# Comprehensive Engineering Statement

prepared for

**Washington DC FCC License Sub, LLC**

WTOP-FM Washington, DC

Facility ID 11845

Ch. 278B 44 kW (MAX- DA) 158 m

*Washington DC FCC License Sub, LLC ("Hubbard")* is the licensee of WTOP-FM, Channel 278B, Washington, DC, (FCC Facility ID 11845, FCC File Number BMLH-20110215ABQ). *Hubbard* herein proposes to replace its transmitting antenna on the same registered tower (ASRN 1045309). The antenna replacement is being performed per §73.1690 (c)(2) of the Commission's Rules. Per the same Rule Section and §73.1620 (a)(3), WTOP-FM is operating at 50% power and requests approval to conduct program tests at full power.

## Antenna Replacement Requirements

*Hubbard* proposes to replace the WTOP-FM antenna on the same tower located at the coordinates indicated above. The center of radiation of the replacement antenna will be 114.6 meters above ground level, for an antenna height of 225.9 meters AMSL. The licensed antenna height is 228 m AMSL. The instant proposal is within the required +2/-4 meter requirement stated in §73.1690 (c)(2) for antenna replacements.

**Attachment I** provides the Manufacturer's antenna Proof of Performance, including the measured vertically polarized, horizontally polarized and composite tabulations. As shown, neither component exceeds the authorized antenna pattern along any azimuth as required by §73.1690 (c)(2)(i). **Attachment I** also provides the manufacturer's RMS calculation of 0.861 for the composite pattern. The calculated RMS of the authorized envelope pattern is 0.915. As demonstrated, the Root Mean Square of the composite measured directional antenna pattern is 94.1 percent of the envelope, which is greater than 85 percent as required by §73.1690 (c)(2)(ii). A detailed description of the procedures used to measure the directional antenna pattern is provided in the same statement, thus complying with §73.1690 (c)(2)(iii).

**Attachment II** is a PDF statement from a licensed land surveyor, certifying that the antenna was oriented to the proper azimuth as specified by the antenna manufacturer. As demonstrated, the antenna was correctly oriented to 30 degrees True. **Attachment III** is the certification from a qualified engineer who oversaw the installation of the directional antenna. Thus, the requirements of §73.1690 (c)(2)(iv) and (v) are satisfied.

The replacement antenna is a new Master FM Antenna to be used by WAMU(FM) (Channel 203B, Washington, DC), WPFW(FM) (Channel 207B, Washington, DC), and WETA(FM) (Channel 215B, Washington, DC). It is a non-directional master antenna manufactured by ERI as model number 1182-6CP-DA-SP, with a separate input port for WTOP-FM to provide the directional pattern specific to its needs. As such, a special combiner / filter was installed to protect the system from generating intermodulation and other spurious products. **Attachment IV** is the manufacturer's test results after installation, and while all other antenna users were operating at full power into the antenna.

**Figure 1** demonstrates the 70 dBμ City Grade contour coverage using the measured pattern, as required by §73.1690 (c)(2). As demonstrated, the proposed antenna pattern fits within the authorized pattern, and the City Grade contour fully encompasses the community of license, Washington, DC.

**Green Bank, Monitoring Station, International Considerations**

The facility is located outside the Green Bank coordinates identified in §73.1030(a)(1). The site is located 2,371 km from Canada and 475.4 km from the Mexican border, well beyond the 320 km coordination distance for both countries. The nearest FCC monitoring station is 34.6 km distant at Laurel, Maryland. Since no change in authorization is being requested, it is believed that no coordination with the monitoring station is required. With respect to AM stations, according to information extracted from the Commission's Media Bureau database, there are no facilities within 3.2 km of the proposed site.

**Environmental Considerations**

The proposed facility utilizes a Master FM antenna system, in common with WAMU(FM), WPFW(FM), and WETA(FM), with a circularly-polarized antenna at 114.6 meters AGL on registered tower ASRN 1045309. The use of existing transmitting locations has been characterized as being environmentally preferable by the Commission, according to Note 1 of §1.1306 of the FCC Rules. Because no change in structure height is proposed, no change in current structure marking and lighting requirements is anticipated. Therefore, it is believed that this application may

be categorically excluded from environmental processing pursuant to §1.1306 of the Commission's rules.

**Human Exposure to Radiofrequency Radiation**

In keeping with §1.1307(b) of the Commission's Rules, the proposed operation has been evaluated for human exposure to radiofrequency energy using the procedures outlined by the Federal Communications Commission in FCC OET Bulletin 65 ("OET-65"). OET-65 describes a means of determining whether a proposed facility exceeds the radiofrequency exposure guidelines specified in §1.1310 of the Commission's Rules. Under present Commission policy, a facility may be presumed to comply with the limits in §1.1310 of the Commission's Rules if it satisfies the exposure criteria set forth in OET-65. Based upon that methodology, and as demonstrated in the following, the proposed transmitting system will comply with the cited adopted guidelines.

An effective radiated power ("ERP") of 44 kW, circularly polarized, will be employed, utilizing an ERI model number 1183-4CP-DA-SP 4-bay antenna with a bay spacing of 100 inches, or 0.877 wavelengths at 103.5 MHz. **Figure 2** depicts the vertical (elevation) pattern as provided by the manufacturer[1]. The tabulation for the elevation pattern is provided in one degree increments as **Table I**. The "uncontrolled/general population" limit specified in §1.1310 for FM Channel 203 (88.5 MHz) is 200 μW/cm².

OET-65's formula for FM signal density in this analysis is essentially the same as equation (10) in OET-65:

$$S = (33.4098)(F^2)(ERP) / D^2$$

Where:

| | | |
|---|---|---|
| S | = | power density in microwatts/cm$^2$ |
| ERP | = | total (average) ERP in Watts |
| F | = | relative field factor |
| D | = | distance in meters |

[1] The FCC prefers the use of FM Model to predict the RF exposure of a proposal. In this case, FM Model does not have a choice that includes the type of antenna being proposed. As a worst-case prediction, the default "ring-stub" style antenna exaggerates the downward radiation compared to the data provided by the manufacturer. All other FM Model choices are not appropriate for the type of antenna employed.

Using this formula, the antenna's elevation pattern, and the above assumptions, the proposed facility would contribute a maximum power density of 9.18 μW/cm² at two meters above ground, or 4.59 percent of the general population/uncontrolled MPE limit. **Figure 3** is a graphical depiction of the calculated RF exposure attributable to the instant proposal along radials extending 1,000 meters from the proposed support structure at two meters above ground level. At ground level locations away from the base of the tower, the calculated RF power density is lower, due to the increasing distance from the transmitting antenna. Thus, the proposed facility complies with §1.1307(b) of the Commission's Rules regarding exposure to radiofrequency radiation.

§1.1307(b)(3) states that facilities at locations with multiple transmitters (such as the case at hand) are categorically excluded from responsibility for taking any corrective action in the areas where their contribution is less than five percent. Since the instant situation meets the five percent exclusion test at all ground level areas, the impact of any other facilities using this site may be considered independently from this proposal. Accordingly, it is believed that the impact of the proposed operation should not be considered to be a factor at or near ground level as defined under §1.1307(b).

As demonstrated herein, excessive levels of RF energy attributable to the proposal will not be caused at publicly accessible areas at ground level near the antenna supporting structure. Consequently, members of the general public will not be exposed to RF levels in excess of the Commission's guidelines. Nevertheless, tower site access will continue to be restricted and controlled through the use of a locked fence. Additionally, appropriate RF exposure warning signs will continue to be posted.

## Safety of Tower Workers and the General Public

With respect to worker safety, it is believed that based on the preceding analysis, excessive exposure would not occur in areas at ground level. A site exposure policy will continue to be employed protecting maintenance workers from excessive exposure when work must be performed on the tower in areas where high RF levels may be present. Such protective measures may include, but will not be limited to, restriction of access to areas where levels in excess of the guidelines may be expected, power reduction, or the complete shutdown of facilities when work or inspections

must be performed in areas where the exposure guidelines will be exceeded. On-site RF exposure measurements may also be undertaken to establish the bounds of safe working areas. The applicant will coordinate exposure procedures with all pertinent stations.

Based on the preceding, it is believed that the instant proposal may be categorically excluded from environmental processing under Section 1.1306 of the Rules; hence preparation of an Environmental Assessment is not required.

## Conclusion

It is therefore believed that the proposed facility satisfies all of the pertinent Commission Rules and Policies now in effect.

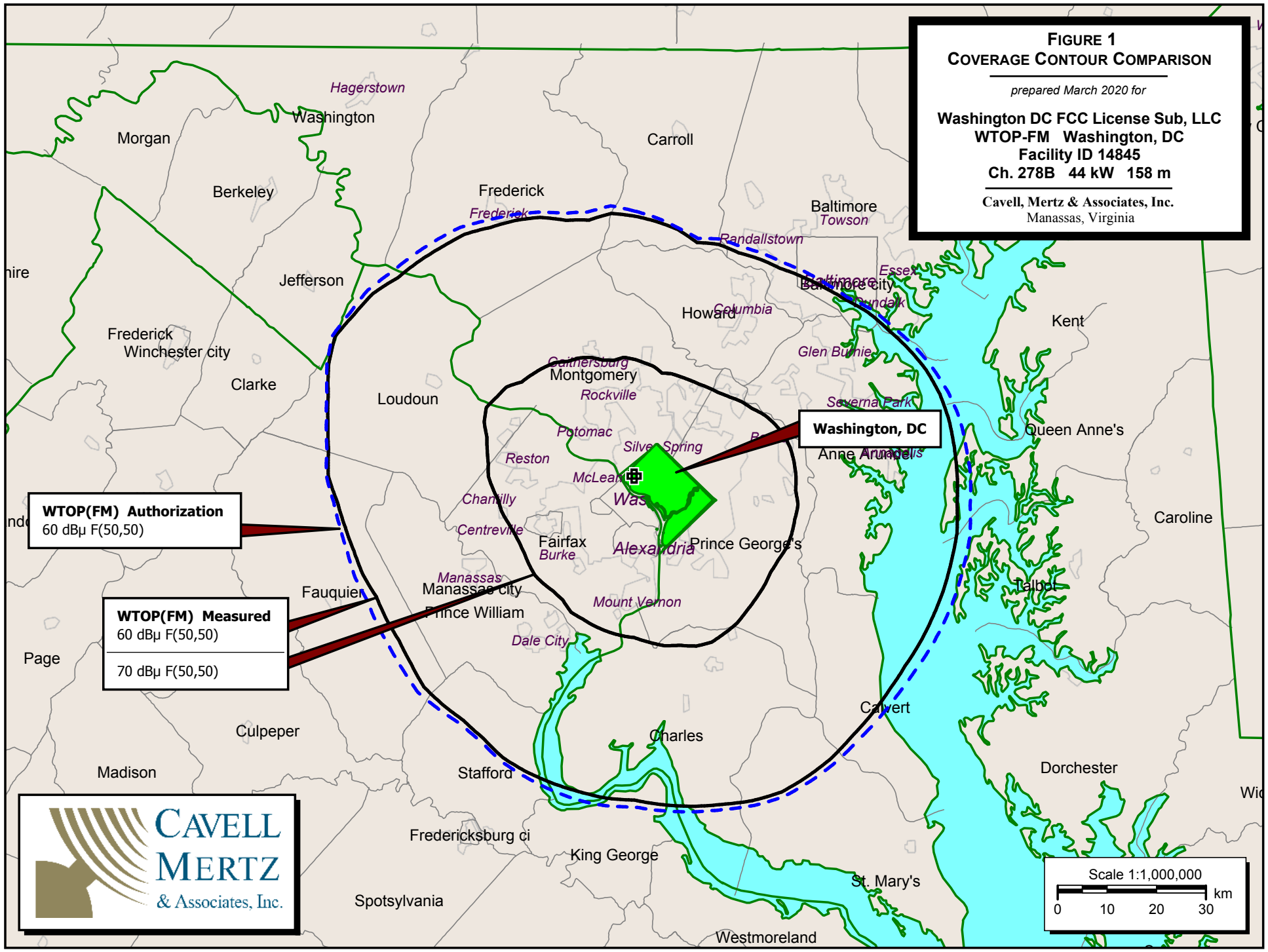


FIGURE 1
COVERAGE CONTOUR COMPARISON
prepared March 2020 for
Washington DC FCC License Sub, LLC
WTOP-FM Washington, DC
Facility ID 14845
Ch. 278B 44 kW 158 m
Cavell, Mertz & Associates, Inc.
Manassas, Virginia
Washington, DC
WTOP(FM) Authorization
60 dBµ F(50,50)
WTOP(FM) Measured
60 dBµ F(50,50)
70 dBµ F(50,50)
CAVELL MERTZ & Associates, Inc.
Scale 1:1,000,000
km
0 10 20 30
Hagerstown
Washington
Morgan
Berkeley
Frederick
Carroll
Baltimore
Towson
Randallstown
Jefferson
Frederick
Winchester city
Clarke
Loudoun
Howard
Columbia
Baltimore city
Kent
Glen Burnie
Gaithersburg
Montgomery
Rockville
Potomac
Silver Spring
Reston
McLean
Chantilly
Centreville
Fairfax
Burke
Alexandria
Prince George's
Anne Arundel
Queen Anne's
Caroline
Talbot
Fauquier
Manassas
Manassas city
Prince William
Mount Vernon
Dale City
Page
Culpeper
Madison
Stafford
Charles
Calvert
Dorchester
Fredericksburg ci
King George
St. Mary's
Spotsylvania
Westmoreland

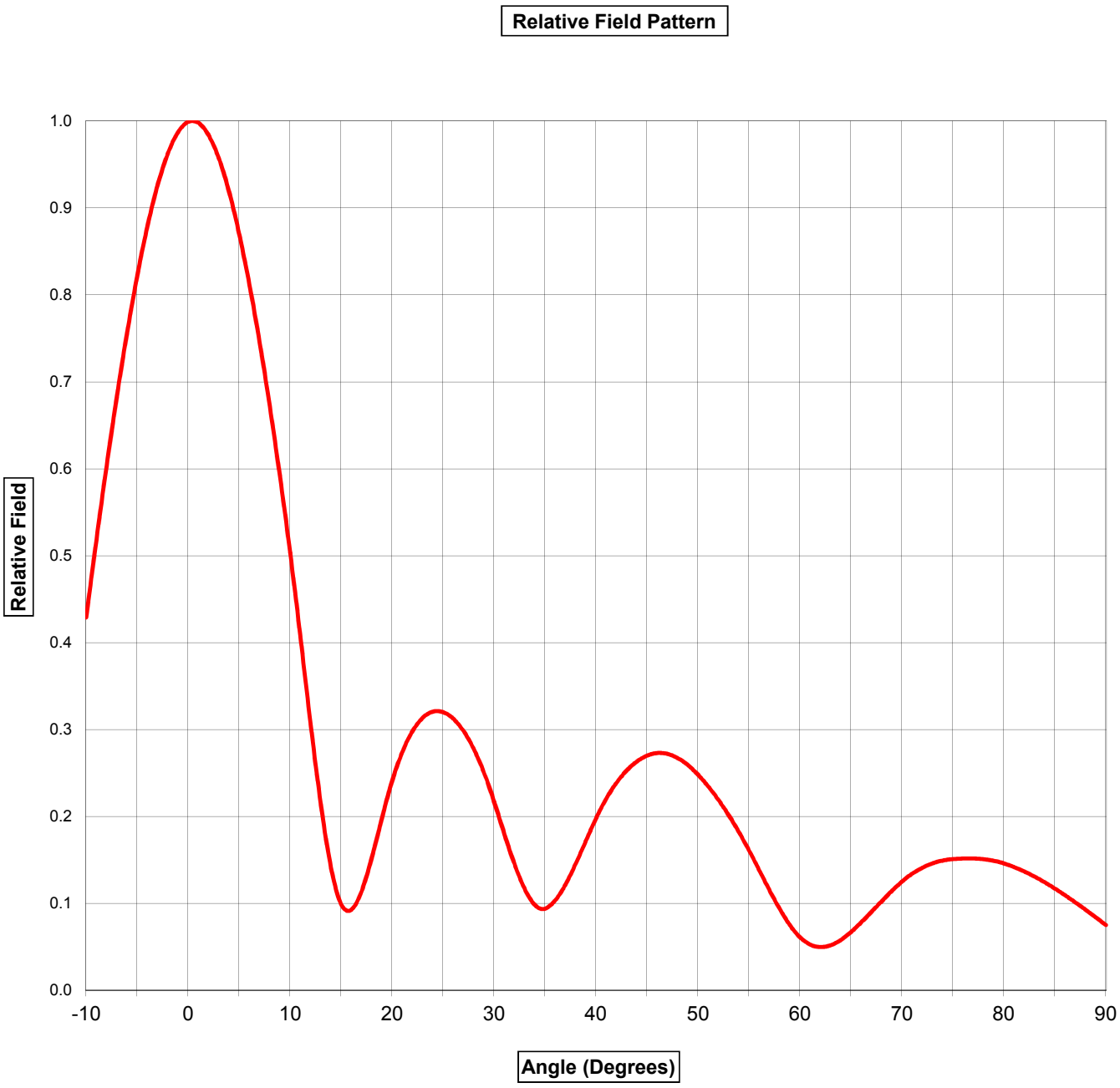



**FIGURE 2**

**ANTENNA VERTICAL (ELEVATION) PLANE RADIATION PATTERN**

prepared March 2020 for

**Washington DC FCC License Sub, LLC**
WTOP-FM Washington, DC
Facility Id 11845
Ch. 278B 44 kW 158 m

**Cavell, Mertz & Associates, Inc.**
Manassas, Virginia

Table I

# ANTENNA ELEVATION PATTERN TABULATION

prepared for

Washington DC FCC License Sub, LLC

WTOP-FM Washington, DC

Facility ID 11845

Ch. 278B 44 kW 158 m

| Angle (deg) | Relative Field | Angle (deg) | Relative Field | Angle (deg) | Relative Field |
|---|---|---|---|---|---|
| -10 | 0.429 | 23 | 0.315 | 57 | 0.119 |
| -9 | 0.516 | 24 | 0.322 | 58 | 0.098 |
| -8 | 0.601 | 25 | 0.320 | 59 | 0.078 |
| -7 | 0.681 | 26 | 0.311 | 60 | 0.061 |
| -6 | 0.756 | 27 | 0.296 | 61 | 0.047 |
| -5 | 0.822 | 28 | 0.274 | 62 | 0.041 |
| -4 | 0.880 | 29 | 0.247 | 63 | 0.045 |
| -3 | 0.927 | 30 | 0.217 | 64 | 0.055 |
| -2 | 0.963 | 31 | 0.185 | 65 | 0.067 |
| -1 | 0.987 | 32 | 0.152 | 66 | 0.080 |
| 0 | 0.999 | 33 | 0.123 | 67 | 0.093 |
| **0.4** | **1.000** | 34 | 0.101 | 68 | 0.105 |
| 1 | 0.998 | 35 | 0.094 | 69 | 0.116 |
| 2 | 0.984 | 36 | 0.102 | 70 | 0.125 |
| 3 | 0.957 | 37 | 0.123 | 71 | 0.133 |
| 4 | 0.919 | 38 | 0.148 | 72 | 0.139 |
| 5 | 0.870 | 39 | 0.174 | 73 | 0.145 |
| 6 | 0.811 | 40 | 0.198 | 74 | 0.148 |
| 7 | 0.743 | 41 | 0.220 | 75 | 0.151 |
| 8 | 0.668 | 42 | 0.238 | 76 | 0.152 |
| 9 | 0.588 | 43 | 0.253 | 77 | 0.152 |
| 10 | 0.503 | 44 | 0.264 | 78 | 0.151 |
| 11 | 0.417 | 45 | 0.270 | 79 | 0.149 |
| 12 | 0.331 | 46 | 0.273 | 80 | 0.146 |
| 13 | 0.246 | 47 | 0.272 | 81 | 0.141 |
| 14 | 0.167 | 48 | 0.267 | 82 | 0.136 |
| 15 | 0.099 | 49 | 0.259 | 83 | 0.131 |
| 16 | 0.070 | 50 | 0.248 | 84 | 0.124 |
| 17 | 0.101 | 51 | 0.235 | 85 | 0.117 |
| 18 | 0.151 | 52 | 0.219 | 86 | 0.110 |
| 19 | 0.199 | 53 | 0.201 | 87 | 0.102 |
| 20 | 0.241 | 54 | 0.182 | 88 | 0.093 |
| 21 | 0.274 | 55 | 0.161 | 89 | 0.084 |
| 22 | 0.299 | 56 | 0.140 | 90 | 0.075 |

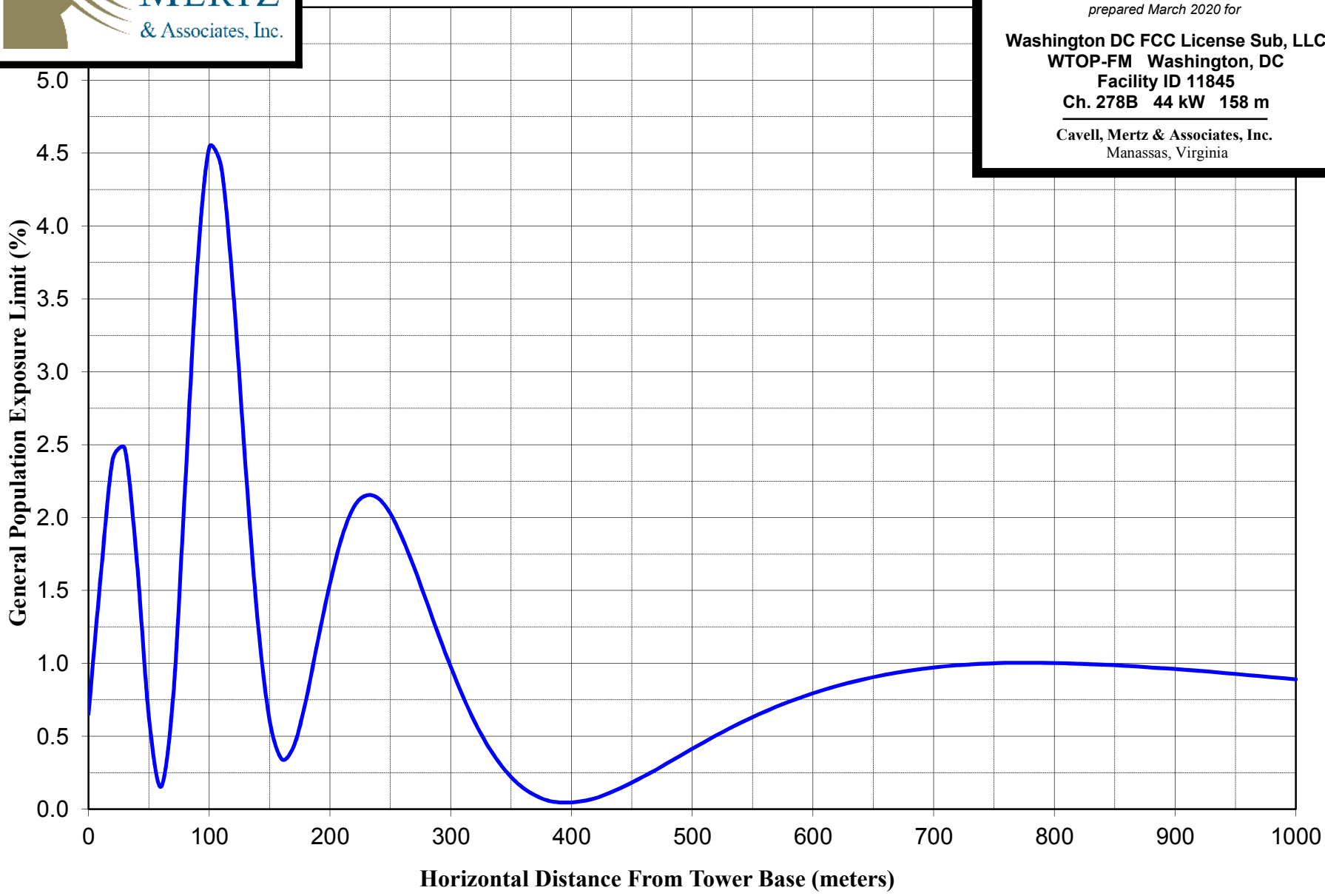
CAVELL MERTZ & Associates, Inc.

**FIGURE 3**
**RF EXPOSURE CALCULATION**

*prepared March 2020 for*

**Washington DC FCC License Sub, LLC**
**WTOP-FM Washington, DC**
**Facility ID 11845**
**Ch. 278B 44 kW 158 m**

**Cavell, Mertz & Associates, Inc.**
Manassas, Virginia



**Attachment I**

# Antenna System Proof-of-Performance

**APPLICATION FOR STATION LICENSE**
**Supporting Antenna Replacement for FCC License BMLH-20110215ABQ**
**WTOP-FM Washington, District of Columbia (Facility ID 11845)**

ELECTRONICS RESEARCH, INC. ERI®

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone (812) 925-6000 Fax (812) 925-4030 http://www.eriinc.com/

# *Directional Antenna System for WTOP, Washington, DC*

February 25, 2019

Electronics Research Inc. is providing a custom fabricated multiplexed antenna system that is specially designed to meet the FCC requirements and the general needs of radio station WTOP.

The antenna is the ERI model 1183-4CP-DA-SP configuration. The circular polarized system consists of four 100 inch spaced bays using one driven circular polarized radiating element per bay. The antenna was tested on a 20" o.d. pole, which is the structure the station plans to use to support the array. All tests were performed on a frequency of 103.5 megahertz, which is the center of the FM broadcast channel assigned to WTOP. The design of the system will include five additional stations WAMU 88.5 MHZ, WPFW 89.3 MHz, WETA 90.9 MHz, WWMJ 102.3 MHz and WTOP Aux 103.5 MHz inserted into the fourth port of the hybrid at each element.

Pattern measurements were made on a sixty-acre antenna pattern range that is owned and operated by Electronics Research, Inc. The tests were performed under the direction of Thomas B. Silliman, president of Electronics Research, Inc. Mr. Silliman has the Bachelor of Electrical Engineering and the Master of Electrical Engineering degrees from Cornell University and is a registered professional engineer in the states of Indiana, Maryland and Minnesota.

# Directional Antenna System
# For
# WTOP, Washington, DC

(Continued)

## DESCRIPTION OF THE TEST PROCEDURE

The test antenna consisted of one bay level of the circular polarized system. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. The lines were properly grounded during all tests.

The power distribution and phase relationship to the antenna elements was adjusted in order to achieve the directional radiation patterns for both horizontal and vertical polarization components.

The proof-of-performance was accomplished using a 20" o.d. pole with identical dimension and configuration including all braces, ladders, conduits, coaxial lines and other appurtenances that are included in the actual aperture at which the antenna will be installed. The structure was erected vertically on a turntable mounted on a non-metallic building with the antenna centered vertically on the structure, making the center of radiation of the test approximately 30 feet above ground. The turntable is equipped with a motor drive and a US Digital angle position indicator. The resolution of this angle position indicator is one-hundredth of a degree.

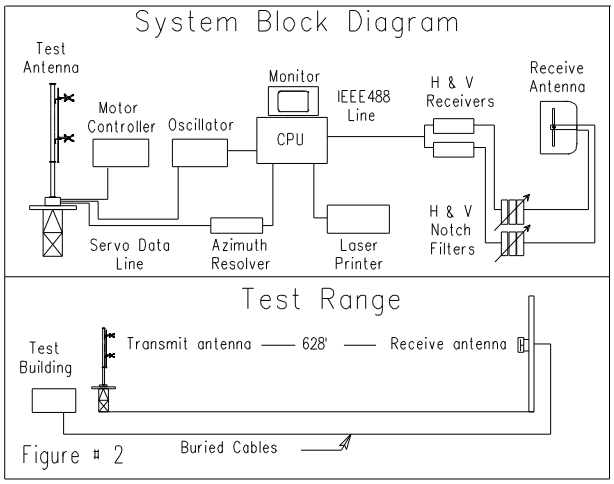


Figure # 2

The antenna under test was operated in the transmitting mode and fed from a HP8657D signal generator. The frequency of the signal source was set at 103.5 MHz and was constantly monitored by a Rohde & Schwarz ESVD measuring receiver.

A broadband horizontal and vertical dipole system, located approximately 628 feet from the test antenna, was used to receive the emitted test signals. The dipole system was mounted at the same height above terrain as the center of the antenna under test.

The signals received by the dipole system were fed to the test building by way of two buried Heliax cables to a Rohde & Schwarz measuring receiver. This data was interfaced to a laser jet printer by means of a computer system. Relative field strength was plotted as a function of azimuth.

The measurements were performed by rotating the test antenna in a counter-clockwise direction and plotting the received signal on polar co-ordinated graph paper in a clockwise direction. Both horizontal and vertical components were recorded separately.

## CONCLUSIONS

The circular polarized system consists of four 100 inch spaced bays using three driven circular polarized radiating element per bay. The power distribution and phase relationship will be fixed when the antenna is manufactured. Proper maintenance of the elements should be all that is required to maintain the pattern in adjustment.

The 1183-4CP-DA-SP array is to be mounted on the 20" o.d. pole at a bearing of North 30 degrees East. Blue prints provided with the antenna will show the proper antenna orientation alignment. The antenna alignment procedure should be directed by a licensed surveyor as prescribed by the FCC.

Figure #1 represents the measured individual horizontal and vertical components, the composite maximum of either the horizontal or vertical component at any azimuth and the FCC filed envelope pattern. The horizontal plane relative field list for the composite pattern and the individual H & V components are shown as Figure #1 & 1A respectively. The actual measured pattern does not exceed the authorized FCC composite pattern at any azimuth. A calculated vertical plane relative field pattern is shown on Figure #3 attached. The power in the maximum will reach 44 kilowatts (16.435 dBk).

The power at North 10 degrees East does not exceed 14.5 kilowatts (11.614 dBk).

# Directional Antenna System
# For
# WTOP, Washington, DC

(Continued)

The RMS of the vertically polarized horizontal plane component does not exceed the RMS of the horizontally polarized horizontal plane component.

The composite horizontal and vertical maximum relative field pattern obtained from the measured data as shown on Figure #1 has an RMS that is greater that 85% of the filed composite pattern.

The clear vertical length of the structure required to support the antenna is 45 feet if the antenna is to be top mounted.

The directional antenna should not be mounted on the top of an antenna tower that includes a top-mounted platform larger than the cross-sectional area of the tower in the horizontal plane. No obstructions other than those that are specified by the blue prints supplied with the antenna are to be mounted within 75 ft. horizontally of the system.

The vertical distance to the nearest obstruction should be a minimum of 10 ft. from the directional antenna. Metallic guy wires should be a minimum distance of forty feet horizontally from the antenna.

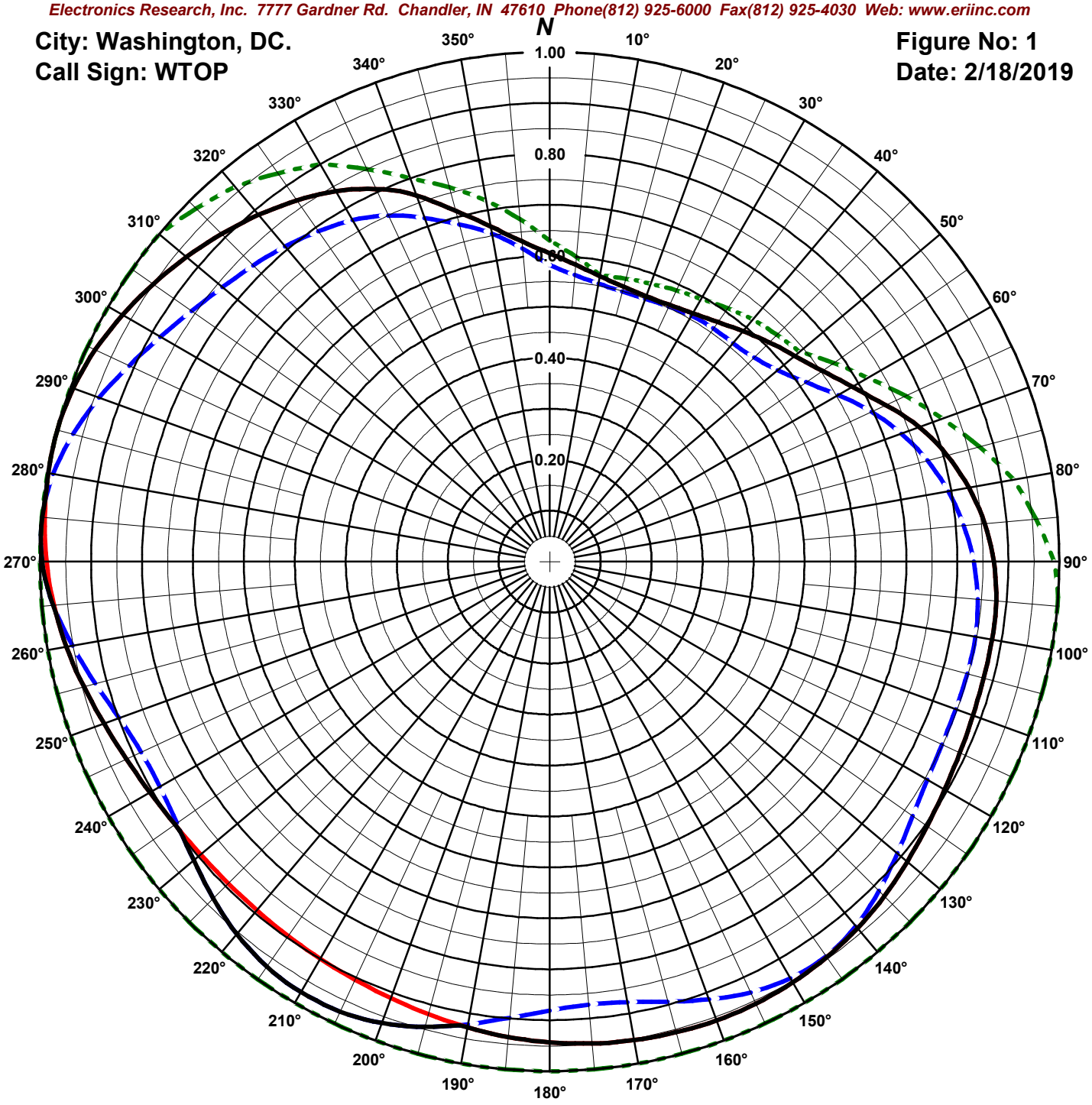
ELECTRONICS RESEARCH, INC.

# ERI® Horizontal Plane Relative Field Pattern

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone(812) 925-6000 Fax(812) 925-4030 Web: www.eriinc.com

**City: Washington, DC.**
**Call Sign: WTOP**

**Figure No: 1**
**Date: 2/18/2019**




**Antenna Orientation: 30° True**

**Frequency: 103.5 MHz**
**Antenna Type: 1183-4CP-DA-SP**

**Antenna Mounting: Cogwheel**
**Tower Type: 20" Pole**

| HORIZONTAL | VERTICAL | COMPOSITE | FCC ENVELOPE |
|---|---|---|---|
| RMS: .854 | RMS: .83 | RMS: .861 | RMS: .915 |
| Maximum: 1 @ 283° | Maximum: 1 @ 274° | Maximum: 1 @ 274° | Maximum: 1 @ 94° |
| Minimum: .554 @ 21° | Minimum: .548 @ 17° | Minimum: .554 @ 21° | Minimum: .57 @ 10° |

**Measured patterns of the horizontal and vertical components. The composite pattern shows the maximum of either the H or V azimuth values. This patterns is greater than 85% of the FCC filed composite pattern BMLH-20110215ABQ.**

# ERI® Horizontal Plane Relative Field Pattern

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone(812) 925-6000 Fax(812) 925-4030 Web: www.eriinc.com

**Figure# 1** **Date: 2/18/2019**
**Station: WTOP** **Antenna: 1183-4CP-DA-SP**
**Location: Washington, DC.** **Antenna Orientation: 30° True**
**Frequency: 103.5 MHz** **Number of Bays: 4**

| Azimuth | Envelope | | | Polarization | Azimuth | Envelope | | | Polarization |
|---|---|---|---|---|---|---|---|---|---|
| | Field | kW | dBk | Maximum | | Field | kW | dBk | Maximum |
| 0° | 0.605 | 16.084 | 12.064 | Horizontal | 180° | 0.943 | 39.166 | 15.929 | Horizontal |
| 5° | 0.585 | 15.059 | 11.778 | Horizontal | 185° | 0.936 | 38.583 | 15.864 | Horizontal |
| 10° | 0.569 | 14.225 | 11.530 | Horizontal | 190° | 0.928 | 37.896 | 15.786 | Horizontal |
| 15° | 0.558 | 13.722 | 11.374 | Horizontal | 195° | 0.945 | 39.308 | 15.945 | Vertical |
| 20° | 0.554 | 13.516 | 11.308 | Horizontal | 200° | 0.963 | 40.844 | 16.111 | Vertical |
| 25° | 0.556 | 13.593 | 11.333 | Horizontal | 205° | 0.974 | 41.728 | 16.204 | Vertical |
| 30° | 0.563 | 13.923 | 11.437 | Horizontal | 210° | 0.975 | 41.858 | 16.218 | Vertical |
| 35° | 0.574 | 14.501 | 11.614 | Horizontal | 215° | 0.969 | 41.341 | 16.164 | Vertical |
| 40° | 0.590 | 15.325 | 11.854 | Horizontal | 220° | 0.954 | 40.079 | 16.029 | Vertical |
| 45° | 0.609 | 16.298 | 12.121 | Horizontal | 225° | 0.934 | 38.376 | 15.841 | Vertical |
| 50° | 0.628 | 17.372 | 12.399 | Horizontal | 230° | 0.912 | 36.569 | 15.631 | Vertical |
| 55° | 0.653 | 18.744 | 12.729 | Horizontal | 235° | 0.898 | 35.507 | 15.503 | Horizontal |
| 60° | 0.686 | 20.710 | 13.162 | Horizontal | 240° | 0.906 | 36.101 | 15.575 | Horizontal |
| 65° | 0.727 | 23.237 | 13.662 | Horizontal | 245° | 0.916 | 36.951 | 15.676 | Horizontal |
| 70° | 0.772 | 26.210 | 14.185 | Horizontal | 250° | 0.930 | 38.066 | 15.805 | Horizontal |
| 75° | 0.807 | 28.661 | 14.573 | Horizontal | 255° | 0.947 | 39.427 | 15.958 | Horizontal |
| 80° | 0.835 | 30.696 | 14.871 | Horizontal | 260° | 0.963 | 40.793 | 16.106 | Horizontal |
| 85° | 0.857 | 32.293 | 15.091 | Horizontal | 265° | 0.978 | 42.085 | 16.241 | Vertical |
| 90° | 0.871 | 33.414 | 15.239 | Horizontal | 270° | 0.996 | 43.645 | 16.399 | Vertical |
| 95° | 0.879 | 34.033 | 15.319 | Horizontal | 275° | 0.999 | 43.955 | 16.430 | Vertical |
| 100° | 0.881 | 34.182 | 15.338 | Horizontal | 280° | 0.999 | 43.911 | 16.426 | Horizontal |
| 105° | 0.882 | 34.202 | 15.341 | Horizontal | 285° | 1.000 | 43.976 | 16.432 | Horizontal |
| 110° | 0.884 | 34.358 | 15.360 | Horizontal | 290° | 0.995 | 43.531 | 16.388 | Horizontal |
| 115° | 0.888 | 34.702 | 15.404 | Horizontal | 295° | 0.984 | 42.569 | 16.291 | Horizontal |
| 120° | 0.895 | 35.240 | 15.470 | Horizontal | 300° | 0.968 | 41.218 | 16.151 | Horizontal |
| 125° | 0.904 | 35.977 | 15.560 | Horizontal | 305° | 0.950 | 39.672 | 15.985 | Horizontal |
| 130° | 0.916 | 36.919 | 15.673 | Horizontal | 310° | 0.930 | 38.049 | 15.803 | Horizontal |
| 135° | 0.929 | 37.947 | 15.792 | Horizontal | 315° | 0.910 | 36.405 | 15.612 | Horizontal |
| 140° | 0.939 | 38.830 | 15.892 | Horizontal | 320° | 0.888 | 34.719 | 15.406 | Horizontal |
| 145° | 0.948 | 39.522 | 15.968 | Horizontal | 325° | 0.865 | 32.925 | 15.175 | Horizontal |
| 150° | 0.954 | 40.014 | 16.022 | Horizontal | 330° | 0.839 | 30.993 | 14.913 | Horizontal |
| 155° | 0.957 | 40.302 | 16.053 | Horizontal | 335° | 0.807 | 28.642 | 14.570 | Horizontal |
| 160° | 0.958 | 40.375 | 16.061 | Horizontal | 340° | 0.765 | 25.723 | 14.103 | Horizontal |
| 165° | 0.956 | 40.253 | 16.048 | Horizontal | 345° | 0.713 | 22.337 | 13.490 | Horizontal |
| 170° | 0.954 | 40.004 | 16.021 | Horizontal | 350° | 0.668 | 19.631 | 12.929 | Horizontal |
| 175° | 0.949 | 39.641 | 15.981 | Horizontal | 355° | 0.631 | 17.514 | 12.434 | Horizontal |

**Horizontal Polarization:**
**Maximum: 2.651 (4.233 dB)**
**Horizontal Plane: 2.645 (4.224 dB)**
**Maximum ERP: 44.000 kW**

**Vertical Polarization:**
**Maximum: 2.651 (4.233 dB)**
**Horizontal Plane: 2.645 (4.224 dB)**
**Maximum ERP: 44.000 kW**

**Total Input Power: 16.600 kW**
**Reference: WTOP1M.FIG**
**This list shows the the maximum azimuth values of either the horizontal or vertical components.**

# ERI® Horizontal Plane Relative Field Pattern

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone(812) 925-6000 Fax(812) 925-4030 Web: www.eriinc.com

**Figure# 1A** **Date: 2/18/2019**
**Station: WTOP** **Antenna: 1183-4CP-DA-SP**
**Location: Washington, DC.** **Antenna Orientation: 30° True**
**Frequency: 103.5 MHz** **Number of Bays: 4**

| Azimuth | Horizontal | | | Vertical | | | Azimuth | Horizontal | | | Vertical | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Field | kW | dBk | Field | kW | dBk | | Field | kW | dBk | Field | kW | dBk |
| 0° | 0.605 | 16.084 | 12.064 | 0.582 | 14.923 | 11.739 | 180° | 0.943 | 39.166 | 15.929 | 0.881 | 34.133 | 15.332 |
| 5° | 0.585 | 15.059 | 11.778 | 0.564 | 14.021 | 11.468 | 185° | 0.936 | 38.583 | 15.864 | 0.899 | 35.524 | 15.505 |
| 10° | 0.569 | 14.225 | 11.530 | 0.554 | 13.506 | 11.305 | 190° | 0.928 | 37.896 | 15.786 | 0.922 | 37.383 | 15.727 |
| 15° | 0.558 | 13.722 | 11.374 | 0.549 | 13.255 | 11.224 | 195° | 0.919 | 37.184 | 15.704 | 0.945 | 39.308 | 15.945 |
| 20° | 0.554 | 13.516 | 11.308 | 0.549 | 13.252 | 11.223 | 200° | 0.911 | 36.554 | 15.629 | 0.963 | 40.844 | 16.111 |
| 25° | 0.556 | 13.593 | 11.333 | 0.552 | 13.418 | 11.277 | 205° | 0.905 | 36.034 | 15.567 | 0.974 | 41.728 | 16.204 |
| 30° | 0.563 | 13.923 | 11.437 | 0.557 | 13.639 | 11.348 | 210° | 0.900 | 35.625 | 15.518 | 0.975 | 41.858 | 16.218 |
| 35° | 0.574 | 14.501 | 11.614 | 0.559 | 13.749 | 11.383 | 215° | 0.896 | 35.324 | 15.481 | 0.969 | 41.341 | 16.164 |
| 40° | 0.590 | 15.325 | 11.854 | 0.560 | 13.776 | 11.391 | 220° | 0.894 | 35.132 | 15.457 | 0.954 | 40.079 | 16.029 |
| 45° | 0.609 | 16.298 | 12.121 | 0.567 | 14.129 | 11.501 | 225° | 0.893 | 35.054 | 15.447 | 0.934 | 38.376 | 15.841 |
| 50° | 0.628 | 17.372 | 12.399 | 0.585 | 15.042 | 11.773 | 230° | 0.894 | 35.162 | 15.461 | 0.912 | 36.569 | 15.631 |
| 55° | 0.653 | 18.744 | 12.729 | 0.614 | 16.583 | 12.197 | 235° | 0.898 | 35.507 | 15.503 | 0.893 | 35.126 | 15.456 |
| 60° | 0.686 | 20.710 | 13.162 | 0.654 | 18.817 | 12.745 | 240° | 0.906 | 36.101 | 15.575 | 0.883 | 34.331 | 15.357 |
| 65° | 0.727 | 23.237 | 13.662 | 0.696 | 21.344 | 13.293 | 245° | 0.916 | 36.951 | 15.676 | 0.884 | 34.418 | 15.368 |
| 70° | 0.772 | 26.210 | 14.185 | 0.734 | 23.731 | 13.753 | 250° | 0.930 | 38.066 | 15.805 | 0.899 | 35.558 | 15.509 |
| 75° | 0.807 | 28.661 | 14.573 | 0.767 | 25.881 | 14.130 | 255° | 0.947 | 39.427 | 15.958 | 0.923 | 37.488 | 15.739 |
| 80° | 0.835 | 30.696 | 14.871 | 0.794 | 27.744 | 14.432 | 260° | 0.963 | 40.793 | 16.106 | 0.951 | 39.786 | 15.997 |
| 85° | 0.857 | 32.293 | 15.091 | 0.816 | 29.281 | 14.666 | 265° | 0.977 | 41.959 | 16.228 | 0.978 | 42.085 | 16.241 |
| 90° | 0.871 | 33.414 | 15.239 | 0.832 | 30.461 | 14.837 | 270° | 0.987 | 42.875 | 16.322 | 0.996 | 43.645 | 16.399 |
| 95° | 0.879 | 34.033 | 15.319 | 0.843 | 31.261 | 14.950 | 275° | 0.995 | 43.528 | 16.388 | 0.999 | 43.955 | 16.430 |
| 100° | 0.881 | 34.182 | 15.338 | 0.848 | 31.664 | 15.006 | 280° | 0.999 | 43.911 | 16.426 | 0.989 | 43.041 | 16.339 |
| 105° | 0.882 | 34.202 | 15.341 | 0.848 | 31.660 | 15.005 | 285° | 1.000 | 43.976 | 16.432 | 0.968 | 41.199 | 16.149 |
| 110° | 0.884 | 34.358 | 15.360 | 0.848 | 31.609 | 14.998 | 290° | 0.995 | 43.531 | 16.388 | 0.940 | 38.914 | 15.901 |
| 115° | 0.888 | 34.702 | 15.404 | 0.849 | 31.739 | 15.016 | 295° | 0.984 | 42.569 | 16.291 | 0.910 | 36.454 | 15.617 |
| 120° | 0.895 | 35.240 | 15.470 | 0.856 | 32.213 | 15.080 | 300° | 0.968 | 41.218 | 16.151 | 0.882 | 34.218 | 15.343 |
| 125° | 0.904 | 35.977 | 15.560 | 0.870 | 33.288 | 15.223 | 305° | 0.950 | 39.672 | 15.985 | 0.858 | 32.374 | 15.102 |
| 130° | 0.916 | 36.919 | 15.673 | 0.890 | 34.889 | 15.427 | 310° | 0.930 | 38.049 | 15.803 | 0.838 | 30.887 | 14.898 |
| 135° | 0.929 | 37.947 | 15.792 | 0.914 | 36.738 | 15.651 | 315° | 0.910 | 36.405 | 15.612 | 0.822 | 29.743 | 14.734 |
| 140° | 0.939 | 38.830 | 15.892 | 0.934 | 38.395 | 15.843 | 320° | 0.888 | 34.719 | 15.406 | 0.807 | 28.679 | 14.576 |
| 145° | 0.948 | 39.522 | 15.968 | 0.946 | 39.340 | 15.948 | 325° | 0.865 | 32.925 | 15.175 | 0.791 | 27.538 | 14.399 |
| 150° | 0.954 | 40.014 | 16.022 | 0.944 | 39.211 | 15.934 | 330° | 0.839 | 30.993 | 14.913 | 0.773 | 26.313 | 14.202 |
| 155° | 0.957 | 40.302 | 16.053 | 0.933 | 38.297 | 15.832 | 335° | 0.807 | 28.642 | 14.570 | 0.749 | 24.710 | 13.929 |
| 160° | 0.958 | 40.375 | 16.061 | 0.914 | 36.775 | 15.656 | 340° | 0.765 | 25.723 | 14.103 | 0.718 | 22.652 | 13.551 |
| 165° | 0.956 | 40.253 | 16.048 | 0.894 | 35.158 | 15.460 | 345° | 0.713 | 22.337 | 13.490 | 0.685 | 20.648 | 13.149 |
| 170° | 0.954 | 40.004 | 16.021 | 0.878 | 33.908 | 15.303 | 350° | 0.668 | 19.631 | 12.929 | 0.653 | 18.782 | 12.737 |
| 175° | 0.949 | 39.641 | 15.981 | 0.873 | 33.530 | 15.254 | 355° | 0.631 | 17.514 | 12.434 | 0.617 | 16.737 | 12.237 |

**Horizontal Polarization:**
**Maximum: 2.651 (4.233 dB)**
**Horizontal Plane: 2.645 (4.224 dB)**
**Maximum ERP: 44.000 kW**

**Vertical Polarization:**
**Maximum: 2.651 (4.233 dB)**
**Horizontal Plane: 2.645 (4.224 dB)**
**Maximum ERP: 44.000 kW**

**Total Input Power: 16.600 kW**
**Reference: WTOP1M.FIG**
**This list shows the azimuth values for the horizontal and vertical components.**

Electronics Research, Inc.
7777 Gardner Road
Chandler, In. 47610

Figure 4

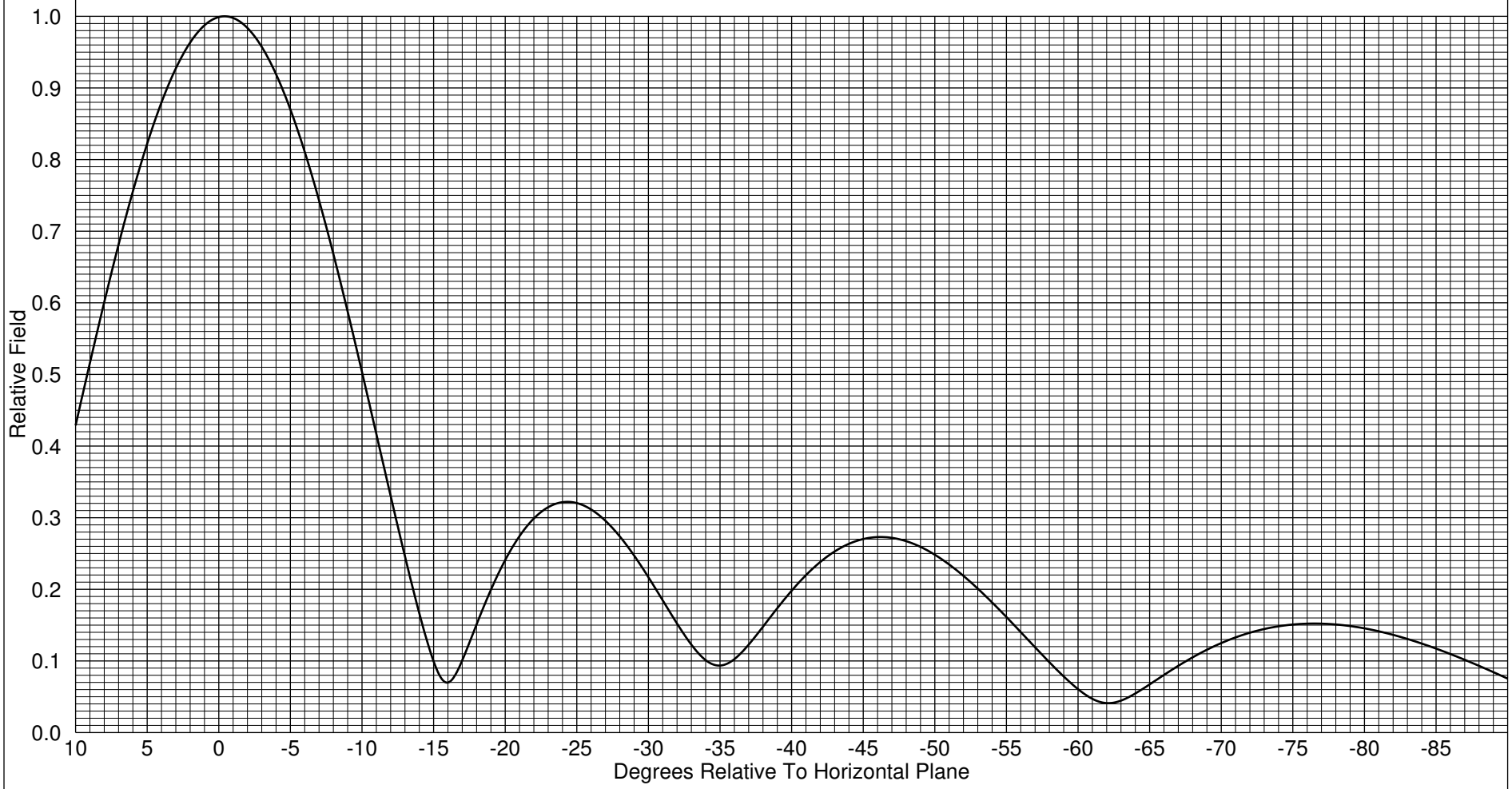
----Theoretical----

Vertical Plane Relative Field
4 ERI Type 1180 Elements
-0.41 Degree(s) Electrical Beam Tilt
6.9 Percent First Null Fill
9.1 Percent Second Null Fill

12/24/2018 11:23:25 AM

103.5 MHz

Element Spacing:
100 Inches



# Directional Antenna System
# for
# WTOP, Washington, DC

(Continued)

## ANTENNA SPECIFICATIONS

| | |
|---|---|
| Antenna Type: | 1183-4CP-DA-SP |
| Frequency: | 103.5 MHz |
| Number of Bays: | Four |

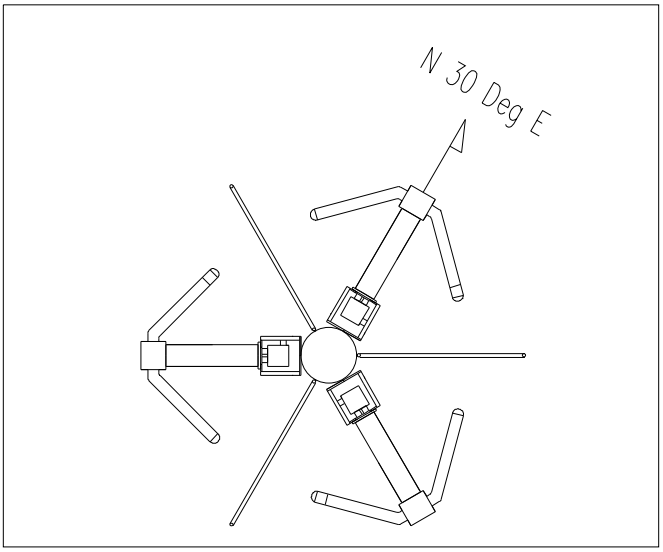
## MECHANICAL SPECIFICATIONS

| | |
|---|---|
| Mounting: | Custom |
| System length: | 33 ft 4 in |
| Aperture length required: | 45 |
| Orientation: | 30° true |

Input flange to the antenna 3 1/8" female.

## ELECTRICAL SPECIFICATIONS
(For directional use)

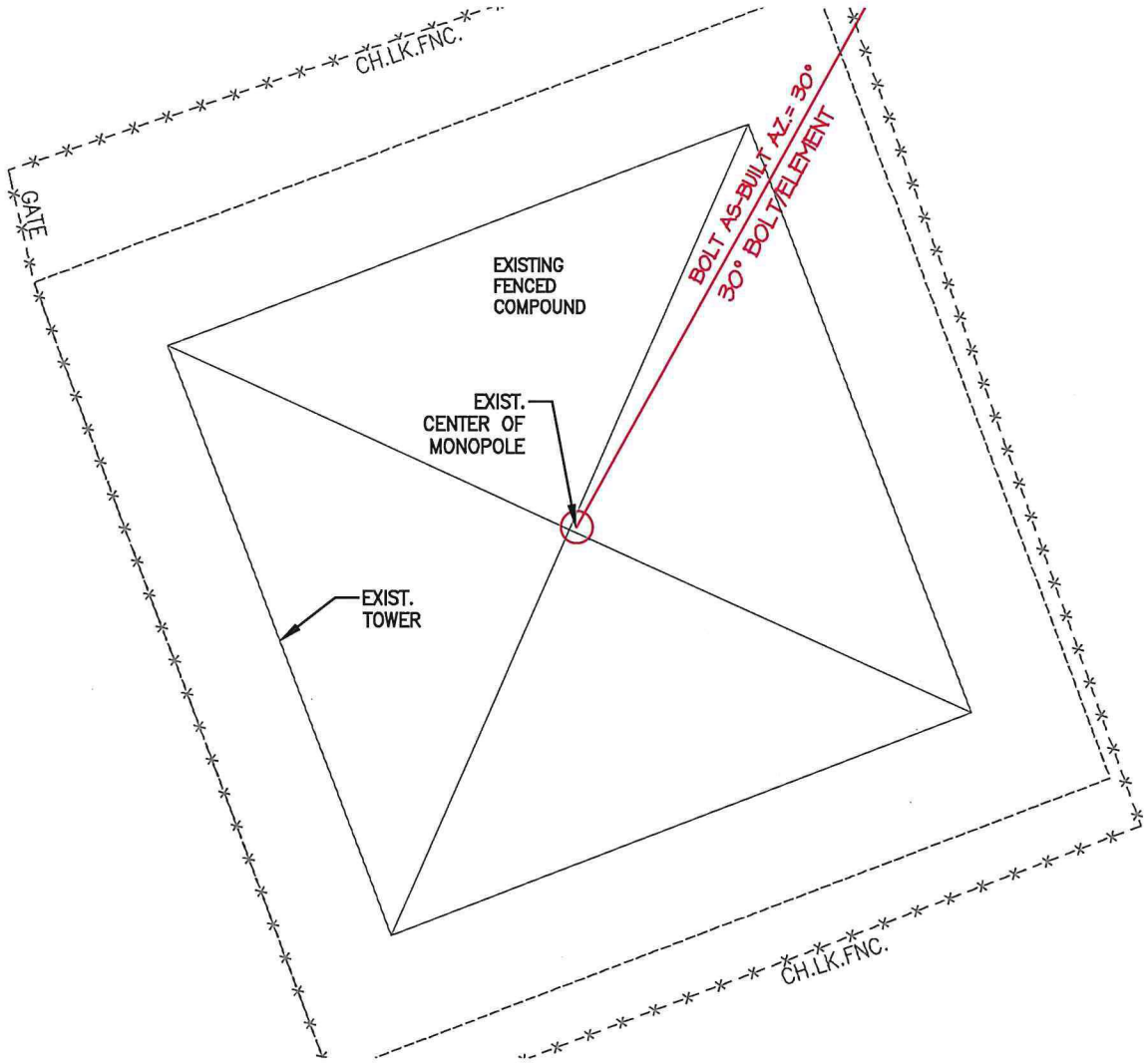
| | |
|---|---|
| Maximum horizontal ERP: | 44.000 kW (16.435 dBk) |
| Horizontal maximum power gain: | 2.651 (4.233 dB) |
| Horizontal H Plane power gain: | 2.645 (4.224 dB) |
| Maximum vertical ERP: | 44.000 kW (16.435 dBk) |
| Vertical maximum power gain: | 2.651 (4.233 dB) |
| Vertical H plane power gain: | 2.645 (4.224 dB) |
| Total input power: | 16.600 kW (12.201 dBk) |



**Attachment II**

# Antenna Orientation – Land Surveyor's Report

**APPLICATION FOR STATION LICENSE**
**Supporting Antenna Replacement for FCC License BMLH-20110215ABQ**
**WTOP-FM Washington, District of Columbia (Facility ID 11845)**




I hereby certify that I was in responsible charge of the preparation of this Antenna Azimuth As-Built and the surveying work reflected in it. The As-built Azimuth of 30° shown heron is accurate to within +/- 2° and was field located from ground control established by GPS observation based on the North American Datum of 1983 (NAD 83/91) by Morris & Ritchie Associates, Inc. on 3/14/2020.

DISTRICT OF COLUMBIA
KENNETH L. EVANS JR.
LS905836
LICENSED
LAND SURVEYOR

Surveyor Signature/Seal: _____ (SEAL)
Printed Name: Kenneth L. Evans Jr.
Professional Surveyor #: D.C. Land Surveyor No. LS905836
Company: Morris & Ritchie Associates, Inc.
Phone: 410-792-9792
Date: March 17, 2020

# WTOP ANTENNA AZIMUTH AS-BUILT

AMERICAN UNIVERSITY
WAMU RADIO
4400 MASSACHUSETTS AVENUE, NW
WASHINGTON, D.C. 20016-8163

MRA
MORRIS & RITCHIE ASSOCIATES, INC.
ENGINEERS, PLANNERS, SURVEYORS, AND LANDSCAPE ARCHITECTS
14280 Park Center Drive, Suite A
Laurel, MD 20707
(410)792-9792
Fax: (410)792-7395

SCALE: 1"=20' DRAWN BY: SAS
DATE: 3/17/2020 CHECKED BY: KLE
JOB NO. 19764 PLAT NO.: 1 OF 1

**Attachment III**

# Engineer's Certification

**APPLICATION FOR STATION LICENSE**
**Supporting Antenna Replacement for FCC License BMLH-20110215ABQ**
**WTOP-FM Washington, District of Columbia (Facility ID 11845)**

Washington DC FCC License Sub, LLC
WTOP-FM
3415 University Avenue, West
St. Paul, MN 55114

**Engineer's Certification**

I, David C Garner do hereby certify that I oversaw the installation and survey of the WTOP-FM directional antenna referenced in the instant application. I have also recently inspected the combiner/filter installation specific to the directional WTOP-FM operation. I certify that the antenna and filter system is installed in compliance with all manufacturers' instructions and according to good engineering practice.

I further certify that I am an experienced broadcast engineer with 40+ years' experience in the field. I am the VP of Engineering for Hubbard Radio (WTOP-FM).

Signed this 17th day of March, 2020

David C Garner
5425 Wisconsin Ave, Chevy Chase, MD 20815
dgarner@wtop.com

**Attachment IV**

# Spurious Emissions / Intermodulation Products Report

**APPLICATION FOR STATION LICENSE**
**Supporting Antenna Replacement for FCC License BMLH-20110215ABQ**
**WTOP-FM Washington, District of Columbia (Facility ID 11845)**

ELECTRONICS RESEARCH, INC. ERI

# Report Of

# Intermodulation Product Findings

## Washington, D.C.
## ERI Antenna: 1183-4CP-DA-SP

**WTOP 103.5 MHz.**

*March 5, 2020*

**Electronics Research Inc.**
**7777 Gardner Road**
**Chandler, Indiana 47610**
**Phone (812) 925-6000 Fax (812) 925- 4030**

# TABLE OF CONTENTS

**Washington, D.C.**

## Report of Findings for Intermodulation Product Measurements



## Exhibits Accompanying This Report

# REPORT OF FINDINGS
# WTOP
103.5 MHz.

**Introduction:** This report of findings is based on data collected at the WTOP broadcast facility located in Washington, D.C. The report includes measurements offered as proof that the operations of WTOP (103.5 MHz.), transmitter is in compliance with the FCC Rules and Regulations as required by the Code of Federal Regulations (CFR) Title 47 section 73.317 paragraph (b) through (d). In brief, the collection of measurements presented in this report shows that all possible third order inter-modulation (IM) products generated by this system are less than the maximum allowable level as required by section 73.317 (b) through (d). WAMU (88.5 MHz), WPFW (89.3 MHz.), WETA (90.0 MHz.), operates into the right slant of the antenna while WTOP (103.5 MHz.), operates into the left slant of the antenna on the tower. WMMJ (102.3 MHz.) and WPGC (95.5 MHz.), operate into separate antennas, that are co-located on the tower. Their effects on the station operating from the system are considered in this report. Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on March 5, 2020.

**The following exhibits are provided:**

Exhibit A:
- A-1 Drawing Depicting Antenna.
- A-2 1183-4CP-DA-SP Antenna Specification Sheet.
- A-3 Drawing Depicting Combiner.
- A-4 783-8 Constant Impedance Combiner Specification Sheet.
- A-5 Theoretical Vertical Plane Relative Field Antenna Plot

Exhibit B:
- B-1 Equipment Employed in Intermodulation Product Measurements.
- B-2 Broadcasting Scheme of the Broadcast Systems.

Table 1. Carrier Reference Level.
Table 2. Calculated Third Order Products.
Table 3. Intermodulation Analysis Measurements.

**Exhibits Accompanying Report:** Exhibit A provides comprehensive information on the filters used by this radio station. Exhibit B illustrates the broadcasting scheme of each the station, the layout of the equipment used to isolate and measure potential intermodulation products and forward carrier reference levels. Found within Table 1 are the narrow band carrier frequency measurements that provide relative output signal levels for the IM analysis. Table 2 lists the calculated third order products that can be generated from FM transmitters broadcasting from the multi station broadcast facilities. The IM Analysis Measurements, in Table 3, provides detailed information obtained from the product frequency investigation.

**The Nature of Intermodulation Products (IM):** Intermodulation products result from inadequate transmitter-to-transmitter isolation. Intermodulation products are commonly generated from radio stations operating into multiplexed facilities and congested antenna broadcast sites. The mechanics associated with the phenomenon have been well documented. When two or more transmitters are coupled to each other, new spectral components are produced by the mixing of the station frequencies in the active circuits of each transmitter. The common term used to describe this phenomenon is third order product denoted by the mathematical expression $[2(F_1)-(F_2)]$, where $F_1$ signifies the frequency of the transmitter that is generating the intermodulation product, and F2 signifies the frequency causing the interference.

**The Multiplexed System:** These measurements were taken with all FM stations operating from their respective antenna systems. The WAMU, WPFW, WETA, and WTOP, multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The 1183-4CP-DA-SP Cog antenna, 783-8 Constant Impedance combiner units, MACXLine 650 feedline, are products of Electronics Research, Inc.
Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of four transmitter signals into a common antenna and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of: (4) 783-8 Constant Impedance combiner modules were installed for frequencies, 88.5, 89.3, 90.9, and 103.5 MHz. Note: WTOP (103.5 MHz.), has the ability to operate in non-directional mode but normally operates in directional mode on a separate 783-8 Constant Impedance Combiner module. Interconnecting "u-links" are required to complete the combiner which is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -72 dB. Other performance measurements, such as match, loss, group-delay, etc, revealed that the multiplexer unit was in proper working condition. Refer to Exhibit A-4 for the Combiner Specification Sheet.

**The IM Investigation: A** directional couplers was placed at the output of the transmitter to monitor and maintain band pass performance. The coupler furnished with the system is factory calibrated and capable of delivering accurate and repeatable RF measurements. To facilitate the taking of the measurements, the coupler located at the transmitter output of the system was used. Care was taken in the selection of the measurement location to ensure that the measurements would be made far removed from transmitters and any filtering used to reduce broadcast emissions. The coupler selected would normally be used for antenna reflection measurements and thus would provide greater than -43 dB directivity and a forward signal sample of -45.8 dB.

The forward port of the coupler was used for sampling the outgoing carrier levels and IM products. The IM sampled signal was fed by shielded cable into a directional coupler where all extraneous energy was steeply attenuated. Various attenuation pads were used, when needed, on the Spectrum Analyzer to ensure an adequate signal level for measurements without overloading the measurement equipment. An IFR 2399A Spectrum Analyzer serial# 02113071 was employed to record the level of all signals investigated. A Copper Mountain S5048 Network Analyzer serial# 15077029 was used for selective tuning of the Band Pass Filter. The IFR Spectrum Analyzer was also used to measure the close in spectral attenuation of each carrier and wide band search for any anomalies that may need further investigation. See attached Exhibit B-1 for an illustration of the measurement equipment.

Prior to recording measurements, all pertinent broadcasting equipment including Transmitters, Filters, Feed Line and Antenna were adjusted to optimal performance. Also, it was confirmed before taking any measurements that all stations of concern were operating at their full licensed power level. From the equipment setup described above, the relative output signal level of each stations forward carrier was made. The resulting signal levels of these measurements are listed in Table 1, column labeled "Adjusted Level". This level will be used as the reference level for possible IM products of the carrier and was necessary to confirm that no significant levels of spurious energy, referenced to each carrier, were present from any transmitter operating from the broadcast system.

## Table 1 – Carrier Reference Levels.

| **Carrier Frequency (MHz)** | Pad One (dB) | Bandpass Filter Loss (dB) | Measured Level (dBm) | **Adjusted Level (dBm)** | Notes |
|---|---|---|---|---|---|
| **WTOP 103.5 MHz.** | **3** | **-** | **24.62** | **27.62** | |

Predictable third-order products due to system harmonics mixed with all on-site interfering frequencies that could be generated from the multiplexed system are calculated and listed in Table 2.

## Table 2 - Third Order Products.

| | Carrier Frequency |
|---|---|
| **Interfering Frequencies** | **103.5** |
| WAMU 88.5 MHz. | 118.5 |
| WPFW 89.3 MHz. | 117.7 |
| WETA 90.9 MHz. | 116.1 |
| WPGC 95.5 MHz. | 111.5 |
| WMMJ 102.3 MHz. | 104.7 |
| WTOP 103.5 MHz. | ---- |

Using the equipment previously described the IM product measurements were recorded and are listed in Table 3. The signal levels referenced to the carriers are calculated and listed in the column labeled "Level Referenced to Carrier". Refer to Exhibit B-2 for a layout of the measurement equipment.

**Table 3 – Intermodulation Measurements**

| IM Measurements Taken in Washington, D.C. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Product Frequency (MHz)** | **Transmitter Frequency (MHz)** | **Interfering Frequency (MHz)** | **Pad (dB)** | **Bandpass Filter Loss (dB)** | **Total Loss** | **Measured Level (dB)** | **Adjusted Level (dB)** | **Carrier Reference Level (dB)** | **Level Referenced to Carrier (dB)** | **Notes*** |
| | | | | | | | | | | |
| **Transmitter Mixes** | | | | | | | | | | |
| | **103.5** | **Ref.** | 3 | | 3 | 24.62 | 27.62 | **27.62** | | |
| | | | | | | | | | | |
| 104.7 | 103.5 | 102.3 | 3 | 11.3 | 14.3 | -68.7 | -54.4 | 27.62 | **-82.02** | |
| 111.5 | 103.5 | 95.5 | 3 | 10.7 | 13.7 | -68.07 | -54.37 | 27.62 | **-81.99** | |
| 116.1 | 103.5 | 90.9 | 3 | 10.7 | 13.7 | -69.36 | -55.66 | 27.62 | **-83.28** | |
| 117.7 | 103.5 | 89.3 | 3 | 9.9 | 12.9 | -68.94 | -56.04 | 27.62 | **-83.66** | |
| 118.5 | 103.5 | 88.5 | 3 | 10.5 | 13.5 | -67.47 | -53.97 | 27.62 | **-81.59** | |
| | | | | | | | | | | |

The Spectrum Analyzer was used to check the close in spectral attenuation of the carrier to confirm the operation of the transmitter is in compliance with Sections (b) and (c) of the FCC Rules and Regulations.

As a final proof of the systems IM Product performance, a wide band search was undertaken using the Spectrum Analyzer. The purpose for this measurement was to look for suspicious anomalies that may warrant further investigation. My search ranged the complete frequency span of the receiver and resulted in no additional investigations.

**Conclusion:** Based upon my observations and measurements taken on March 5, 2020 as summarized in this document, I, Jeff Taylor, find the subject system-specifically the transmitter, combiner, and antenna system for the operation of WTOP into the antenna to be in proper working order. Furthermore, based on the measured data, it is my opinion that there are no inter-modulation products in excess of 80 dB below carrier levels. Based on this recorded data, I conclude that WPGC is in compliance with the requirements of Section 73.317 paragraph (b) through (d) of the FCC Rules and Regulations.

Respectfully submitted,
Electronics Research, Inc.

Jeff Taylor, Field Technician

State of Indiana)
) SS:
County of Warrick)

## AFFIDAVIT

I, Jeff Taylor, hereby declare that the following statements are true and correct to the best of my knowledge and belief :

1.) I am a Field Technician for Electronics Research, Inc ("ERI ") and have been employed by ERI for 24 years. I am familiar with and have assisted in the design, manufacturing and installation of FM Antennas and FM Multiplexers in my long tenure with ERI.

2.) I have either prepared and/or directly supervised the preparation of all technical information contained in this Report of Findings and to my knowledge to be accurate and true.

3.) ERI has been requested by Hubbard Broadcasting on behalf of radio Station WTOP in Washington, D.C. to prepare this Report of Findings.

Jeff Taylor; Field Technician

*Subscribed and sworn to before me on this 13th, day of March, 2020.*

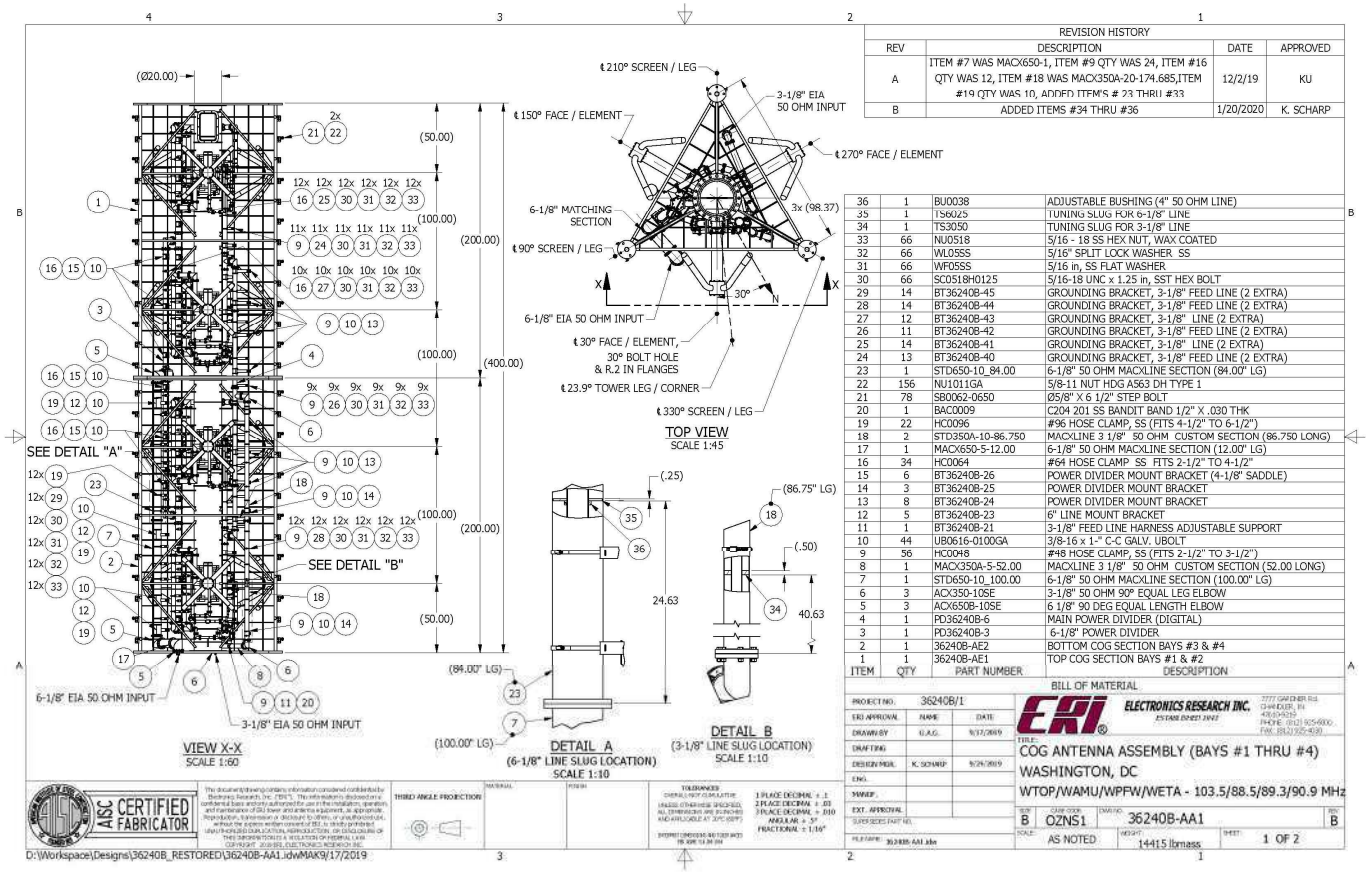
Cindy D. Tomes; Notary Public
My commission expires September 17, 2022

CINDY D TOMES
Notary Public, State of Indiana
Warrick County
Commission # 658197
My Commission Expires
September 17, 2022



8

# EXHIBIT, A – 1




| REVISION HISTORY | | | |
|---|---|---|---|
| REV | DESCRIPTION | DATE | APPROVED |
| A | ITEM #7 WAS MACX650-1, ITEM #9 QTY WAS 24, ITEM #16 QTY WAS 12, ITEM #18 WAS MACX350A-20-174.685,ITEM #19 QTY WAS 10, ADDED ITEMS # 23 THRU #33 | 12/2/19 | KU |
| B | ADDED ITEMS #34 THRU #36 | 1/20/2020 | K. SCHARP |

| ITEM | QTY | PART NUMBER | DESCRIPTION |
|---|---|---|---|
| 36 | 1 | BU0038 | ADJUSTABLE BUSHING (4" 50 OHM LINE) |
| 35 | 1 | TS6025 | TUNING SLUG FOR 6-1/8" LINE |
| 34 | 1 | TS3050 | TUNING SLUG FOR 3-1/8" LINE |
| 33 | 66 | NU0518 | 5/16 - 18 SS HEX NUT, WAX COATED |
| 32 | 66 | WL05SS | 5/16" SPLIT LOCK WASHER SS |
| 31 | 66 | WF05SS | 5/16 in, SS FLAT WASHER |
| 30 | 66 | SC0518H0125 | 5/16-18 UNC x 1.25 in, SST HEX BOLT |
| 29 | 14 | BT36240B-45 | GROUNDING BRACKET, 3-1/8" FEED LINE (2 EXTRA) |
| 28 | 14 | BT36240B-44 | GROUNDING BRACKET, 3-1/8" FEED LINE (2 EXTRA) |
| 27 | 12 | BT36240B-43 | GROUNDING BRACKET, 3-1/8" LINE (2 EXTRA) |
| 26 | 11 | BT36240B-42 | GROUNDING BRACKET, 3-1/8" FEED LINE (2 EXTRA) |
| 25 | 14 | BT36240B-41 | GROUNDING BRACKET, 3-1/8" LINE (2 EXTRA) |
| 24 | 13 | BT36240B-40 | GROUNDING BRACKET, 3-1/8" FEED LINE (2 EXTRA) |
| 23 | 1 | STD650-10_84.00 | 6-1/8" 50 OHM MACXLINE SECTION (84.00" LG) |
| 22 | 156 | NU1011GA | 5/8-11 NUT HDG A563 DH TYPE 1 |
| 21 | 78 | SB0062-0650 | Ø5/8" X 6 1/2" STEP BOLT |
| 20 | 1 | BAC0009 | C204 201 SS BANDIT BAND 1/2" X .030 THK |
| 19 | 22 | HC0096 | #96 HOSE CLAMP, SS (FITS 4-1/2" TO 6-1/2") |
| 18 | 2 | STD350A-10-86.750 | MACXLINE 3 1/8" 50 OHM CUSTOM SECTION (86.750 LONG) |
| 17 | 1 | MACX650-5-12.00 | 6-1/8" 50 OHM MACXLINE SECTION (12.00' LG) |
| 16 | 34 | HC0064 | #64 HOSE CLAMP SS FITS 2-1/2" TO 4-1/2" |
| 15 | 6 | BT36240B-26 | POWER DIVIDER MOUNT BRACKET (4-1/8" SADDLE) |
| 14 | 3 | BT36240B-25 | POWER DIVIDER MOUNT BRACKET |
| 13 | 8 | BT36240B-24 | POWER DIVIDER MOUNT BRACKET |
| 12 | 5 | BT36240B-23 | 6" LINE MOUNT BRACKET |
| 11 | 1 | BT36240B-21 | 3-1/8" FEED LINE HARNESS ADJUSTABLE SUPPORT |
| 10 | 44 | UB0616-0100GA | 3/8-16 x 1" C-C GALV. U-BOLT |
| 9 | 56 | HC0048 | #48 HOSE CLAMP, SS (FITS 2-1/2" TO 3-1/2") |
| 8 | 1 | MACX350A-5-52.00 | MACXLINE 3 1/8" 50 OHM CUSTOM SECTION (52.00 LONG) |
| 7 | 1 | STD650-10_100.00 | 6-1/8" 50 OHM MACXLINE SECTION (100.00" LG) |
| 6 | 3 | ACX350-10SE | 3-1/8" 50 OHM 90° EQUAL LEG ELBOW |
| 5 | 3 | ACX650B-10SE | 6 1/8" 90 DEG EQUAL LENGTH ELBOW |
| 4 | 1 | PD36240B-6 | MAIN POWER DIVIDER (DIGITAL) |
| 3 | 1 | PD36240B-3 | 6-1/8" POWER DIVIDER |
| 2 | 1 | 36240B-AE2 | BOTTOM COG SECTION BAYS #3 & #4 |
| 1 | 1 | 36240B-AE1 | TOP COG SECTION BAYS #1 & #2 |

BILL OF MATERIAL

ELECTRONICS RESEARCH INC.

COG ANTENNA ASSEMBLY (BAYS #1 THRU #4)
WASHINGTON, DC
WTOP/WAMU/WPFW/WETA - 103.5/88.5/89.3/90.9 MHz

PROJECT NO. 36240B/1
DRAWN BY K.A.G. 9/17/2019
DESIGN MGR. K. SCHARP 9/24/2019
SIZE B | CAGE CODE OZNS1 | DRAWING 36240B-AA1 | REV B
SCALE AS NOTED | WEIGHT 14415 lbmass | SHEET 1 OF 2

ASC CERTIFIED FABRICATOR

# A-2 ERI Antenna Specification Sheet

Washington, D.C.

## *General Specifications*

Antenna Type ..... High Power FM-Broadcast
Model Number ..... 1183-4CP-DA-SP
Number of Bay Levels ..... Four
Polarization ..... Left Hand Circular

## *Electrical Specifications*

Antenna Input Power Capability ..... 21 kW Max (1)
Operating Frequency Band ..... 103.5 Megahertz.
VSWR. ..... <1.00:1 @ Operating Frequency (2)
Azimuthal Pattern Circularity ..... Better Then +/- 1.5dB From RMS (Free Space)
Power Split ..... 50/50 (Horizontal & Vertical)
Frequency Specific Information:

| Frequency | Station ERP | Beam Tilt | First Null Fill | Second Null Fill | Power Gain | Line Loss (3) | Filter Loss (2) | Computed TPO |
|---|---|---|---|---|---|---|---|---|
| **103.5** | **44 kW** | **-0.41°** | **6.9 %** | **9.1%** | **2.651** | **0.762 dB** | **0.269 dB** | **21.04 kW** |

## *Mechanical Specifications*

Antenna Feed System ..... Fed with One Line
Input Connector ..... 3 1/8"-50 Ohm EIA Flanged
Element Deicing ..... None
Interbay Spacing ..... 100" Center to Center
Array Length ..... 33.33 Feet
Construction Material (Antenna) ..... All Noncorrosive
Construction Material (Mounting) ..... Galvanized and Stainless Steel

**1) Power Capability Has Been Rated Assuming an Operating Transmission VSWR of 1.5:1**
**2) VSWR Specification Achieved After on Site Tuning for User Specific Frequencies.**
**3) Line Loss Assumes A Feed Run of 471 Feet, 3 1/8" HJ8-50B Comscope Heliax and 86 Feet of 3 1/8" ERI Rigid.**

# N/A

# A-4 ERI Combiner Specification Sheet

**TRANSMISSION SITE**
**WASHINGTON, D.C.**

## *General Specifications:*

**Multiplexer Type .....Constant Impedance**
**Number of Combining Units ..... One**
**Injected Port to Injected Port Isolation..... < - 72 dB**
**Output Connector.....3 1/8 "50 Ohm EIA (Flanged)**
**Output Power (Designed) .....22 kW(1)**

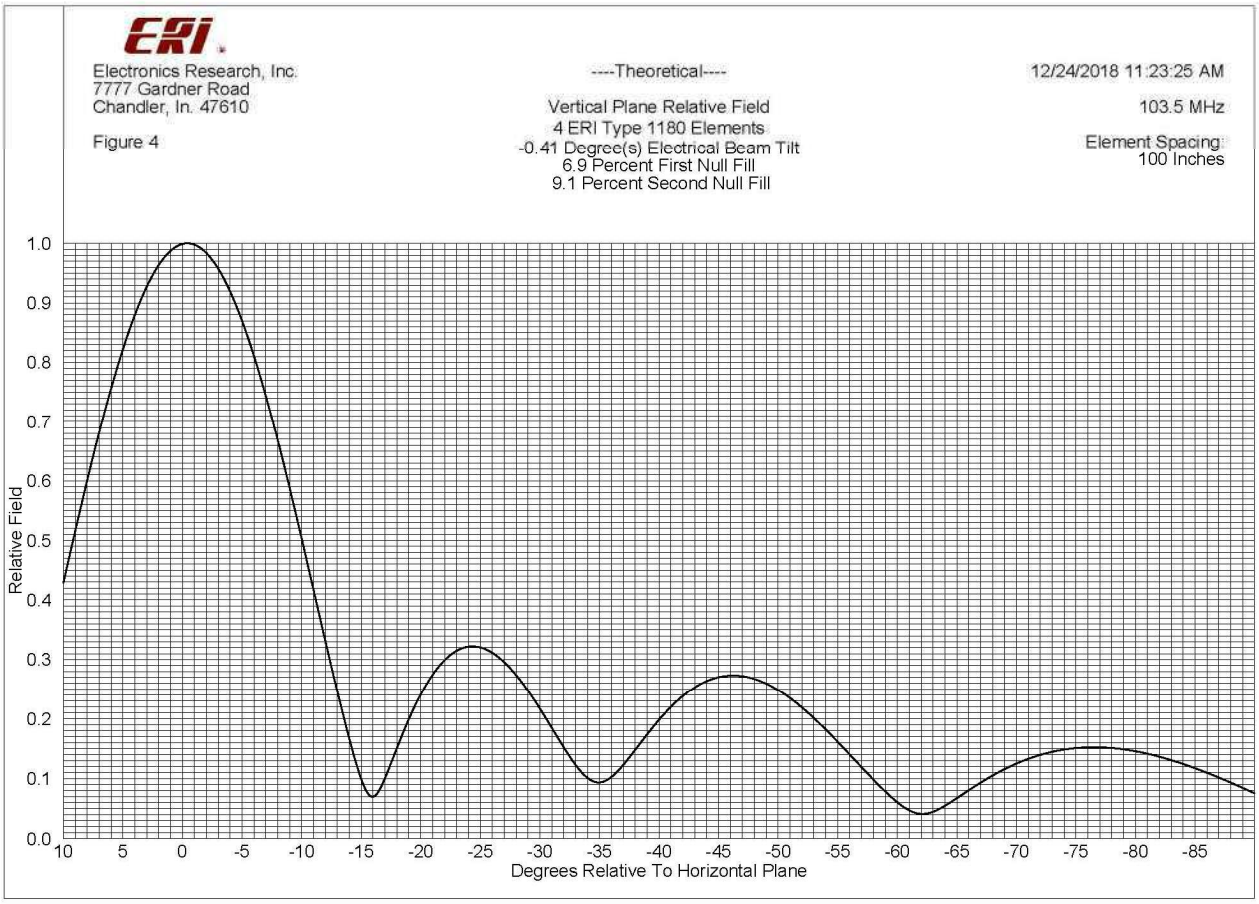
**Heat Removal ..... Natural Convection Cooling**
**Physical Arrangement.....Rack Mounted**

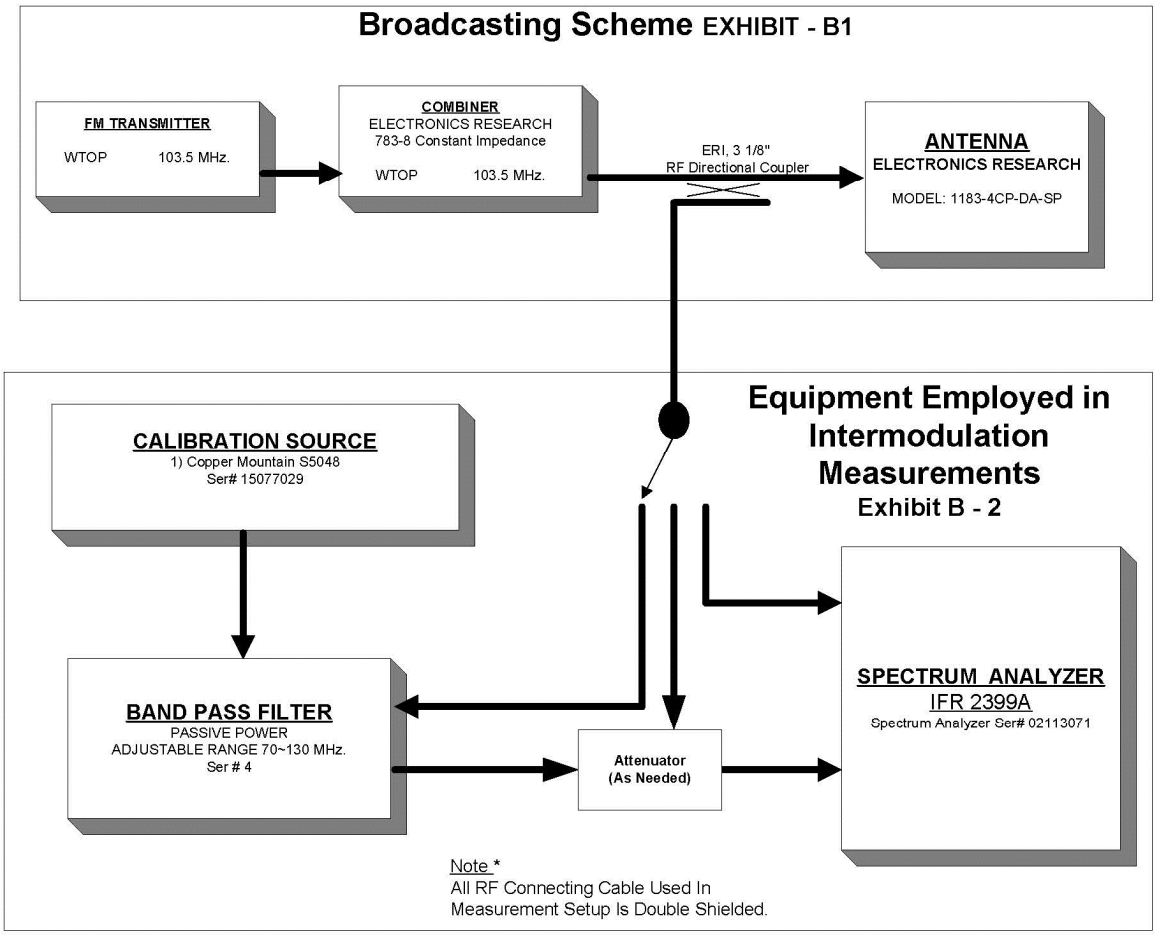
## *Injected Port Specifications:*

**Frequency Assignment .....103.5 MHz.**
**Power Rating, Each Injected Port (Designed) ..... 21.04 kW 103.5 MHz.**
**Input Connector ..... 3-1/8" 50 Ohm EIA (Flanged).**
**VSWR.....< 1.07:1 @ +/-200 KHz.(2)**
**Group Delay..... Less than 150 ns Overall Variation, Carrier @ +/- 150 KHz.**
**Insertion Loss (Measured):**

**103.5 MHz. ..... - 0.269 dB**

**1) Power Rating Listed is as Designed Only. Actual Power Capabilities May Vary.**
**2) When Terminated in 50 Ohm Resistive Load.**


Electronics Research, Inc.
7777 Gardner Road
Chandler, In. 47610
Figure 4
----Theoretical----
Vertical Plane Relative Field
4 ERI Type 1180 Elements
-0.41 Degree(s) Electrical Beam Tilt
6.9 Percent First Null Fill
9.1 Percent Second Null Fill
12/24/2018 11:23:25 AM
103.5 MHz
Element Spacing:
100 Inches
Relative Field
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85
Degrees Relative To Horizontal Plane




**Broadcasting Scheme and Equipment Employed in Intermodulation Measurements**

**EXHIBIT B**