.4 | -81.9 | -68.9 | -73.1 | -78.7 | -82.8 | -77.9 | -89.3 | -77.4 |
| 65 | -73.3 | -78.4 | -78.0 | -68.7 | -76.0 | -75.6 | -70.0 | -73.0 | -70.1 | -75.3 |
| 66 | -84.2 | -88.1 | -85.4 | -82.3 | -83.2 | -93.3 | -91.6 | -86.3 | -87.4 | -89.5 |
| 68 | -77.7 | -70.0 | -77.1 | -70.0 | -78.9 | -76.6 | -75.5 | -74.1 | -72.2 | -81.7 |

rooms for a given frequency channel was 10.3 dB. The DTV signal spectrums captured in residence 1 are shown in Figure 93 through Figure 114. Many of the figures show the frequency selective fading characteristic of the WSSUS channels simulation results presented in Section 4.2.




• **Figure 91 – Residence 3 Pilot Carrier Power Variation By Frequency Channel**




• **Figure 92 – Residence 3 Pilot Carrier Power Variation By Room**

• Table 16 – Residence 3 Raw Pilot Carrier Power Measurements (dBm)

| Frequency Assignment | BR1 | BA1 | LR | BA2 | DR | K | FR | BA3 | BR2 | BA4 | BR3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 527 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 563 | -86.6 | -90.6 | -85.0 | -87.5 | -85.4 | -85.7 | -85.5 | -88.7 | -86.6 | -87.5 | -86.0 |
| 575 | -82.8 | -88.5 | -85.1 | -85.2 | -87.3 | -83.2 | -87.4 | -88.3 | -90.1 | -88.0 | -85.2 |
| 581 | -84.4 | -83.2 | -86.3 | -87.1 | -91.3 | -85.6 | -82.5 | -89.3 | -90.6 | -93.3 | -84.8 |
| 599 | -84.5 | -93.8 | -90.2 | -87.3 | -87.1 | -82.6 | -93.2 | -88.7 | -90.5 | -91.0 | -84.6 |
| 605 | -86.9 | -95.6 | -87.4 | -93.1 | -90.8 | -86.1 | -84.8 | -86.4 | -89.8 | -87.9 | -94.0 |
| 617 | -90.6 | -90.0 | -90.4 | -82.3 | -86.5 | -88.3 | -86.9 | -90.9 | -89.3 | -87.3 | -86.5 |
| 623 | -102.1 | -100.1 | -102.0 | -101.5 | -103.0 | -99.0 | -102.1 | -101.7 | -98.5 | -104.7 | -101.3 |
| 635 | -104.1 | -96.2 | -99.6 | -98.7 | -100.3 | -99.7 | -98.5 | -91.8 | -102.9 | -100.7 | -93.5 |
| 641 | -98.6 | -100.3 | -101.4 | -96.0 | -101.5 | -86.6 | -101.8 | -95.9 | -99.6 | -102.4 | -100.2 |
| 647 | -92.3 | -97.1 | -99.2 | -90.8 | -95.2 | -89.2 | -98.4 | -93.1 | -94.2 | -96.0 | -97.1 |
| 671 | -95.8 | -100.6 | -95.0 | -98.5 | -99.6 | -91.5 | -97.4 | -94.4 | -96.9 | -99.7 | -95.6 |
| 677 | -87.4 | -103.7 | -92.7 | -94.6 | -93.2 | -98.3 | -97.2 | -98.1 | -100.6 | -95.6 | -95.8 |
| 683 | -99.5 | -101.7 | -97.3 | -92.9 | -95.3 | -96.0 | -95.6 | -101.3 | -95.4 | -99.1 | -103.6 |
| 695 | -98.4 | -95.5 | -98.2 | -96.8 | -101.5 | -98.4 | -102.5 | -99.7 | -95.7 | -96.8 | -103.9 |
| 707 | -96.9 | -98.6 | -98.6 | -98.1 | -93.9 | -90.6 | -96.4 | -98.2 | -99.3 | -96.4 | -92.0 |
| 743 | -94.4 | -100.4 | -98.6 | -91.9 | -98.4 | -92.9 | -100.9 | -99.7 | -95.5 | -99.7 | -94.3 |
| 749 | -93.3 | -87.0 | -96.5 | -92.6 | -93.2 | -91.2 | -94.9 | -89.6 | -96.4 | -93.8 | -95.5 |
| 755 | -101.2 | -97.4 | -97.8 | -97.3 | -97.0 | -92.4 | -99.0 | -91.0 | -99.4 | -100.3 | -99.2 |
| 779 | -92.2 | -96.2 | -91.5 | -92.4 | -85.8 | -85.2 | -90.6 | -90.6 | -92.1 | -94.2 | -92.1 |
| 785 | -103.7 | -104.5 | -103.9 | -101.7 | -103.9 | -93.1 | -99.9 | -99.1 | -104.2 | -102.7 | -103.3 |
| 797 | -94.0 | -90.4 | -93.0 | -93.3 | -93.6 | -85.4 | -95.8 | -94.3 | -93.3 | -93.6 | -98.8 |