Proposed Field Measurement Study of Full-Service, Stringent and Simple Transmitter Mask Filters in Digital Television DTS Facilities and Its Impact on Interference to Adjacent-Channel Television Reception

December 15, 2023

by

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PURPOSE

Currently under Commission Rules, an SFN node is required to operate with a “full service” out-of-channel emissions mask filter[1] for the purposes of protecting from interference adjacent-channel television station reception near or within the SFN’s noise-limited service contour.

The purpose of this test is to determine the effectiveness of employing a simple out-of-channel emissions mask filter and a stringent out-of-channel emissions mask filter vs. the effectiveness of a full service out-of-channel emissions mask filter in reducing or eliminating adjacent-channel interference to neighboring stations, in this particular case to low power television station WWDD-LD, Channel 24 in Havre de Grace, Maryland. If the results of this field test show that these other mask filters are viable, their use would considerably reduce the cost of DTS node build outs. This evidence would then be presented to the FCC for the purpose of initiating a Notice of Proposed Rulemaking to allow such filters to be utilized in low power SFN design.

BACKGROUND INFORMATION

Single Frequency Networks

A single frequency network is a type of broadcasting network that uses the same frequency to transmit the same signal to and from multiple transmitters, all of which are synchronized to ensure that the signals arrive at the same time at a given receiver in order to reduce multipath interference.

The main advantage of an SFN is that it provides improved coverage and increased signal strength in comparison to a traditional single transmitter facility. This means that the signal can reach a wider area, with fewer reception errors and weak signal areas, resulting in better quality reception for end users.

In an SFN, each transmitter operates on the same frequency and is synchronized with the others to ensure that the signals arrive at the same time. This is achieved through the use of GPS timing systems, which accurately measure the time delay between each transmitter and adjust the transmission accordingly. The result is a uniform coverage area, with little multipath interference in which overlapping signals arrive at a receive antenna at different times.

SFNs are particularly useful for areas with difficult terrain, such as mountains or densely populated cities, where traditional single transmitter networks may struggle to reach all users. They are also useful for events where large numbers of people are gathered in a single location, such as sporting events or concerts, where a single transmitter network may struggle to cope with the demand for coverage.

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[1] FCC Rule 47 CFR § 73.622(h)

In conclusion, a single frequency network is a type of broadcasting network that provides improved coverage and increased signal strength by transmitting the desired programming on the same frequency from multiple synchronized transmitters. This results in better quality reception for end users and is particularly useful for areas with difficult terrain or high-density populations.

ATSC 1.0 SFNs haven't exactly lived up to its original promise of continuous coverage between all transmitter sites, but the difference between ATSC 1.0 and ATSC 3.0 is vast. ATSC 3.0 uses a sophisticated new tuner design that leverages the different carriers on SFN streams on the same RF channel to additively improve the carrier-to-noise (C/N) ratio. ATSC 3.0 SFNs are designed to maximize C/N by using higher towers and eliminating outdoor TV receiving antennas.

There are sweet spots and nulls between SFN transmitters due to the propagation delays between the separated transmitting antennas and a single TV receiving antenna. Delay is computed by adding 8.2 μs/mile to allow for propagation delay from the towers to the target TV location. Nulls move too, and they are generally less predictable due to receiver site variables.

TV SFNs don't hand off signals from one tower to another. TV SFN transmitters don't know who is watching or their Quality of Service (QoS). The ATSC 3.0 receiver's equalizer monitors and controls the desired-to-undesired (D/U) ratio of the signals being processed, which automatically tweaks and peaks viewer QoS.

Different D/U ratios of signals are used in adjacent-channel interference calculations in the LPTV industry, depending on the type of out-of-channel emission mask employed. Measuring the signal strength of both WWDD-LD and the WNUV DTS stations at test measurement locations, and using a frequency-tuned WNUV signal attenuator, can help determine if these D/U ratios are accurate in real-world scenarios.

Furthermore, the FCC petition may suggest that these other emission masks only apply to SFNs that do not exceed the LPTV's maximum allowable power levels, as using a simple or stringent mask filter may not be permitted for main (high power) facilities. The citation in FCC Rule § 74.793 states that interference prediction analysis for low power TV and TV translator stations is based on the interference thresholds and criteria specified in § 73.623(c)(2) through (4), with the D/U signal strength ratio applied to first adjacent channel protection corresponding to the LPTV or TV translator station's specified out-of-channel emission mask. Please see accompanying table below:

FCC D/U Ratios (in dB) for Different LPTV Out-of-Channel Emission Masks

Simple mask	Stringent mask	Full service mask
−7	−12	Lower (−28)/Upper (−26)

WNUV-DT - Baltimore, MD

WNUV-DT is a digital television station operating on RF Channel 25 located in Baltimore, Maryland, and is licensed to BALTIMORE (WNUV-TV) LICENSEE, INC. It operates as a CW affiliate, airing popular programming to the community. The station first went on air in 1981 as an independent station, but later became a UPN affiliate in 1995. In 2006, when UPN and The WB merged to form The CW, WNUV-DT became a CW affiliate.

WNUV-DT transmits from a tower with FCC Antenna Structure Registration (ASR) Number 1044237. The coordinates of the transmitter are Latitude 39° 20' 10.4" N and Longitude 76° 38' 57.9" W. The structure is a guyed tower, with an overall height of 390.1 meters and a support structure height of 389.2 meters above ground. The ground elevation at the base of the tower is 82.0 meters above mean sea level, and the height of the WNUV-DT antenna radiation center above ground level is 374.8 meters.

The station's transmitter power output (TPO) is 14.30 dBk (26.9 kW). The transmission line loss is 1.27 dB, the antenna input power is 13.03 dBk and the max. antenna power gain is 15.72 dB. The effective radiated power (ERP) is 28.75 dBk (750 kW).

The antenna is a horizontally-polarized Dielectric TUD-C5SP-10/36SPH-1-B directional antenna oriented toward the southwest. The antenna employs 0.9 degrees of electrical beam tilt. See the current WNUV-DT authorization in the Appendix.

WNUV-DT - DTS Node

BALTIMORE (WNUV-TV) LICENSEE, INC. was granted authorization to construct a DTS node in Towson, MD on November 22, 2022. On December 13, 2023 that facility was turned on and licensed with the FCC[2].

The FCC Antenna Structure Registration (ASR) Number for the antenna structure is 1037283. The structure is a building with a tower and antenna on top, 85.3 meters in overall height, and 57.9 meters in support structure height. The ground elevation is 145.4 meters above mean sea level and the authorized height of the antenna radiation center above ground level is 69.6 meters. The effective radiated power is to be 7.0 kW.

The antenna type is an elliptically-polarized Dielectric model: TFU-4WB-C160 with 0.5 degrees of electrical beam tilt. The antenna is oriented with its main lobe of radiation toward the southwest. See appendix for authorization.

[2] FCC LMS Number 0000231488

WWDD-LD - Baltimore, MD

WWDD-LD is a low-power television (LPTV) station located in Havre de Grace, MD. It is owned by WORD OF GOD FELLOWSHIP, INC. a subsidiary of Daystar. It broadcasts a digital signal on RF UHF Channel 24 (and PSIP Channel 49) and operates as part of a religious television network, providing viewers with a variety of religious programming and content. WWDD-LD is available to viewers in its local area and can be streamed online for those unable to receive the signal over the air.

The coordinates for its transmitter site are 39 30' 54.4" N 76 14' 24.7" W. The licensed antenna is an elliptically-polarized System With Reliability (SWR) model SWEDL4EC, oriented to the northwest. The station operates with an ERP of 6.5 kW. The antenna radiation center is 97.7 meters above ground, 198.0 meters above mean sea level and 143 meters above average terrain.[3] See appendix for authorization.

Emission Mask Filters

FCC Rule 47 CFR § 74.794[4] concerns digital emissions for LPTV or TV translator station construction permits. The applicant must specify which emission mask filter (simple, stringent, or full service) will be used to reduce out-of-channel emissions. The power level of emissions on frequencies outside the authorized channel must be reduced to a specified level below the average transmitted power. The reduction level is determined by the mask specifications listed in the FCC Rule.

While not stated specifically, the FCC assumes that all full-service DTS/SFN nodes will be constructed with full-service emission masks.

Full Service Out-Of-Channel Emission Mask Filter

Full service mask requirements specify that emissions on frequencies outside the authorized channel must be reduced by certain levels. Within the first 500 kHz from the authorized channel edge, the reduction must be 47 dB. Beyond 6 MHz from the channel edge, the reduction must be 110 dB. For frequencies between 0.5 and 6 MHz from the channel edge, the reduction must be determined by the specified formula:

$$\text{Attenuation in dB} = -11.5([\text{Delta}]f + 3.6)$$

When determining compliance with the FCC’s requirements, the attenuation measurement is based on a bandwidth of 500 kHz, but other bandwidths can be used with correction factors. The FCC specifies that the measurement should not be made closer to the band edge than half of the resolution bandwidth. The emissions being measured should include sidebands, spurious

[3] FCC LMS File Number 0000205105
[4] https://www.law.cornell.edu/cfr/text/47/74.794

emissions, and radio frequency harmonics and should be measured at the output terminals of the transmitter, including any filters used. Greater attenuation may be required in case of interference to other services.

Stringent Out-Of-Channel Emission Mask Filter

Stringent service masks require that emissions near the channel edges must be attenuated by at least 47 dB in the first 500 kHz, and by at least 76 dB more than 3 MHz from the channel edges. Within 0.5 to 3 MHz from the channel edges, the required level of attenuation is determined by the formula:

$$A(dB) = 47 + 11.5\ (\Delta f - 0.5)$$

Simple Out-Of-Channel Emission Mask Filter

Simple service masks require that emissions at the channel edges must be attenuated by at least 46 dB, while emissions more than 6 MHz away from the channel edges must be attenuated by at least 71 dB. For frequencies between 0 and 6 MHz from the channel edges, the required attenuation is determined by the formula:

$$A\ (dB) = 46 + (\Delta f^{2} / 1.44)$$

FIELD TEST OBJECTIVES

The objective of this field test is to assess the performance of the three types of transmitter mask filters (simple, stringent and full-service) in eliminating adjacent-channel interference while deployed in real-world situations. The following are the specific objectives of this field test:

1. Evaluate the effectiveness of the different mask filters in reducing the level of adjacent-channel interference from WNUV-DT to WWDD-LD: The field test will measure the level of EMI before and after the different filters are applied. The results will be used to compare the performance of the different filters and determine which ones are effective in reducing adjacent-channel interference.

2. Compare the cost and benefits of the different filters: The field test results will be used to compare the cost and benefits of the different filters and determine which one offers the best combination of performance, cost-effectiveness, and compatibility.

3. Determine whether or not to initiate a proposed FCC rulemaking to allow for such filter choices and possibly changes to the Commission’s Desired-to-Undesired ratios for calculating adjacent channel interference to other stations.

Overall, the field test is an important step in evaluating the performance of the different mask filters and ensuring that they effectively reduce the level of adjacent-channel interference while maintaining the quality and performance of the devices being tested.

FIELD TEST TRANSMITTER DESCRIPTION

Please see discussion in the Background Information section and Table A1-1 in the appendix. See Figure A1-2 for design of the WNUV DTS node.

An innovative transmitter design that allows switching between full service, stringent, and simple mask filters for the proposed test procedure will need to be engineered. It is likely that an operator will need to be on site to do a manual switch over at the appropriate time as designated by the test facilitator.

The interference caused by adjacent channel energy impacts the receiver in a dual manner. The initial source of disturbance arises from energy within the desired channel bandwidth, resulting from an imperfect transmitter filter that emits energy into the adjacent channel bandwidth. Since this energy is within the receiver's channel, it cannot be filtered out, and only the transmitter filter's quality can influence it.

The second source of interference stems from the receiver's less-than-perfect channel filter, causing it to pick up some energy from the neighboring channel bandwidth. This interference is determined by the quality of the receiver filter.

When attenuating the adjacent channel at the van, only the second type of interference is affected, leaving the first unaffected. To comprehend how this relates to real-world scenarios, conducting tests and calibrations in a lab setting would likely be necessary to establish a correlation between altering the signal level in the undesired channel and adjusting the transmitter power.

Therefore, it has been determined that attenuating the signal at the transmitter will result in more accurate test data. This will require the transmitter operator to adjust the attenuator in 1 db increments a usable WWDD-LD signal is received.

FIELD TEST VEHICLE DESCRIPTION

For this field test, we will use an electronic news gathering (ENG) van with a pneumatic mast capable of reaching at least 30’ above ground level (AGL), a motorized pan and tilt head, and an AC generator power source. The equipment setup will be similar to that used for the Dallas SFN field test conducted a couple of years ago. Figure A2-1a contains a picture of the field test van exterior while Figure A2-1b shows the interior with all of the test equipment. The van’s electronic system block diagram of the reference test equipment used for outdoor measurements is illustrated in Figure A2-2.

The test van employs a GPS unit to determine the exact location (latitude and longitude, in fractional degrees) of each test site, allowing the distance and bearing back to the transmit site to be calculated as part of the data entry spreadsheet. The GPS coordinates also provide accurate site location information for a computer mapping program in order to subsequently identify and plot exact test site locations for the written report.

The broadband (CH 7 – CH 51) 75-Ohm antenna used for these fixed outdoor (i.e., non-mobile, non-indoor) field test measurements on CH 25 & 24 will be a MaxView omni-directional antenna (Omni-Max Pro) that was previously calibrated by comparison to an accurate commercial reference dipole antenna. A broadband (50 – 800 MHz) 75-Ohm-to-50-Ohm low-loss impedance transformer can be externally added to a 75-Ohm antenna in order to optimally interface to the 50-Ohm truck measurement system. The impedance conversion loss (≈0.25 dB) was accounted for in the overall antenna gain calibration. This test antenna is compact in size, with good (balun) impedance matching, and reasonable circularity (i.e., replication of true circular azimuth pattern). The omni-directional test antenna will be mounted on the roof of the test van, about 11’ AGL. A picture of this omnidirectional UHF antenna is shown in Figure A2-3a.

While this omni-directional antenna does not realistically simulate what a viewer might currently use on the roof or in the attic of a single-family residence for outdoor reception of UHF signals, it does allow a worst-case measurement and analysis methodology to be achieved for interference evaluation.

The calibrated reference dipole antenna that was used to calibrate the consumer test antenna was an A.H. Systems TV-2 (UHF), which theoretically is defined to have 0 dBd of gain but was considered to have on average an actual “gain” of about -0.5 dBd with a front-to-back ratio of 0 dB. That is, the dipole manufacturer calibrated this reference antenna (which uses very accurate low-loss baluns) on an antenna range at different frequencies and different heights above ground level. The reference dipole gain value to be used in this field test is therefore based on the average of the calibration data provided by the antenna manufacturer, and accounts for component losses. While the specific calibration values may vary from this typical number by ± 0.5 dB over frequency and height above ground, this small error is more than acceptable in this type of field test. A picture of the UHF reference dipole antenna and its accessories is shown in Figure A2-3b.

The dipole factor, which varies inversely with channel frequency, allows direct mathematical conversion between field strength (in dBμV/m) at the input to a dipole antenna and signal power (in dBm) at its output. The CH 24 dipole factor value (based on a 50-Ohm system) that will be used for calculation of the field strength values (in dBμV/m) from the measured signal power levels (in dBm) during the field test will be determined. The dipole factor value is used to calculate the DTV field strengths at each test site from the measured signal powers, along with the antenna gain (in dBd), test van RF distribution system gain (in dB), measured signal power level (in dBm in a 6 MHz bandwidth), and the user-selected variable attenuator value (in dB).

The system gain in the truck will be made up of the 50-Ohm coaxial down-lead cable and a 50-Ohm RF Winegard low-noise amplifier system that includes a variable 1-dB electronic step (0 – 63-dB range) input attenuator, a robust low-noise RF amplifier (LNA), and a 4-way splitter (7.0 dB loss) at its output for simultaneously feeding the amplified incoming DTV signals to a reference DTV receiver for monitoring and a spectrum analyzer for signal measurements (plus additional pieces of test equipment).

Signal power will be measured with a Rohde & Schwarz spectrum analyzer (FPC-P3) using 6 MHz bandpower markers, and therefore represents an average (integrated) power across the entire 6 MHz DTV channel. A built-in tracking generator allows the spectrum analyzer to also sweep electronic components and system hardware, such as the entire system gain of the test van.

An ETRI/Cleverlogic ATSC3 receiver, in conjunction with ETRI/AGOS PC software (IMAS), will be employed in this field test to determine DTV reception status (service and margin). This unit contains an ATSC3 tuner with COFDM demodulation and decoding circuitry for DTV signal reception and monitoring capability. Both data error rates and video/audio decoding capability (for display on the control computer) are available from this unit. Additionally, this commercial receiver provides other measurement parameters (e.g., MER, RF Spectrum, channel impulse response, and the ATSC3 physical layer control parameters that are transmitted with the signal).

When signal levels reach the SNR data error threshold of the specific PLP Mod-Cod under test, the situation is described as being either at the threshold of visibility (TOV) or the threshold of audibility (TOA), depending on the signal that is being monitored. Data errors cause the video to pixelate and they cause audio to mute. For ATSC1, TOV and TOA occur essentially at the same 15-dB SNR value since there is only one PLP with constant Additive White Gaussian Noise (AWGN) threshold. However, ATSC3 allows different thresholds for different PLPs, and therefore TOV and TOA do not necessarily occur at the same SNR value. Figure A2-4 is a picture of this DTV receiver.

The block diagram in Figure A2-2 illustrates the equation for calculating the field strength as well as identifying the individual parameters that describe the calibrated components.

FIELD TEST PLAN

Measurement Overview

The test procedure evaluates the performance of three different types of mask filters on the quality of service of an adjacent-channel station at different measurement locations. The procedure involves measuring signal strength using an omnidirectional receive antenna, observing picture quality on ATSC 1.0 receivers, recording GPS reading, time/date and weather conditions. The tests will be conducted with WNUV-DT's SFN separately employing full service, stringent and simple mask filters and the recorded results used to determine adjacent-channel station signal quality, coverage area, signal degradation, visual quality, signal performance correlation with weather conditions, etc.

General Measurement Methodology

Our approach involves utilizing the standard measurement technique commonly used in fixed outdoor digital television field tests. Field strength (signal strength) and service availability (error-free transmission) are the key factors that provide the necessary information for television stations to assess their reach to over-the-air viewers. This data can be acquired through meticulous field measurements utilizing calibrated test equipment in the test van.

The WNUV-DT main transmitter will emit its authorized DTV signal while airing typical programming. The tests will include (1) signal power measurement for determining field strength using dipole factor, antenna gain, and van system gain and (2) error-free service assessment of WWDD-LD for a 30-second interval at all test sites, regardless of field strength.

Once a baseline has been established, and it has been determined that the location we are at would have a usable WWDD signal without the presence of the WNUV DTS node we can begin our filter test. We will cycle through measurements with the full service, stringent, and then the simple mask filters operational to determine effectiveness of each filter.

Typically, a higher receive antenna leads to a higher received signal field strength value. While this may not always be the case (such as in certain multipath scenarios), it occurs frequently. When comparing field performance (field strength, service availability, and margin) at different receive antenna heights (10' AGL or 30' AGL), there is often a decline in signal coverage and service at lower heights, highlighting the varied viewer reception conditions that typically exist in the field.

For a long time, the conventional 30' AGL receive antenna has been challenged (since the inception of the ATSC1 system in 1994). However, field tests using a 30' AGL receive antenna enables comparison to the FCC theoretical curves, Longley-Rice simulations, and prior analog and digital field tests. That is the height chosen for this field test.

More recent field tests at lower receive antenna heights have shed light on digital television service for a more typical viewer reception scenario (i.e., lower receive antenna heights). These lower antenna heights also provide a baseline worst-case scenario and a more accurate representation of what is believed to be the majority of home antenna locations.

Additionally, this field test will utilize an omni-directional antenna instead of the traditional directional antenna to evaluate the impact of different mask filters. The omni-directional antenna will be able to receive signals from multiple directions based on the receiver and transmitter positions, while a directional antenna only receives signals from a specific direction.

Therefore, a consumer omni-directional antenna calibrated for 6 MHz DTV spectral signals will be mounted on the lowered test van's pneumatic mast at approximately 11’ AGL. The omni-directional nature of the antenna eliminates the need for adjustments for maximum signal strength, which is typical with directional antennas, and the antenna will remain mounted on the mast during the data gathering process, streamlining the process.

Measurement Locations

Figure A3-1 is a Longley-Rice coverage map of WNUV-DT and its DTS node. The Longley-Rice model is an empirical propagation model used to predict the path loss, or the decrease in signal strength, between a transmitting antenna and a receiving antenna. It was designed for the prediction of radio wave propagation over long distances and takes into account various environmental factors such as the Earth's curvature, atmospheric absorption, and the presence of obstacles. The model provides a more accurate prediction of radio wave propagation compared to simpler models, making it useful in applications such as the design and optimization of communication systems.

Figure A3-2 is a Longley-Rice coverage map of WWDD-LD. A large portion of WWDD’s coverage contour resides inside that of WNUV. As such, one would expect to find areas of adjacent channel interference due to the proximity of the two stations. Adjacent channel interference refers to the disturbance that occurs when a radio signal from an adjacent frequency band interferes with the signal being received on a specific frequency. This interference can cause degradation of signal quality and reduce the overall performance of a communication system. Adjacent channel interference is a common problem in wireless communication systems.

Figure A3-3 is a map on which Longley-Rice-based predicted interference from WNUV-DT’s SFN node to the predicted coverage of WWDD-LD is plotted, with the WNUV-DT SFN node operating with a full service mask filter. The map shows interference received from all sources. It is important to note that the new (unique) interference from the SFN node is in bright green. This is the interference that will be most important in our test.

Figure A3-4 is the same Longley-Rice interference study with the WNUV-DT SFN node operating with a stringent mask filter.

Figure A3-5 results from the study with the WNUV-DT SFN node operating with a simple mask filter.

Utilizing the interference map with the simple mask filter as the starting point, we overlaid the Longley-Rice predicted interference pattern over a satellite image of the Baltimore area. We attempted to pick test locations that were 1.) central to each “cell” of predicted interference; 2.)

easy to access with the test van; and 3.) along the most efficient driving route in order to cut down on the time required to implement the test procedure. Figure A3-6 the resultant map of the test locations.

Figure A3-7 presents a comprehensive map that outlines the measurement locations situated around the WWDD-LD transmitter site, which are strategically organized along four radials. Each of these radials extends approximately 5 miles in length, and they encompass a total of 20 measurement locations. To ensure precise and consistent data collection, these locations are carefully spaced at intervals of roughly 1 mile apart, allowing for a thorough examination of the area surrounding the transmitter site.

Table A3-8 are the details of particular locations suggested for the 75-site field test.

Site-Specific Measurement Procedure

The test procedure is designed to evaluate the performance of the three different types of mask filters and their effectiveness on eliminating adjacent-channel interference at the different measurement locations.

1. Picture quality observation of WWDD-LD with WNUV-DT DTS facility off the air: If there is no usable picture for WWDD-LD, then location is discarded and the test van moved to the next measurement site since no useful data will be collected from this site.

2. Signal strength measurement #1 with WNUV-DT DTS facility off the air: The signal strengths of the WNUV-DT main and WWDD-LD are measured using the omnidirectional receive antenna.

3. Operate WNUV-DT DTS with the full service mask filter.

4. Signal strength measurement #2: WNUV-DT Main and DTS are measured using the omnidirectional receive antenna.

5. Picture quality observation: The picture quality of WWDD-LD is observed on an ATSC 1.0 receiver to determine if signal degradation is occurring. Grading will occur on a 1-4 scale.
    a. Grade 1 - No viewable signal
    b. Grade 2 - Signal viewable if content is a priority.
    c. Grade 3 - Some interference artifacts but no detrimental effects to content.
    d. Grade 4 - Perfect picture quality

6. Assuming a unusable WWDD-LD picture is observed, begin utilizing WNUV-DT signal attenuator and reduce signal in 1 dB increments until WWDD-LD picture begins to appear.

7. GPS reading: The GPS reading is recorded to accurately locate the measurement location. This information is useful in mapping the signal strength and quality across an area.

8. Time/Date: The time and date of each measurement is recorded to establish a timeline for the measurement data.

9. Weather conditions: The weather conditions are recorded to determine if any atmospheric conditions may have an impact on the signal quality and strength. This information helps to identify any correlations between weather conditions and signal performance.

10. Repeat the process with the stringent mask filter operational.

11. Repeat the process with the simple mask filter operational.

TEST RESULTS

Table A4-1 is a summary of field test results that are intended to be captured.

SUMMARY

The purpose of this field test is to gauge the effectiveness of a Simple Out-Of-Channel Emissions mask filter vs. Stringent Out-Of-Channel Emissions mask filter vs. a Full Service Out-Of-Channel Emissions mask in reducing interference to neighboring stations. The field test aims to assess the performance of the filters in blocking external sources of adjacent-channel interference while being used in real-world situations. The objective is to evaluate the effectiveness of the different mask filters, compare cost and benefits, and determine whether or not to initiate a proposed FCC rulemaking to allow for such filter choices and possibly changes to the Commission’s Desired-to-Undesired ratios for calculating adjacent channel interference to other stations.

APPENDIX

Federal Communications Commission

DISTRIBUTED TRANSMISSION SYSTEM LICENSE

Licensee/Permittee
Baltimore (WNUV-TV) Licensee, Inc.
2000 W. 41st Street
Baltimore, MD, 21211

Call Sign	File Number
WNUV	0000231488

Facility ID: 7933
NTSC TSID: 1408
Digital TSID: 1409
This License Covers Construction Permit No. 0000214278

Grant Date 12/13/2023		**Expiration Date** 10/01/2020
Hours of Operation Unlimited		
Station Location City BALTIMORE State MD	**Frequency (MHz)** 536.0 - 542.0	**Station Channel** 25
Antenna Reference Coordinates Latitude 9999 39-20-10.4 N Longitude 76-38-57.9 W		**Facility Type** Commercial

DTS Site Number:1

Antenna Structure Registration Number 1044237	
Transmitter Type Accepted. See Sections 73.1660, 73.1665 and 73.1670 of the Commission's Rules.	**Transmitter Output Power(kW)** As required to achieve authorized ERP.
Antenna Coordinates Latitude 39-20-10.4 N Longitude 76-38-57.9 W	**Antenna Type** Directional

Description of Antenna **Make** DIE **Model** TUD-C5SP-10/36SPH-1-B	
Antenna Beam Tilt (Degrees Electrical) 0.9	**Antenna Beam Tilt (Degrees Mechanical @ Degrees Azimuth)** Not Applicable
Major Lobe Directions 210.0 282.0	**Maximum Effective Radiated Power (Average)** 750 kW 28.75 DBK
Height of Radiated Center Above Ground (Meters) 374.8	**Height of Radiated Center Above Mean Sea Level (Meters)** 456.8
Height of Radiated Center Above Average Terrain (Meters) 372.8	**Overall Height of Antenna Structure Above Ground (Meters)** See the registration for this antenna structure.

DTS Site Number:2

Antenna Structure Registration Number 1037283	
Transmitter Type Accepted. See Sections 73.1660, 73.1665 and 73.1670 of the Commission's Rules.	**Transmitter Output Power(kW)** As required to achieve authorized ERP.
Antenna Coordinates **Latitude** 39-24-10.4 N **Longitude** 76-36-10.9 W	**Antenna Type** Directional
Description of Antenna **Make** Dielectric **Model** TFU-4WB-C160	
Antenna Beam Tilt (Degrees Electrical) 5.5	**Antenna Beam Tilt (Degrees Mechanical @ Degrees Azimuth)** Not Applicable
Major Lobe Directions 185.0 295.0	**Maximum Effective Radiated Power (Average)** 7.0 kW 8.45 DBK
Height of Radiated Center Above Ground (Meters) 69.6	**Height of Radiated Center Above Mean Sea Level (Meters)** 215.0
Height of Radiated Center Above Average Terrain (Meters) 110.0	**Overall Height of Antenna Structure Above Ground (Meters)** See the registration for this antenna structure.

Waivers/Special Conditions

- The license expiration date provided herein is tolled pursuant to 47 U.S.C. §307(C)(3) pending a final decision on the stations license renewal application. Furthermore, this license is subject to any action taken by the Commission on the renewal application.

Subject to the provisions of the Communications Act of 1934, as amended, subsequent acts and treaties, and all regulations heretofore or hereafter made by this Commission, and further subject to the conditions set forth in this permit, the permittee is hereby authorized to construct the radio transmitting apparatus herein described. Installation and adjustment of equipment not specifically set forth herein shall be in accordance with representations contained in the permittee's application for construction permit except for such modifications as are presently permitted, without application, by the Commission's Rules.

Equipment and program tests shall be conducted only pursuant to Sections 73.1610 and 73.1620 of the Commission's Rules.

Federal Communications Commission

LOW POWER TELEVISION BROADCAST STATION LICENSE

Licensee/Permittee
WORD OF GOD FELLOWSHIP, INC
3901 HIGHWAY 121
BEDFORD, TX, 76021

Call Sign	File Number
WWDD-LD	0000205105

Facility ID: 47692
NTSC TSID: 7050
Digital TSID: 7051
This License Covers Construction Permit No. 0000130050

Grant Date 01/04/2023	**Expiration Date** 10/02/2028	
Hours of Operation Unlimited		
Station Location City Baltimore State MD	**Frequency (MHz)** 530.0 - 536.0	**Station Channel** 24

Antenna Structure Registration Number 1037378	
Transmitter Type Accepted. See Sections 74.750 of the Commission's Rules.	**Transmitter Output Power(kW)** As required to achieve authorized ERP.
Antenna Coordinates Latitude 39-30-54.4 N Longitude 76-14-24.7 W	**Antenna Type** Directional
Description of Antenna Make SWR Model SWEDL4EC	**Major Lobe Directions** 30.0 40.0 260.0 270.0
Antenna Beam Tilt (Degrees Electrical) Not Applicable	**Antenna Beam Tilt (Degrees Mechanical @ Degrees Azimuth)** Not Applicable

Maximum Effective Radiated Power (Average) 6.5 kW 8.13 DBK	
Height of Radiated Center Above Ground (Meters) 97.7	**Height of Radiated Center Above Mean Sea Level (Meters)** 198.0
Out-Of-Channel Emission Mask Full Service	**Overall Height of Antenna Structure Above Ground (Meters)** See the registration for this antenna structure.

Waivers/Special Conditions

- Grant of this license application is conditioned on continuous operations of the licensed facility for the twelve-month period following grant. The failure to so operate will result in the rescission of this grant, dismissal of the license application and the forfeiture of the associated construction permit pursuant to 47 C.F.R. § 73.3598(e) unless the licensee rebuts the presumption that the authorized facilities were temporarily constructed.

Subject to the provisions of the Communications Act of 1934, as amended, subsequent acts and treaties, and all regulations heretofore or hereafter made by this Commission, and further subject to the conditions set forth in this permit, the permittee is hereby authorized to construct the radio transmitting apparatus herein described. Installation and adjustment of equipment not specifically set forth herein shall be in accordance with representations contained in the permittee's application for construction permit except for such modifications as are presently permitted, without application, by the Commission's Rules.

Equipment and program tests shall be conducted only pursuant to Sections 73.1610 and 73.1620 of the Commission's Rules.

Table A1-1 Essential DTV transmitter facility parameters used in the field test.				
Transmitter Parameter	**WNUV-1**	**WNUV-2**	**WWDD-LD**	**Parameter Units**
Designated Market Area	Baltimore, MD	Baltimore, MD	Baltimore, MD	---
Zone	1	1	1	---
Station Owner	Cunningham	Cunningham	Daystar	---
Broadcast Network Affiliation	CW	CW	Word of God Fellowship	---
Transmitted Signal	ATSC3	ATSC3	ATSC1	---
Station Facility ID Number	7933	7933	47692	---
Site Location: Town	Baltimore, MD	Towson, MD	Havre de Grace, MD	---
Site Location: Latitude	39.336222	39.402889	39.515111	deg N
Site Location: Longitude	76.649417	76.603028	76.240194	deg W
Virtual Channel Number	54	54	49	---
Physical RF Channel	25	25	24	---
Center Frequency	539	539	533	MHz
Center Frequency Wavelength	1.66	1.66	1.66	MHz
Exciter Manufacturer	Rhode & Schwarz	N.A.	Linear	---
Exciter Model #	THU9evo-36	N.A.	AT71-500	---
Antenna Manufacturer	Dielectric	Dielectric	Systems With Reliability	---
Antenna Model #	TUD-C5SP-10/36SPH-1-B	TFU-4WB-C160	SWEDL4EC	---
Antenna Type	Broadband Panel	Slotted Cylinder	Slotted Coaxial	---
Antenna ID	1004139	1010246	1010311	---
Antenna Mounting Location	Top Mount	Rooftop	Side Mount	---
Signal Polarization	Horizontal	Elliptical	Elliptical	---
Antenna Pattern	Directional	Directional	Directional	---
Max Antenna Pattern Azimuth	210, 282	185, 295	30, 40, 260, 270	deg relative N
Beam Tilt	0.9	5.5	0.75	deg
Antenna Site Elevation (AMSL)	82	145.4	100.3	meters
Radiation Center (AGL)	374.8	69.6	97.7	meters
Radiation Center (AMSL)	456.8	215	198	meters
Height Above Average Terrain	372.8	110	143	meters
Effective Radiated Power	750	7	6.5	kW

Horizontal Polarization	750	7	6.5	kW, ERP
Vertical Polarization	0	3.6	N.A.	kW, ERP

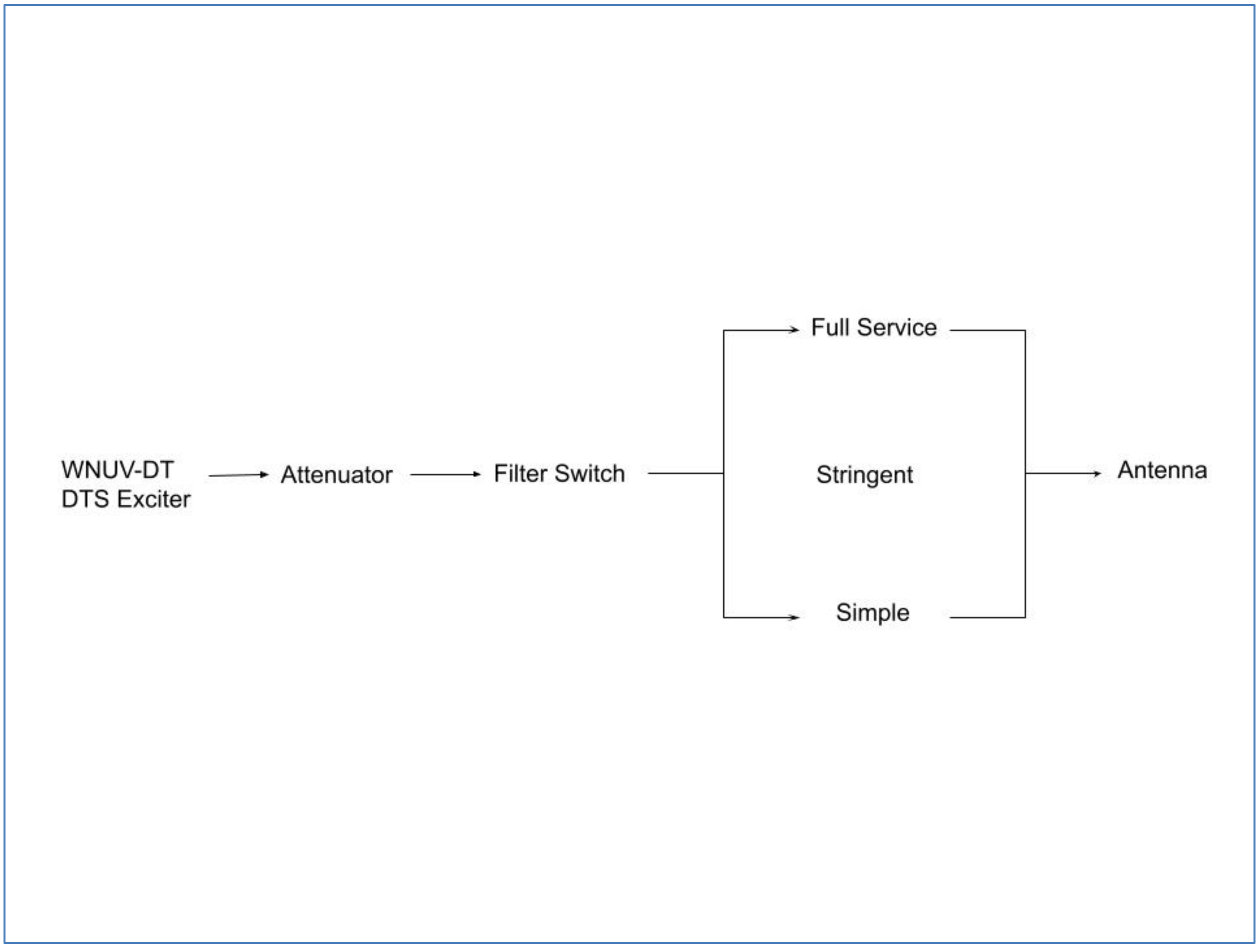
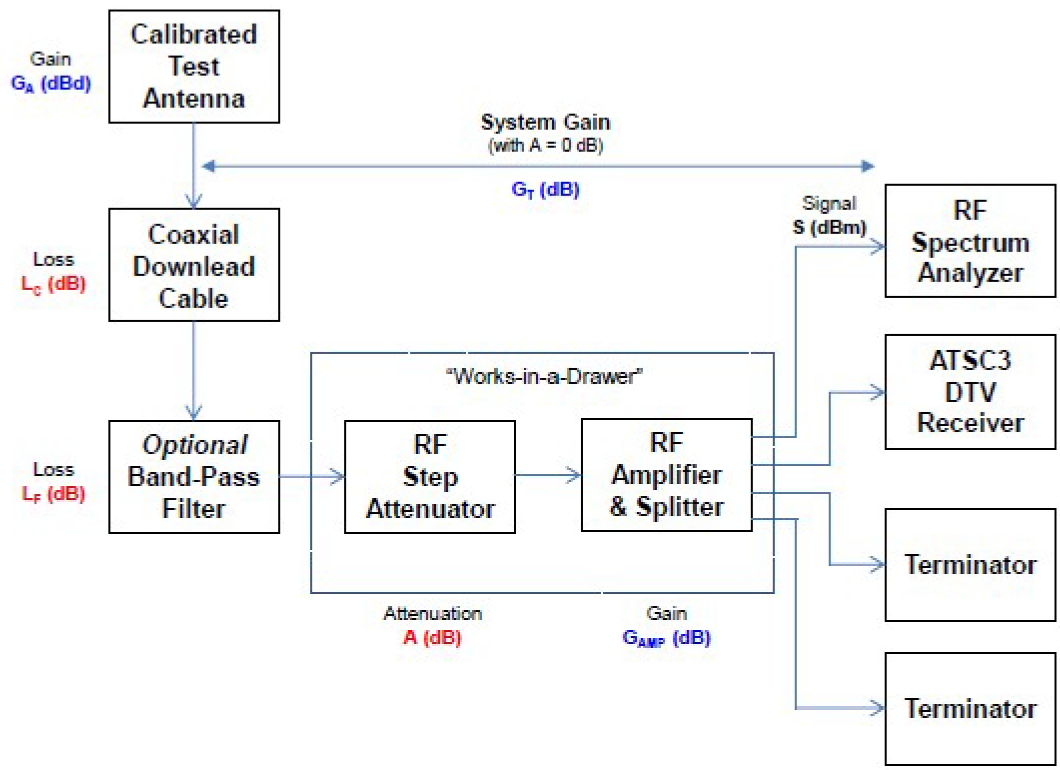


Figure A1-2 - WNUV DTS Transmitter Design

Figure A2-1a Field test van *exterior* photo.

Figure A2-1b Field test van *interior* photo.



$$FS\ (dB\mu V/m) = S\ (dBm) - G_T (dB) + A\ (dB) + K_D\ (dB\mu V/m - dBm) - G_A\ (dBd)$$

where

- **S** ≡ signal level in 6 MHz bandwidth at spectrum analyzer input (in dBm)
- G_T ≡ total system gain of truck with attenuator A = 0 dB (in dB)
- **A** ≡ manual attenuator loss (in dB)
- K_D ≡ dipole factor for given RF test channel center frequency (in dBμV/m - dBm)
- G_A ≡ antenna forward gain over λ/2 matched-impedance dipole for given RF test channel (in dBd)

Figure A2-2 DTV field test receive system block diagram used for *outdoor* reception testing.

Spectrum Co LTD
Omni Master

Frequency Range:
470 – 806 MHz

Gain:
0 dBi (±1 dB)

VSWR:
2.0 dB average

Output Connector:
Female F

Size:
13" x 13" x 5.1"
330 x 330 x 130 mm

Weight:
3.1 lbs
1.4 kg

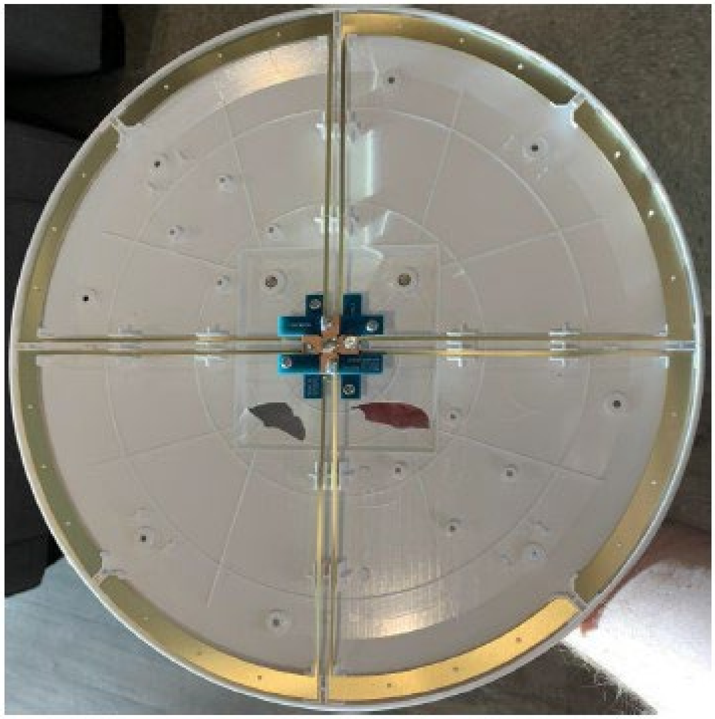


Figure A2-3a *Internal* view of DTV field test van system UHF omni-directional antenna.

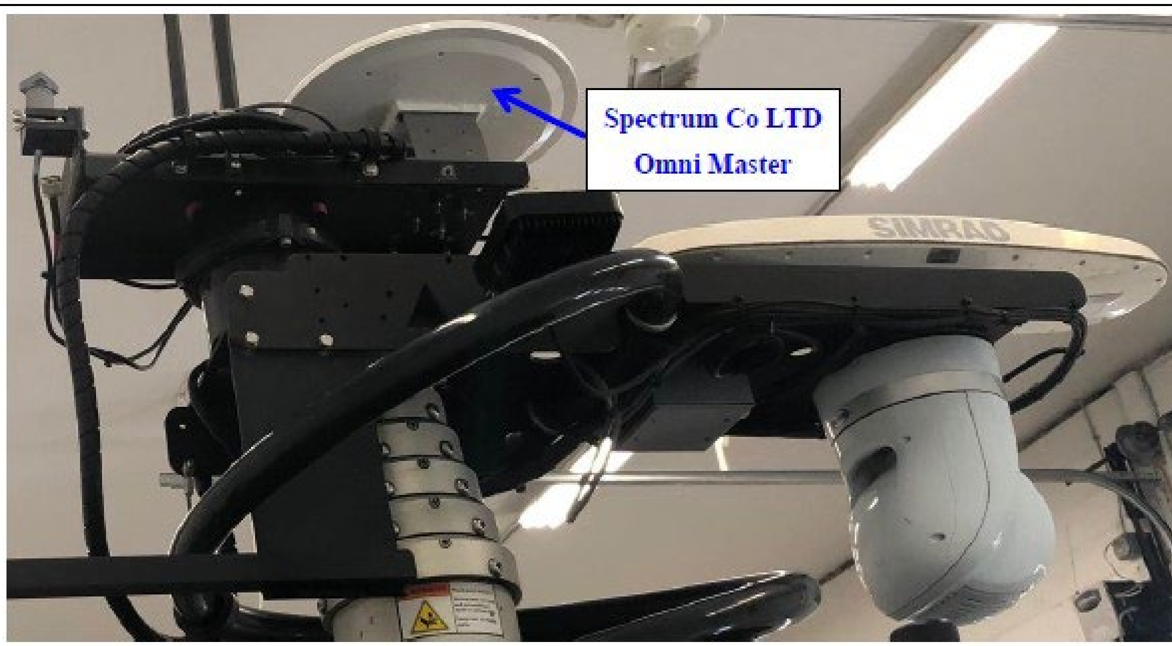


Figure A2-3b UHF omni-directional antenna mounted on top of field test van's mast.

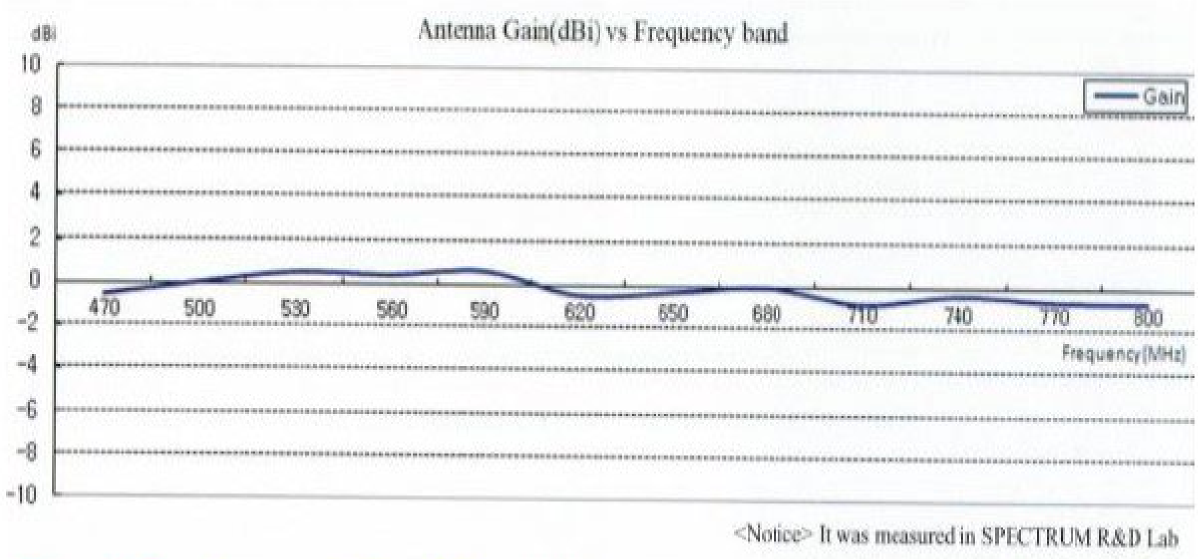


Figure A2-3c **Spectrum Co Omni Master** UHF omni-directional antenna gain versus frequency plot.

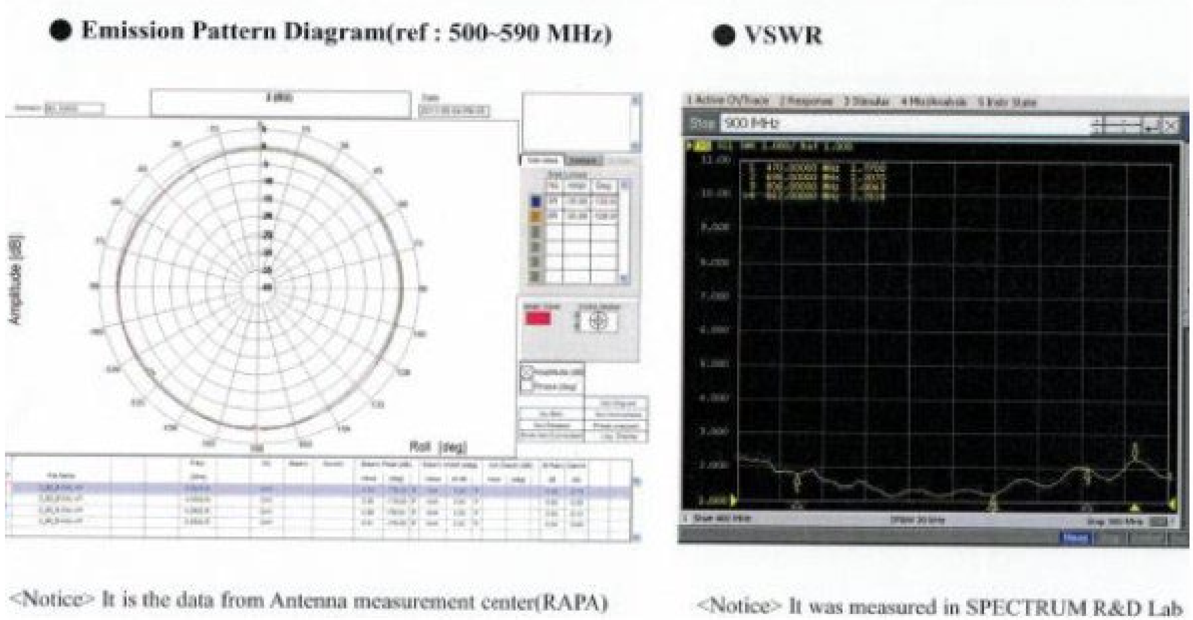


Figure A2-3d **Spectrum Co Omni Master** UHF UHF omni-directional antenna azimuth emission plot.

Figure A2-3e DTV field test van system UHF *reference* dipole antenna (AH Systems TV-2).

Figure A2-4 DTV field test van system reference DTV Receiver (ETRI/Cleverlogic ATSC3 receiver).

Figure A2-5 *Optional* fixed four-cavity 50-Ohm band-pass filter (MFC 3278(4)DB50-##).

Table A2-2 Field test van's list of test equipment.

Component	Manufacturer	Model #	Comments
Receive Antenna	Spectrum Co Ltd	Omni Master	Omni-directional, 0 dBi gain
LTE Low-Pass Filter	Channel Master	CM3201	75-Ohm, 700 MHz bandwidth
Broadband Impedance Transformer	JFW	57ZT BNC M/F	75-to-50-Ohm, BNC connectors
Coaxial Cable	Beldon	???	50-Ohm, double-shielded
Step Attenuator	???	???	50-Ohm, 1-dB step, 0 – 70 dB
RF Channel Bandpass Filter	Microwave Filter Company	MFC 3278(4)DB50-34	50-Ohm, CH 34 (590 –596 MHz)
RF Amplifier	Mini Circuits	???	50 Ohms, X dB gain, XX dBm IP3
2-Way Splitter	Mini Circuits	???	50-Ohm, 2-way, BNC connectors
Spectrum Analyzer	Rohde & Schwarz	FPC-P3	???
ATSC3 Commercial Receiver	Cleverlogic	CL-AR3000	AGOS IMAS software
GPS Receiver	Global Sat	BU-353S4	NEMA compatible, USB powered
Control Computer	???	???	Windows 10 PC

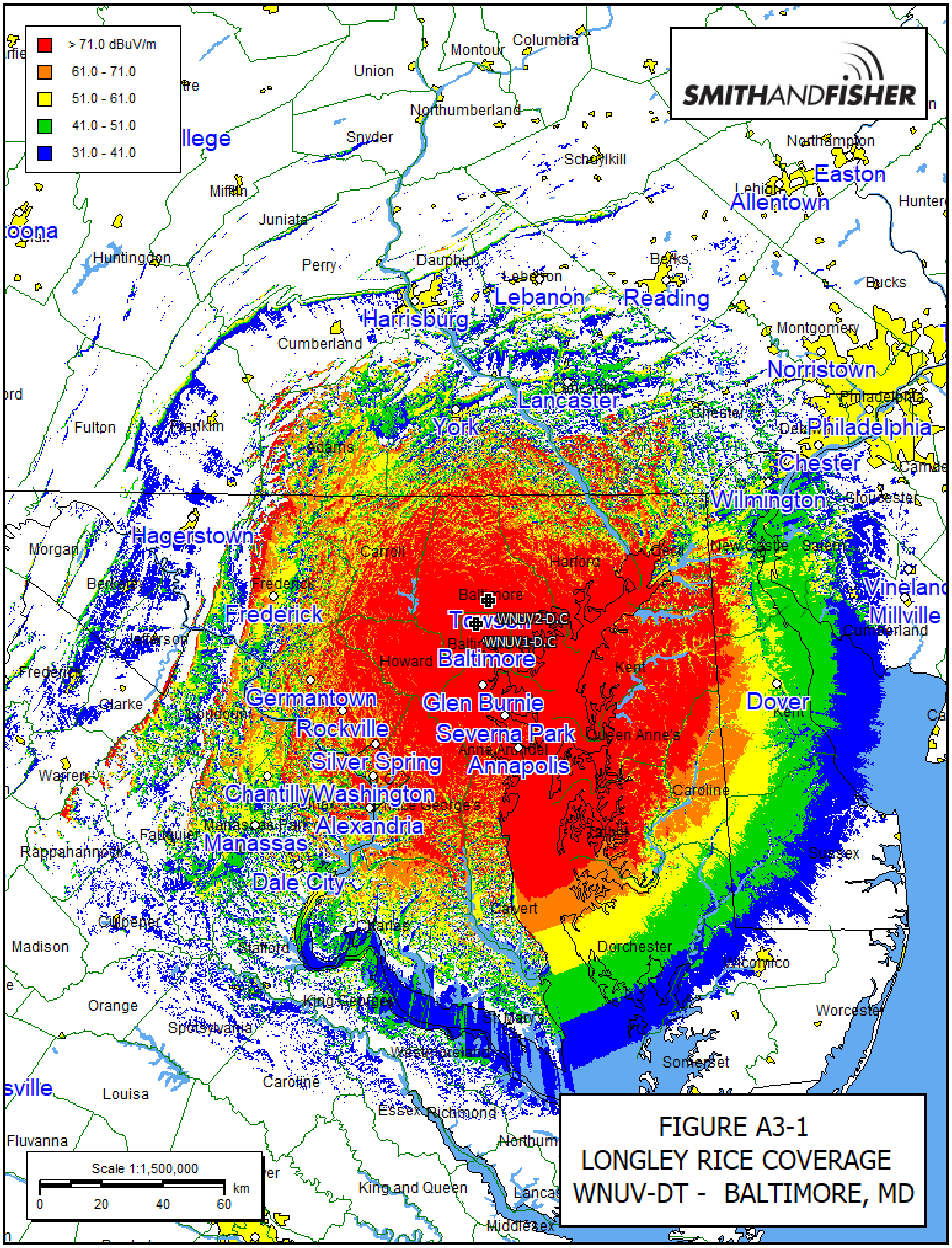


FIGURE A3-1
LONGLEY RICE COVERAGE
WNUV-DT - BALTIMORE, MD

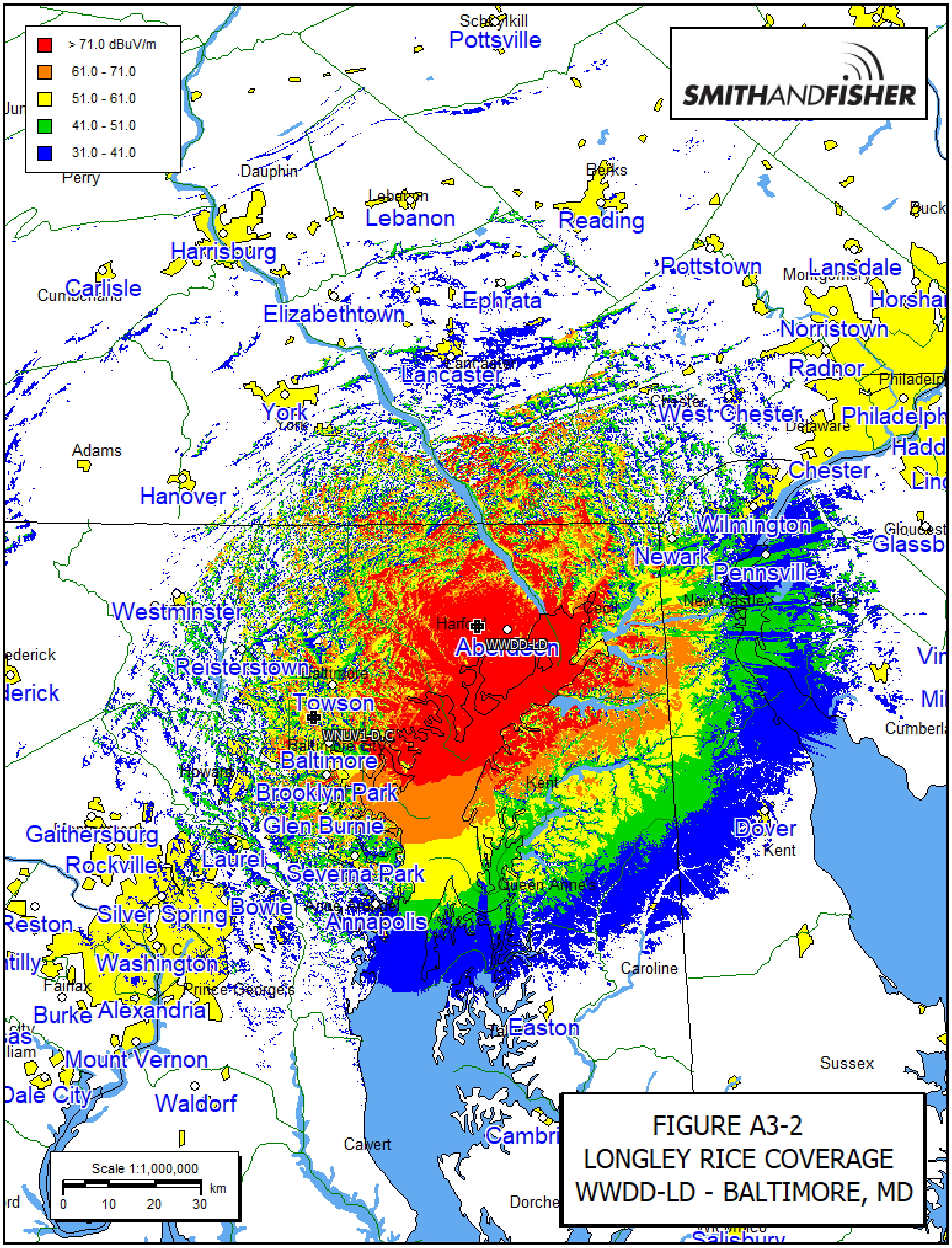


FIGURE A3-2
LONGLEY RICE COVERAGE
WWDD-LD - BALTIMORE, MD

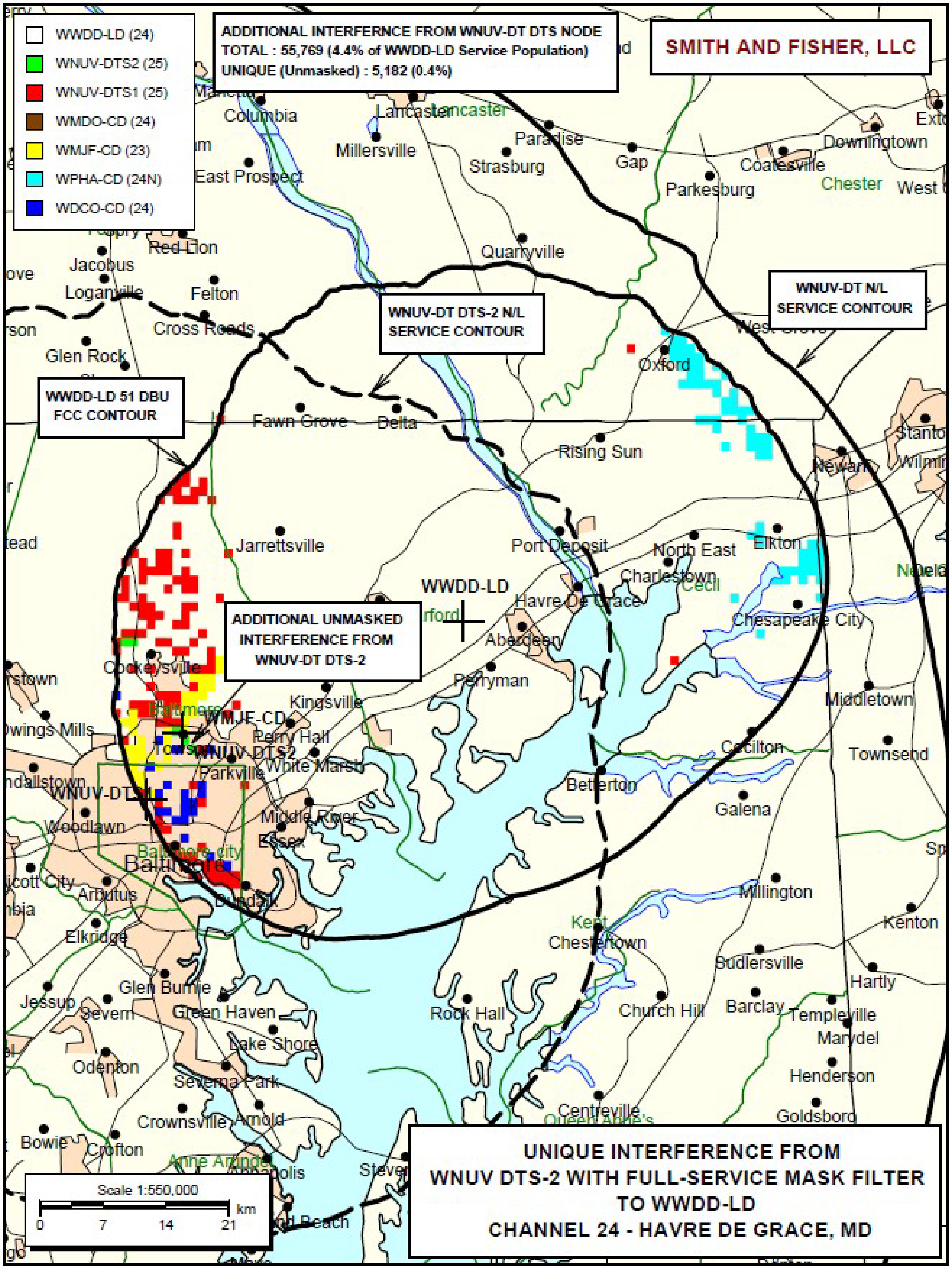

WWDD-LD (24)
WNUV-DTS2 (25)
WNUV-DTS1 (25)
WMDO-CD (24)
WMJF-CD (23)
WPHA-CD (24N)
WDCO-CD (24)
ADDITIONAL INTERFERNCE FROM WNUV-DT DTS NODE
TOTAL : 55,769 (4.4% of WWDD-LD Service Population)
UNIQUE (Unmasked) : 5,182 (0.4%)
SMITH AND FISHER, LLC
WNUV-DT N/L SERVICE CONTOUR
WNUV-DT DTS-2 N/L SERVICE CONTOUR
WWDD-LD 51 DBU FCC CONTOUR
ADDITIONAL UNMASKED INTERFERENCE FROM WNUV-DT DTS-2
WWDD-LD
WMJF-CD
WNUV-DTS2
WNUV-DTS1
UNIQUE INTERFERENCE FROM WNUV DTS-2 WITH FULL-SERVICE MASK FILTER TO WWDD-LD
CHANNEL 24 - HAVRE DE GRACE, MD
Scale 1:550,000
0 7 14 21 km

Figure A3-3

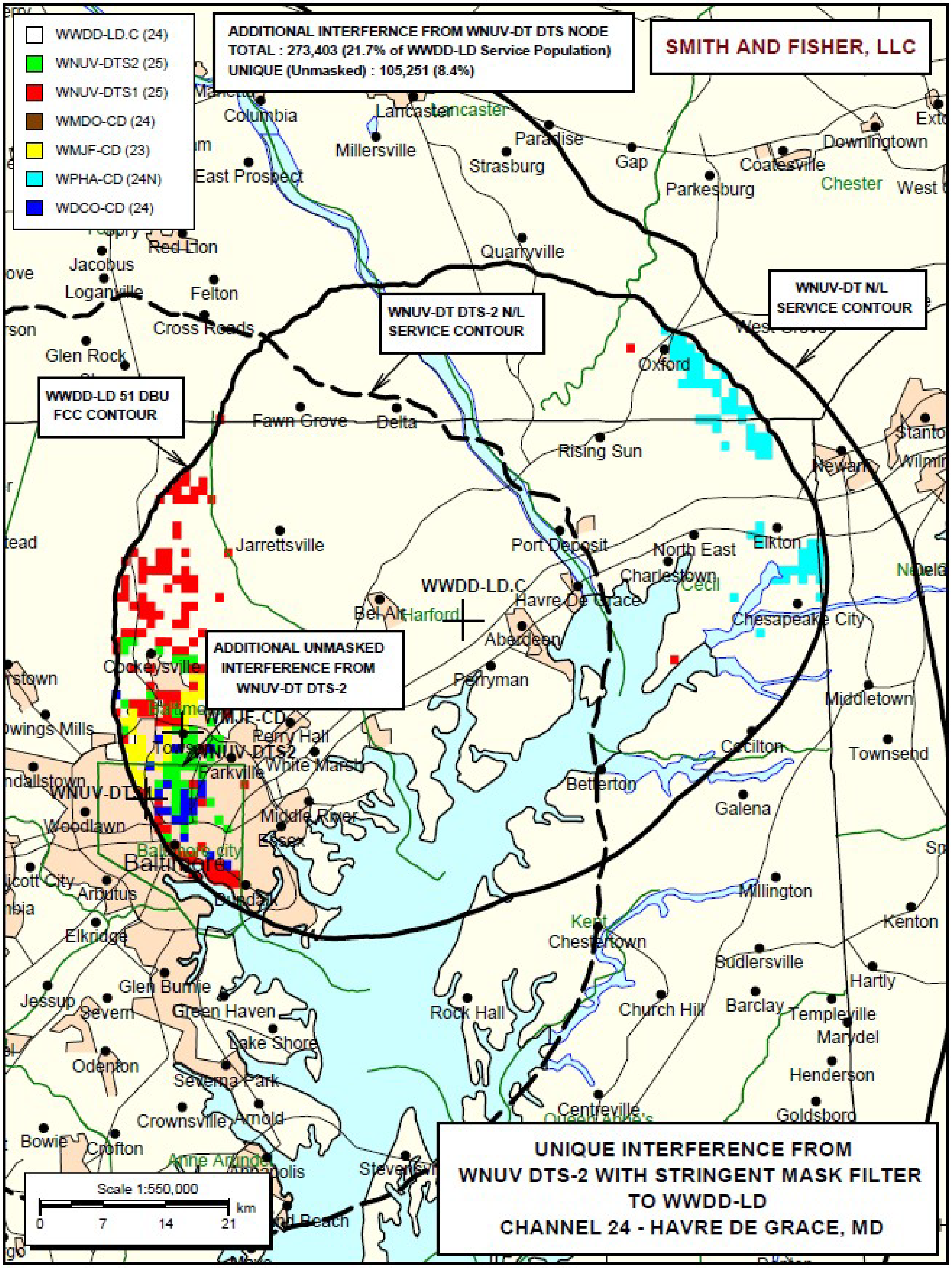

WWDD-LD.C (24)
WNUV-DTS2 (25)
WNUV-DTS1 (25)
WMDO-CD (24)
WMJF-CD (23)
WPHA-CD (24N)
WDCO-CD (24)
ADDITIONAL INTERFERNCE FROM WNUV-DT DTS NODE
TOTAL : 273,403 (21.7% of WWDD-LD Service Population)
UNIQUE (Unmasked) : 105,251 (8.4%)
SMITH AND FISHER, LLC
WNUV-DT N/L SERVICE CONTOUR
WNUV-DT DTS-2 N/L SERVICE CONTOUR
WWDD-LD 51 DBU FCC CONTOUR
ADDITIONAL UNMASKED INTERFERENCE FROM WNUV-DT DTS-2
WWDD-LD.C
WMJF-CD
WNUV-DTS2
WNUV-DTS1
Scale 1:550,000
0 7 14 21 km
UNIQUE INTERFERENCE FROM WNUV DTS-2 WITH STRINGENT MASK FILTER TO WWDD-LD
CHANNEL 24 - HAVRE DE GRACE, MD

Figure A3-4

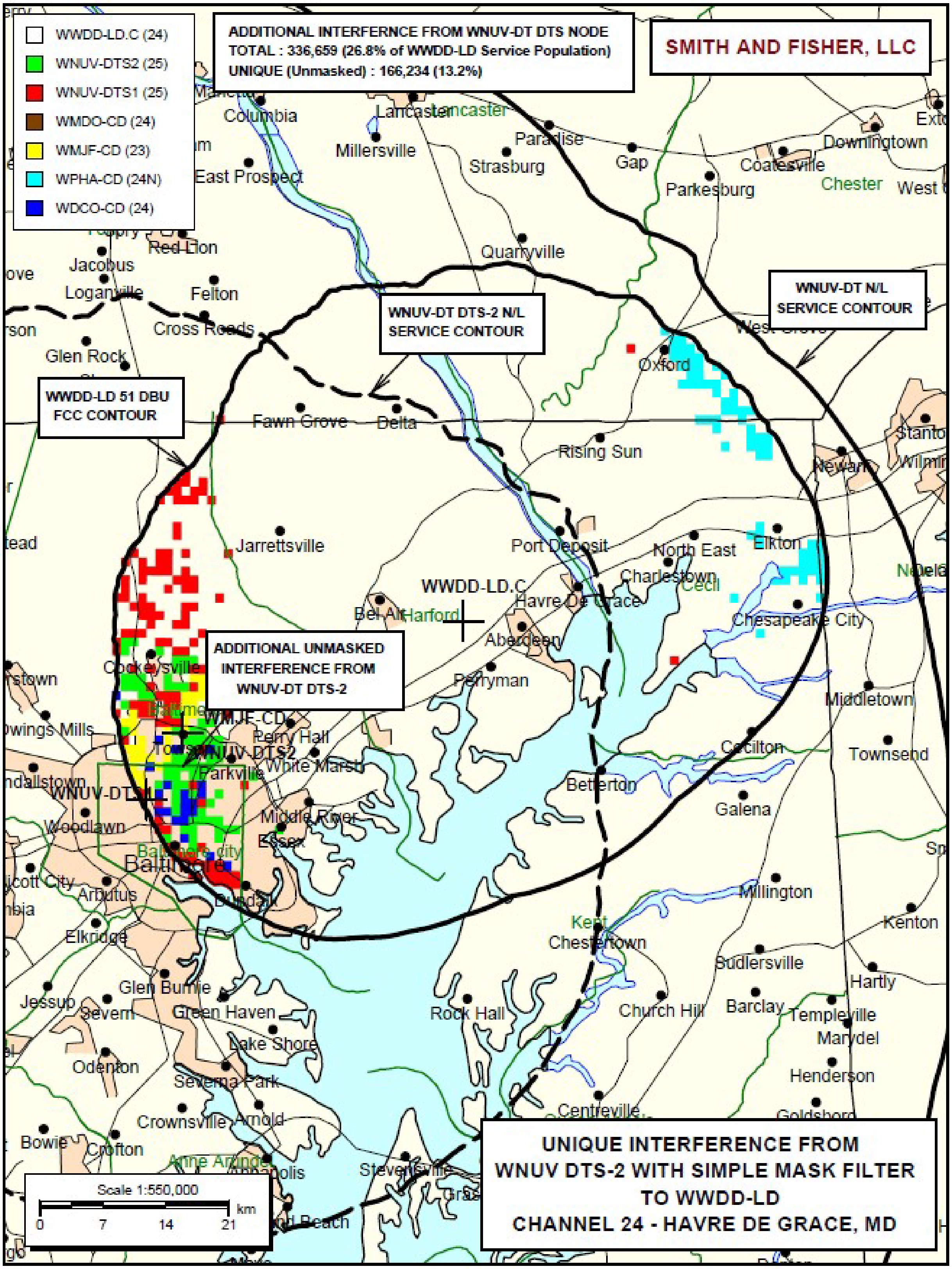

WWDD-LD.C (24)
WNUV-DTS2 (25)
WNUV-DTS1 (25)
WMDO-CD (24)
WMJF-CD (23)
WPHA-CD (24N)
WDCO-CD (24)
ADDITIONAL INTERFERNCE FROM WNUV-DT DTS NODE
TOTAL : 336,659 (26.8% of WWDD-LD Service Population)
UNIQUE (Unmasked) : 166,234 (13.2%)
SMITH AND FISHER, LLC
WNUV-DT N/L SERVICE CONTOUR
WNUV-DT DTS-2 N/L SERVICE CONTOUR
WWDD-LD 51 DBU FCC CONTOUR
ADDITIONAL UNMASKED INTERFERENCE FROM WNUV-DT DTS-2
WWDD-LD.C
WMJF-CD
WNUV-DTS2
WNUV-DTS1
UNIQUE INTERFERENCE FROM WNUV DTS-2 WITH SIMPLE MASK FILTER TO WWDD-LD
CHANNEL 24 - HAVRE DE GRACE, MD
Scale 1:550,000
0 7 14 21 km

Figure A3-5

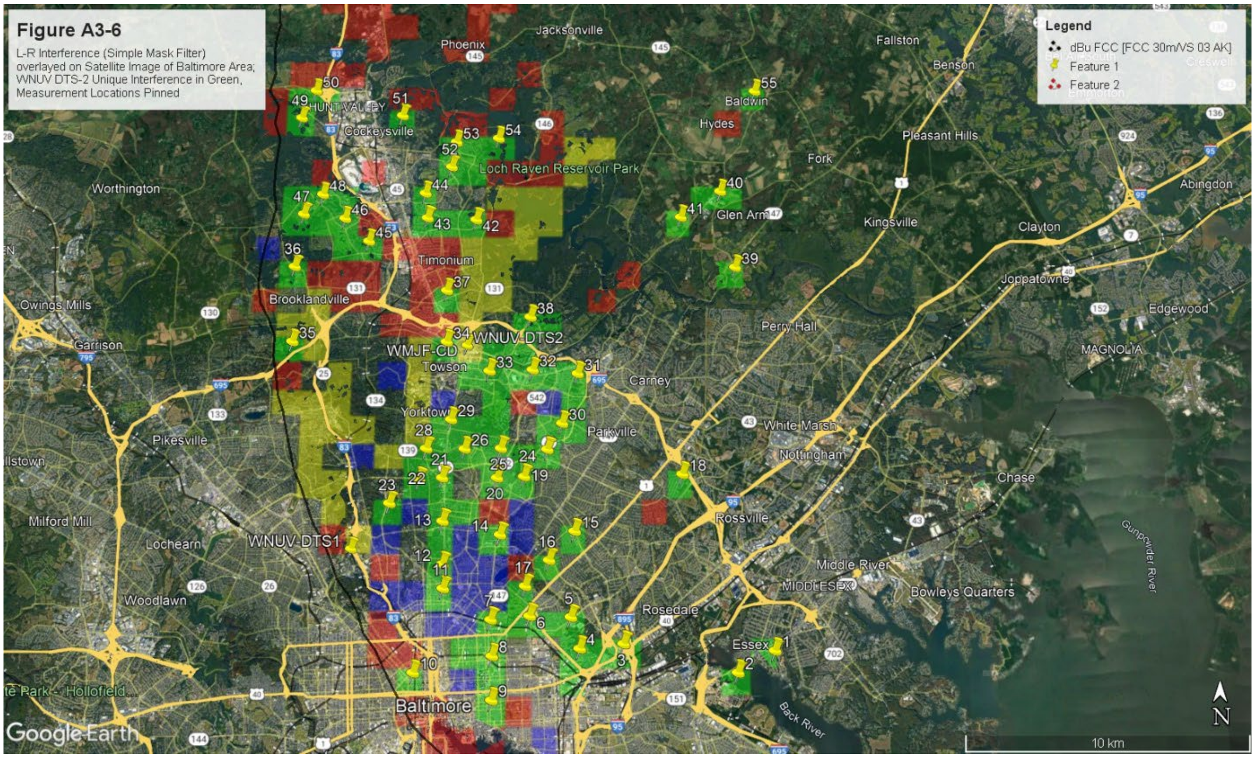


Figure A3-6
L-R Interference (Simple Mask Filter) overlayed on Satellite Image of Baltimore Area; WNUV DTS-2 Unique Interference in Green, Measurement Locations Pinned
Legend
dBu FCC [FCC 30m/VS 03 AK]
Feature 1
Feature 2
WMJF-CD
WNUV DTS2
WNUV-DTS1
Baltimore
10 km
N
Google Earth

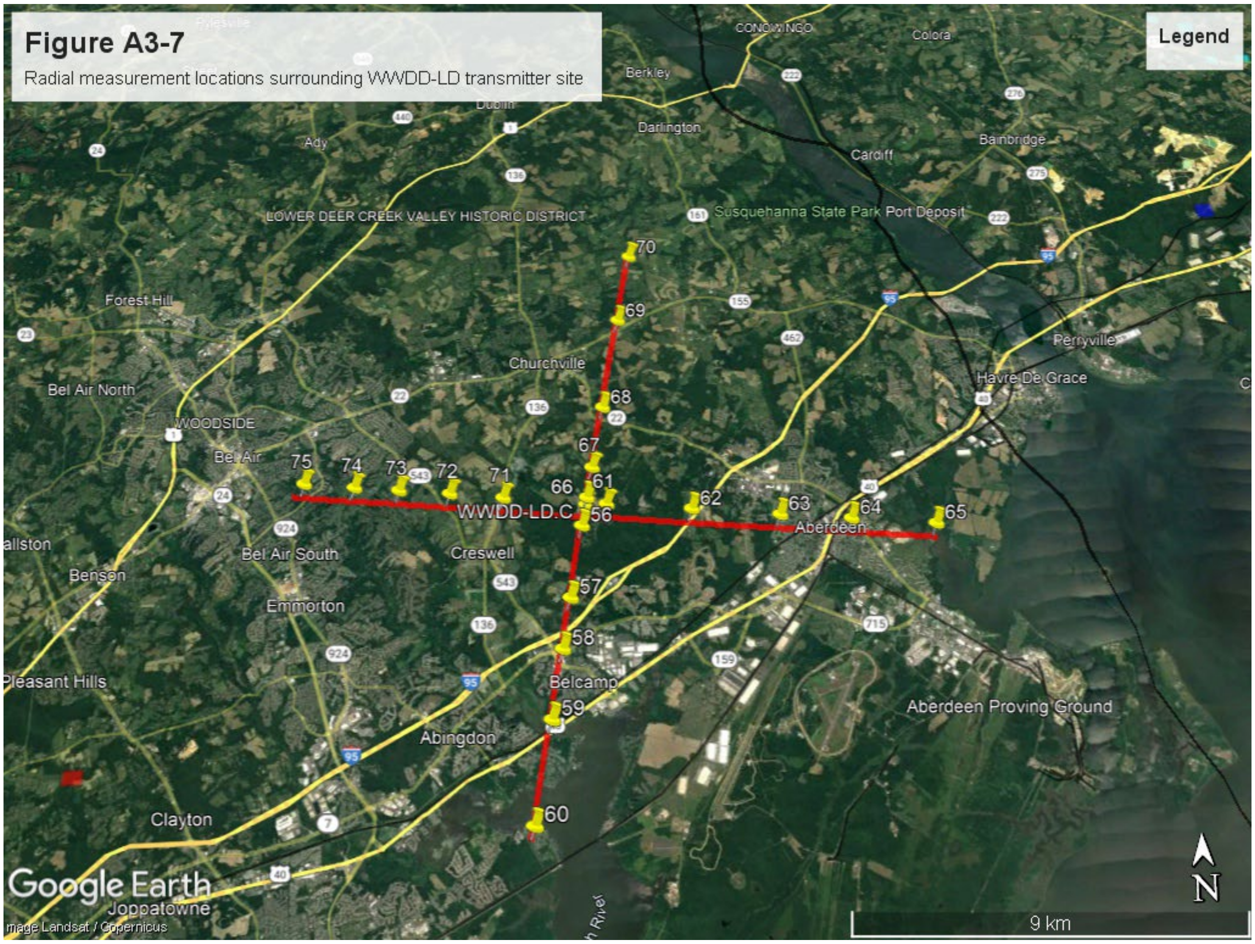


Figure A3-7
Radial measurement locations surrounding WWDD-LD transmitter site
Legend
WWDD-LD.C
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
Bel Air North
Bel Air
Bel Air South
Forest Hill
Churchville
Creswell
Emmorton
Belcamp
Abingdon
Aberdeen
Havre De Grace
Perryville
Aberdeen Proving Ground
Clayton
Joppatowne
Darlington
Cardiff
Port Deposit
Susquehanna State Park
LOWER DEER CREEK VALLEY HISTORIC DISTRICT
Benson
Pleasant Hills
9 km
N
Google Earth

Table A3-8 Details of particular locations suggested for the 75-site field test.							
Site #	Site Address	Latitude	Longitude	Distance to WNUV DTS	Bearing to WNUV DTS	Distance to WWDD	Bearing to WWDD
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
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72							
73							
74							
75							

Table A4-1 Filter Field Test Data Summary												
	Simple Mask Filter				Stringent Mask Filter				Full Service Mask Filter			
Site #	WNUV Field Strength	WWDD Field Strength	WWDD Picture Quality	Margin to Grade 1	WNUV Field Strength	WWDD Field Strength	WWDD Picture Quality	Margin to Grade 1	WNUV Field Strength	WWDD Field Strength	WWDD Picture Quality	Margin to Grade 1
	dBuV/m	dBuV/m	Grade	dB	dBuV/m	dBuV/m	Grade	dB	dBuV/m	dBuV/m	Grade	dB
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
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24												
25												
26												

DOCUMENT REVISION INFORMATION

Version	Date	Amendment	Author
1.1	2/7/2023	First Draft	Kyle Fisher
1.2	2/27/2023	Revisions and Comments	Kevin Fisher
1.3	3/24/2023	Corrected Interference Maps and Tx Attenuator	Kyle Fisher from comments from John Stewart
1.4	7/12/2023	Revisions	Kyle Fisher from comments from Jessica Nyman
1.5	12/6/2023	Re-ran Interference Study to account for 20 deg rotated antenna per Modification of Construction Permit	Kyle Fisher
1.6	12/15/2023	Removed Construction Permit/Added License Authorization	Kyle Fisher from Jessica Nyman