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May 9, 2008

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

Re: *Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band* (WT Docket No. 07-293) and *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band* (IB Docket No. 95-91)

WRITTEN EX PARTE PRESENTATION

Dear Ms. Dortch:

While there are few things on which the Wireless Communications Service ("WCS") and the satellite Digital Audio Radio Service ("SDARS") licenses agree in this proceeding, both sides recognize that path loss – the attenuation of a transmitted signal between two points – plays a critical part in determining whether SDARS subscribers are likely to suffer material interference from WCS mobile devices.[1] The greater the path loss, the less likely interference is to occur. Unfortunately, although both sides agree on the importance of path loss, they continue to disagree on the specific path losses that will occur between a WCS mobile transmitter and a SDARS receiver over the distances relevant here.

WCS Coalition is of the view that the path loss between a WCS mobile and a SDARS receiver at three meters separation is approximately 9 dB greater than the "free space + 3 dB" figure advanced by the SDARS licensees, with even a greater disparity as the separation distance increases. The WCS Coalition had hoped that the material it presented in Attachment A to its March 17, 2008 Reply Comments, which is based on actual field testing by ATECS, LLC ("ATECS") and by NextWave Broadband Inc. ("NextWave"), would have ended the argument.[2] However, a recent *ex parte* presentation to International Bureau staff asserts that the WCS

[1] *See, e.g.* Reply Comments of XM Radio Inc., WT Docket No. 07-293 *et al*, at 18 (filed Mar. 17, 2008); Reply Comments of WCS Coalition, WT Docket No. 07-293 *et al*, Attach. A at 1-3(filed Mar. 17, 2008)["WCS Reply Comments"].

[2] *See* WCS Reply Comments at Attach. A at 1-3.

Coalition "overstates path loss by nearly 10 dB."[3] To assist the Commission in resolving this fundamental issue, the WCS Coalition commissioned ATECS to prepare the attached report, "Comparative Analysis of Log-Distance Path Loss Models in WCS/SDARS Band."

In that report, ATECS reviews the arguments advanced by SDARS and WCS. ATECS establishes that to accurately measure path loss that "measurements should be conducted in the actual environment to be characterized (indoor, outdoor, rural, urban, etc.), at the relevant frequency band and with antennas that accurately represent the mounting and placement of the antennas used in real world applications." It further establishes that in conducting the analysis, "a large quantity of data should be collected over varying propagation distances" and that "[l]inear regression curve fit techniques are then applied to the measured data to derive the path loss versus distance relationship," Regarding the particulars of the WCS/SDARS issue, ATECS notes that the testing should be conducted in "a configuration that consists of SDARS and WCS antennas in the same horizontal plane and incorporates signal loss experienced from a highly reflective rooftops surface."

Reviewing the field tests undertaken by the parties, ATECS takes note that while the WCS testing was conducted using an appropriate methodology, the SDARS report fails to provide sufficient specific information as to the underlying methodology for collecting and analyzing test data. Among other things, ATECS notes that SDARS fails to "provide the measured data points or the curve fit analysis that would be necessary to both derive the measured path loss equation and to inspect visually the accuracy of the curve fit to the measured data." Thus, ATECS concludes that "[w]ithout details of the measured data, analysis, or repeatability of the testing, the claim make by XM and Sirius that path loss follows a 'free space + 3 dB" relationship is unsubstantiated." By contrast, ATECS confirms that the various WCS-sponsored tests showed "excellent correlation and repeatability."

ATECS also establishes that the AWS-3 proceeding filings and others technical papers on which SDARS relies do not actually support the SDARS position because they are distinguishable and not determinative to the issues before the Commission here. Specifically, ATECS establishes that "they are: 1) based on theoretical analyses without supporting measurement data; 2) narrowly focused on use cases that are unlike the WCS/SDARS condition; and/or 3) rely on measurements that use free standing antennas with no ground plane or reflective surface." In addition, ATECS reviews additional technical papers that support the WCS conclusion that path loss at 3 meters will exceed free space by 12 dB, including an NTIA report which shows that a roof-mounted antenna has an additional 8 to 30 dB of path loss as compared to a free-standing antenna.

In short, the ATECS analysis confirms what the WCS Coalition has been saying – the path loss to be expected between a WCS mobile transmit antenna and a SDARS receive antenna

[3] *See* Letter from Patrick L. Donnelly and James S. Blitz, IB Docket No. 95-91, *et al*, Attachment at 16 (filed April 25, 2008).

is greater than the SDARS licensees suggest, and is responsible in large part for the differences in their assessments of the potential for WCS to mute a SDARS receiver. The path loss tests conducted by ATECS and NextWave demonstrate that the SDARS licensees are greatly exaggerating the potential for interference to their subscribers.

Pursuant to Sections 1.1206(b)(1) and 1.49(f) of the Commission's Rules, this letter is being filed electronically with the Commission via the Electronic Comment Filing System. Should you have any questions regarding this presentation, please contact the undersigned.

Respectfully submitted,

/s/ Paul J. Sinderbrand

Paul J. Sinderbrand

Counsel to the WCS Coalition

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COMPARATIVE ANALYSIS OF LOG-DISTANCE PATH LOSS MODELS IN WCS/SDARS BAND

Presented by:

ATECS

May 9, 2008

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1. Summary

Path loss, or the attenuation that a signal undergoes in travelling over a path between two points, is a critical factor in determining the vulnerability of an SDARS receiver to interference from a mobile WCS transmitter. All else being equal, the higher the path loss or the greater the signal attenuation, the less likely interference is to occur. This paper discusses the differences in path loss claims by the WCS Coalition ("WCS"), XM Radio ("XM"), and Sirius Satellite Radio ("Sirius"). This will be accomplished by evaluating: (a) field measurements performed by the three parties; (b) third party studies cited in XM and Sirius FCC reply comments; and (c) additional industry technical studies.

Derived log-distance path loss models are referenced to the log-distance free-space path loss equation of PL (dB) = 39.7 + 20log(d) (d, in meters) at 2.3 GHz.[1,2] XM and Sirius claim a log-distance free-space path loss model of + 3 dB, based primarily on hypothetical assumptions and on published studies for different use cases. The WCS Coalition has presented a path loss relationship of 50.9 + 21.8log(d), which is derived from extensive field measurements at 2.3 GHz using actual SDARS antennas. The WCS results show a + 12 dB loss in excess of free-space at a 3 meter distance.

This paper will demonstrate that XM and Sirius wrongly conclude that path loss will follow a "free-space + 3 dB" relationship at distances up to 16 feet, due to their reliance on theoretical analyses and field tests that are not comprehensive or repeatable.

2. Background

Path loss or path attenuation is the reduction in power density of a radio wave as it propagates between two antennas. Path loss is caused by many factors, including free-space loss, refraction, diffraction, reflection, antenna coupling loss, and absorption. Path loss is also influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height, location and orientation of antennas. Free-space path loss, which occurs in a transparent medium free of obstructions and reflection points, is a function of the frequency used and the square of the distance the radio wave travels. Effects such as multipath, refraction, and diffraction can cause propagation path loss between two antennas to increase significantly above that of free-space.

While the free-space path loss can be computed, characterizing path loss in a real world environment through computation techniques is difficult, if not impossible. Research has instead relied on propagation measurements and empirical techniques to determine path loss. Published studies show that measurements should be conducted in the actual environment to be characterized (indoor, outdoor, rural, urban, etc.), at the relevant frequency band and with antennas that accurately represent the mounting and placement of the antennas used in real world applications. Further, a large quantity of data should be collected over varying propagation distances. Linear regression curve fit techniques

should then be applied to the measured data to derive the path loss versus distance relationship.[3]

Hence, the appropriate method to characterize propagation behavior between a WCS transmitter and an SDARS receiver is to measure the loss between the devices in the 2.3 GHz band under realistic usage conditions. Even over very short distances, the path loss is influenced by antenna placement, antenna orientations, equipment location, and localized obstructions. The mutual coupling of antennas over short distances is also a factor. For example, a typical SDARS user will have an SDARS antenna installed or magnetically mounted on a vehicle rooftop, while a typical WCS user will use a WCS mobile at ear, chest or lap level. A realistic interference scenario consists of an SDARS user momentarily driving past a WCS mobile user located on a sidewalk or inside another vehicle or vice-versa. Thus, in order to depict this interference scenario accurately, a configuration that consists of SDARS and WCS antennas in the same horizontal plane and incorporates signal loss experienced from a highly reflective rooftop surface should be used. This configuration differs significantly from typical free-space path loss measurements that use free standing antennas mounted on tripods with no ground plane or reflective surfaces.

A representative field test configuration is shown in Figure 1 below. This configuration utilizes a 5 MHz TDD WiMAX waveform, a WCS antenna, and an SDARS antenna/LNA with a bias tee connected to a spectrum analyzer. An alternative configuration uses a directional coupler between an SDARS receiver and SDARS antenna/LNA in place of a bias-tee.

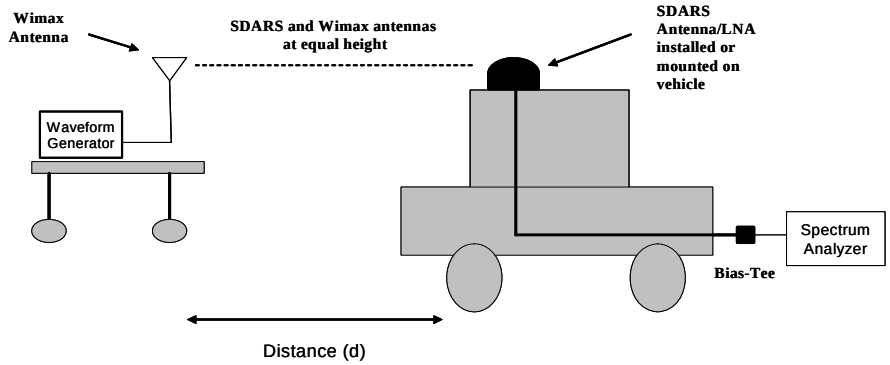

Figure 1. WCS-SDARS path loss field test configuration

A typical field setup consists of the following RF components as shown in Figure 2 and Table 1 below.

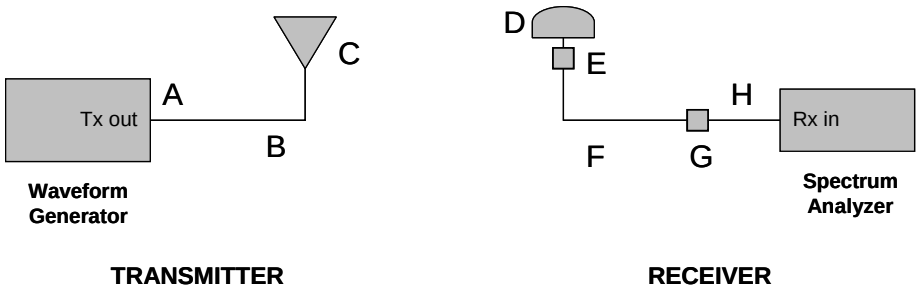

Figure 2. WCS-SDARS path loss RF parameters

RF PARAMETER	DESCRIPTION	UNIT
A	Transmitter output power	dBm
B	Transmitter antenna cable loss	dB
C	Transmitter antenna gain	dBi
D	Receiver antenna gain	dBi
E	LNA gain	dB
F	Receiver antenna cable loss	dB
G	Bias tee insertion/directional coupler loss	dB
H	Jumper cable loss	dB

Table 1. RF parameters to derive path loss

The path loss can then be calculated using measured values of the RF parameters as shown in Equation (1) below and used in a curve fit analysis to generate a log-distance path loss equation.

$$\text{Path Loss} = (A - B + C) + (D + E - F - G - H) - (\text{Rx-in}) \qquad \textit{Equation (1)}$$

3. Discussion

Field measurements performed by the WCS Coalition used the exact test configuration described in Section 2. The Coalition also documented the calibration data for the test configuration in their filed comments. XM and Sirius depict a similar test configuration in their filings, although calibration data was not provided.

Still, the measured results submitted by the WCS Coalition compared with the results submitted by XM and Sirius show a 9 dB difference in log-distance path loss equations at 3 meters. While only limited details on the test configuration and analysis techniques were provided by XM and Sirius, we attempt to explain the variances in the field measurements in Section 3.1 below.

XM and Sirius claim their field measurements are supported by cited industry papers. A discussion of these industry papers is provided in Sections 3.2 through 3.4 below. We find that the cited industry papers do not support the XM and Sirius claims as they are: 1) based on theoretical analyses without supporting measurement data; 2) narrowly focused on use cases that are unlike the WCS/SDARS condition; and/or 3) rely on measurements that use free standing antennas with no ground plane or reflective surface rather than the configuration referenced in Section 2.

The WCS Coalition, on the other hand, relies on field measurements of WCS and SDARS equipment operating under realistic conditions as the basis of its path loss claims. These Coalition findings rely on proven measurement and data analysis techniques that have been used extensively in the literature.

3.1 Field measurements

The WCS Coalition field test measured path loss at two frequencies (WCS C block: 2317.5 MHz and WCS D block: 2347.5 MHz) using two different signal sources (CW tone for WCS C block and WiMAX 5 MHz waveform for WCS C and D blocks). The field setup included a WCS antenna, a Sirius antenna/LNA and an XM antenna/LNA.[4]

The WCS Coalition WCS C block measurements resulted in a log-distance path loss equation of 50.9 + 21.8 log(d), which is the equivalent of free-space + 11.2 dB at 3 meters.[5] The WCS Coalition WCS D block measurements resulted in a log-distance path loss equation of 50.3 + 20.9 log(d), which is the equivalent of free-space + 10.6 dB at 3 meters.[6] Results were based on detailed derivation and measured data. WCS Coalition field measurements demonstrate excellent correlation and repeatability with two types of signal sources (within 3 dB) at two frequencies (within 1 dB).

The XM field test measured path loss at the WCS D block using a 44% uplink duty cycle WiMAX 5 MHz waveform[i] through a dipole antenna and an XM antenna/LNA.[7] The Sirius field test measured path loss at the WCS C block using a 6% uplink duty cycle WiMAX 5 MHz waveform through a dipole antenna and a Sirius antenna/LNA.[8] XM and Sirius both claim a log-distance path loss of free-space + 3 dB.[9]

In their test reports, XM and Sirius provide little detail of measured values of RF parameters. They also do not provide the measured data points or the curve fit analysis that would be necessary to both derive the measured path loss equation and to inspect visually the accuracy of the curve fit to the measured data. Without details of the measured data, analysis, or repeatability of the testing, the claim made by XM and Sirius that path loss follows a “free-space + 3dB” relationship is unsubstantiated.

WiMAX waveforms with 6% uplink, 44% uplink, and continuous duty cycles were used by Sirius, XM and the WCS Coalition, respectively. The measured power of a WiMAX waveform using an Agilent 4438C waveform generator (used by all parties) is determined

[i] Use of a gated waveform, instead of a continuous waveform as used in the WCS Coalition testing, can create uncertainty in the measurement and therefore should not be used.

by the preamble, which is inherent in a continuous duty cycle WiMAX waveform. This preamble is not present in 6% uplink or 44% uplink duty cycle WiMAX waveforms. Thus, the accuracy of the measured output power used in the XM and Sirius measurements is uncertain, while the measured output power in the WCS Coalition's measurements is known.

3.2 AWS-3 submissions

XM and Sirius claim that their free-space + 3 dB path loss field measurements are supported by filings made by CTIA, Verizon and Motorola in the FCC's rulemaking regarding the AWS-3 band (2155-2175 MHz).[10] The AWS-3 band is immediately adjacent to the AWS-1 base transmit band (2110-2155 MHz). In their AWS-3 filings, CTIA, Verizon and Motorola assume a + 3 dB path loss (theoretical free-space loss with an additional 3 dB due to estimated head and body loss) as the basis for their recommendations on maximum AWS-3 transmit power level to protect AWS-1 devices. These AWS-3 contributions address scenarios specific to the case of mobile-to-mobile device path loss where the mobile devices both use free standing antennas in close proximity to one another (less than 1 meter) without obstructions. These assumptions are used in order to represent a typical handheld mobile-to-mobile interference scenario, such as two passing pedestrians or two users sitting on a park bench or on a train, which is expected in the AWS-1 and AWS-3 bands.

A typical WCS to SDARS interference scenario, on the other hand, will differ in a number of critical ways. First, the SDARS antenna will be mounted on a vehicle, the roof of which acts as a ground plane or reflective surface and impacts path loss. Second, the separation between a WCS mobile transmitter and vehicle-mounted SDARS device will almost always be greater than 1 meter. Rather, it is accepted that a typical separation distance between a WCS and SDARS device will be 3 meters.

While the AWS-3 industry papers may support the use of a free-space + 3 dB path loss value in the context of handheld AWS-3 to AWS-1 device interference, the assumptions used to derive this path loss value are inappropriate in the context of WCS to SDARS interference. Therefore, the use of free-space + 3 dB path loss by other industry parties in AWS-3 calculations does not support use of this path loss for WCS to SDARS interference calculations.

3.3 NTIA Report

In its comments, Sirius cites an NTIA Report, entitled "Propagation loss prediction considerations for close-in distances and low-antenna height applications."[11] The NTIA report provides predicted path loss curves of various theoretical propagation models versus distance at 3 GHz at transmit and receiver heights of 2 meters measured between 1 and 10 meters. Measurement data and empirical analysis are not included in this report. Further, the findings are based on free standing antennas.

Sirius notes that, "[o]ne of the results from the recent comprehensive NTIA evaluation of mobile to mobile propagation loss modeling is shown in Figure 4. This too, allowing for slightly different frequencies puts the expected path loss at 3 meters at approximately 50 dB."[12] The conclusion drawn by Sirius is flawed, as it is based on a computational error.

Propagation path loss increases with frequency. The frequency scaling factor between 2.3 GHz and 3 GHz is 2.3 dB. Sirius wrongly asserts that the theoretical curve for 3 GHz corroborates their claim that free-space + 3 dB is an appropriate path loss assumption as they have not correctly accounted for the 2.3 dB frequency scaling effect. The family of path loss curves in the NTIA report cited by Sirius is effectively a path loss curve of free-space versus distance at 3 GHz, and therefore has no direct relationship to the WCS/SDARS condition to which they attempt to ascribe it.

3.4 IEEE VTS technical paper

Another reference cited by Sirius in its comments is an IEEE VTS technical paper entitled, "Propagation Studies for Mobile-To-Mobile Communications."[13] This paper provides propagation measurements at 2.1 GHz using monopole antennas with a ground plane from 1 to 25 meters in an open office area. Line-of-sight (LOS) measurements resulted in a range of free-space path loss -2 dB to + 7 dB depending upon transmit and receive antenna heights, which varied from 0.69 to 1.73 meters. Extensive research has shown the signal propagation inside buildings behaves very differently than under similar distances in an outdoor environment. Given that the WCS to SDARS interference scenario will most likely occur outdoors, this industry paper is irrelevant and does not support the use of free-space + 3 dB path loss.

3.5 Additional technical studies

There has been considerable industry research of propagation studies at similar frequency ranges and under conditions resembling those in which SDARS and WCS will operate. These studies support the use of path loss greater than free-space + 3dB.

One example is an IEEE paper that provides results of an outdoor propagation study using transmit and receive antennas at 1.7 meters with a wideband (100 MHz) signal operating at 1.8 GHz.[14] The IEEE propagation study setup uses comparable antenna heights in a horizontal plane in an outdoor environment similar to the configuration referenced in Section 2 above. The IEEE measurement results demonstrate a path loss exponent of 2.8, which differs from the path loss exponent for free-space of 2.0. Their results also show a 70 dB path loss at 10 meters, which differs from a free-space path loss of 59 dB at 10 meters. These measurements demonstrate that path loss varies at different distances due to the path loss exponent. Thus, the IEEE propagation study supports the WCS Coalition claim that path loss is greater than the free-space + 3 dB claimed by XM and Sirius.

A second example is an NTIA paper comparing propagation measurements of a free standing antenna with those of a roof-mounted antenna on a vehicle in frequencies

ranging from 50 MHz to 869 MHz.[15] NTIA's results showed that a roof-mounted antenna has an additional 8 to 30 dB of path loss than a free standing antenna. The paper demonstrates that propagation behaves differently from a roof-mounted antenna than from a free standing antenna since a roof-mounted antenna has path loss contributions from reflection and scattering due to the presence of a close spaced ground plane – a condition not experienced by a free standing antenna. Thus, like the IEEE propagation study, the NTIA paper supports the use of a greater path loss than the free-space + 3 dB as claimed by XM and Sirius.

4. Conclusions

Log-distance path loss models characterizing WCS-SDARS transmit-receive path loss were evaluated by analyzing field measurements performed by the WCS Coalition, XM, Sirius, and third party reports cited in FCC reply comments.

The WCS Coalition, XM and Sirius, in general, all followed the same field test configuration and log-distance path loss equation derivation method. However, results demonstrate differences in log-distance path loss equations of 9 dB at 3 meters.

The WCS Coalition provided full details of derivations and measured values. This included details of the curve fit analysis used for each field measurement with complete path loss equations. XM and Sirius provided only limited detail on the calibration of their test configuration and computations involved in deriving the path loss relationship. Their reported results contained no curve fit analysis and insufficient data to determine the accuracy or consistency of their claimed "path loss + 3 dB" relationship. Without such details, the derivation of the XM and Sirius log-distance path loss equation cannot be verified.

The WCS Coalition field measurement results, which were performed at multiple locations, at two frequencies, and using two types of test methods, produced consistent results (correlation of test results were in the 1 – 3 dB range).

XM and Sirius cite a handful of references that do not support their position. These references include:

- Studies submitted by CTIA, Verizon, and Motorola in the FCC's AWS-3 proceeding that use a free-space path loss + 3 dB equation. This path loss reference is inapplicable to a WCS/SDARS interference analysis since it is based on theoretical free-space loss and for a mobile-to-mobile device conditions under different use case assumptions,
- A propagation curve from a referenced NTIA report also does not validate the XM/Sirius claim of free-space + 3 dB at 2.3 GHz since the NTIA curve matches free-space path loss at 3 GHz. In addition, the NTIA model uses no empirical measurements of WCS/SDARS transmit-receive coupling loss, and
- A IEEE VTS technical paper that provides propagation measurements at 2.1 GHz does not validate the claim of free-space + 3 dB since the measurements were taken in an indoor open environment without the use of WCS/SDARS end-user equipment in a realistic test configuration.

The WCS Coalition has provided independent research that is consistent with the measured data and corroborates findings that path loss does not follow a free-space + 3 dB relationship. These contributions, which include IEEE and NTIA papers, directly support the Coalition finding that propagation loss at 3 meters will exceed free-space by +12 dB.

5. References

[1] THEODORE RAPPAPORT, WIRELESS COMMUNICATIONS PRINCIPLES AND PRACTICES 102 (1996).

[2] DAVID PARSONS, THE MOBILE RADIO PROPAGATION CHANNEL 19 (1992).

[3] THEODORE RAPPAPORT, WIRELESS COMMUNICATIONS PRINCIPLES AND PRACTICES 105–68 (1996).

[4] Reply Comments of the WCS Coalition, WT Docket No 07-293, Attachment B at 14 (filed Mar. 17, 2008) ("*WCS Coalition Reply*").

[5] *Id*. at 12, Attachment B at 27.

[6] *Id*., Attachment B at 27.

[7] Reply Comments of XM Radio Inc., WT Docket No. 07-293, Exhibit C at 5–9 ("*XM Reply*") (filed Mar. 17, 2008).

[8] Comments of Sirius Satellite Radio Inc., WT Docket No 07-293 at C5–C9 ("*Sirius Comment*") (filed Feb. 14, 2008).

[9] *See* XM Reply, Exhibit B at 7; Sirius Comment, Exhibit A at A15.

[10] *See* Comments of CTIA-The Wireless Association, WT Docket No.04-356 at n.59 (filed Dec 8, 2004); Comments of Verizon Wireless, Inc., WT Docket No. 07-195, Attachment A at 5 (filed Dec. 14, 2007); Comments of Motorola, Inc., WT Docket No. 07-195 at 5 (filed Dec 14, 2007).

[11] *See* Reply Comments of Sirius Satellite Radio Inc., WT Docket No. 07-293 at 23 n.65 (filed Mar. 17, 2008) ("*Sirius Reply*") (citing Nicholas DeMinco, Nat'l Telecomm. and Info. Admin. ("NTIA"), Propagation Loss Prediction Considerations for Close-In Distances and Low-Antenna Height Applications, NTIA Report TR-07-449 (Jul. 2007)).

[12] Sirius Reply, Exhibit B at 6.

[13] *Id*., Exhibit B at 8 (citing Harold, T.J., Nix, A.R., Beach, M.A., Propagation Studies for Mobile-To-Mobile Communications, Vehicular Technology Conference, 2001 IEEE VTS 54th, Vol. 3 at 1251-1255 (Oct. 2001).

[14] Patwari, N., Durgin, G.D., Rappaport, T.S., Boyle, R.J., Peer-to-Peer low antenna outdoor radio wave propagation at 1.8 GHz, Vehicular Technology Conference, 1999 IEEE VTS 49th, Vol. 1 at 371-375 (May 1999); *see also* RAPPAPORT, *supra* note 1, at 102.

[15] Nicholas DeMinco, Inst. for Telecomm. Sci., U.S. Dep't. of Commerce, Modeling Antennas on Automobiles in the VHF and UHF Frequency Bands, Comparisons of Predictions and Measurements (2005).