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February 27, 2008

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C.

**Re: Ex Parte Submission in WT Docket No. 07-293**

Dear Ms. Dortch,

Sirius XM Radio Inc. ("Sirius XM") has commissioned two highly respected independent RF testing companies – Southwest Research Institute ("SWRI") and Motorola, Inc. ("Motorola") – to evaluate radio propagation and satellite radio receiver performance. The results of these tests are attached and are hereby submitted into the record of the above-captioned proceeding. The purpose of this testing is to assist the Commission in determining whether it can allow mobile use in the Wireless Communications Services ("WCS") service in a manner that does not materially degrade satellite radio service to nearly 20 million consumers.

As the Commission is aware, Sirius XM has offered to conduct testing in this proceeding jointly with WCS licensees and other interested parties. Sirius XM believes that given the disparate and contradictory evidence in the record, joint testing would be the preferred mechanism to establish a defensible record on which the Commission can address these issues once and for all. Unfortunately, WCS licensees chose not to participate in such tests and the technical record remains disputed.

The need for unbiased technical data became more imperative after former FCC Chairman Kevin Martin circulated a draft order in December 2008 that, according to press reports, adopted technical parameters for mobile WCS devices highly likely to create devastating interference to Sirius XM's customers.[1] These press reports were

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[1] Neither the recommendations circulated by former Chairman Martin, nor the underlying technical rationale, have ever been made available for public review. This lack of transparency is directly contrary to the open processes the Commission properly followed in its AWS-3 proceeding. In that proceeding, the Commission participated in joint testing and released its analysis of the test results for public comment. *See The FCC's Office of Engineering and Technology Releases Analysis of AWS-3 Interference Tests*,

more than surprising to Sirius XM given the previous determination by the Commission's technical staff that allowing mobile WCS units in bands adjacent to Sirius XM's satellite operations would be "technologically infeasible." Sirius XM submits that the risk of interference to Sirius XM customers is too great for the Commission to arrive at a new determination based on incomplete and conflicting technical data.

Following the press reports describing former Chairman Martin's recommendations, Sirius XM undertook a number of steps to examine and depict the impact mobile operations in the WCS band would have on satellite radio consumers. As one part of this process, Sirius XM conducted a road test on a typical suburban highway, in typical traffic, using typical setups of Sirius XM radios and anticipated WCS transmissions, to demonstrate the impact to satellite radio reception from mobile WCS devices operated under the parameters reportedly in the draft order. Sirius XM recorded a video of these road tests – which were conducted in January 2009 and reported to the Commission in February – providing visual and aural evidence that mobile WCS operations will cause muting of satellite radio reception even at significant separation distances.[2]

And now, Sirius XM has engaged the services of SWRI and Motorola to perform tests and collect data that are the subject of the attached reports. The intent of the studies is to recreate path loss and receiver sensitivity tests that both Sirius XM and WCS interests previously performed, yielding inconsistent results. The outcome of this latest testing should afford the Commission a greater degree of certainty on the impact of its technical decisions. In addition, SWRI and Motorola performed new tests to address issues reportedly raised specifically by the draft order.

In total, four test reports are hereby submitted and described in summary below:

- Exhibit 1 is a test report prepared by SWRI, measuring path losses between WCS transmitters and satellite radio receivers. This exhibit reports on two sets of tests performed by SWRI: 1) outdoor tests where the simulated WCS transmitting device has a clear line-of-site path to a satellite radio receiver antenna mounted on top of a sedan and 2) tests with the WCS transmitting device operated at different locations inside the passenger compartment of one sedan and received by the satellite radio receiver antenna mounted on the top of a second sedan.

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Public Notice, DA 08-2245 (rel. Oct. 10, 2008). The lack of public comment on the former Chairman's recommendations also runs counter to Acting Chairman Copps' recognition of the need to make the FCC "more transparent, open and useful to the stakeholders that we serve". *See e.g.*, Remarks Of Acting Chairman Michael J. Copps to the Federal Communications Commission Staff (January 26, 2009) *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-288096A1.doc.

[2] Last week, counsel for the WCS Coalition told the Commission's staff that the Coalition believed that "there have been fundamental flaws in the design of the test and/or in its implementation" and asked that Sirius XM replicate the tests in the presence of Commission staff and WCS Coalition. Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, FCC, WT Docket No. 07-293, at 1 (filed Feb. 21, 2009). Sirius XM promptly informed the Commission that it welcomes this effort and would be pleased to have the Commission and the Coalition witness a repetition of these road tests.

- Exhibit 2 is a test report prepared by SWRI, providing laboratory test data related to muting of satellite receivers from WCS in-band signal overload and out-of-band emissions (OOBE). This report covers three sets of tests including: 1) the levels of WCS in-band overload signals and OOBE that cause satellite radio receivers to mute, 2) the levels of WCS in-band overload signals that cause satellite radio receivers to mute, and 3) the level of satellite radio terrestrial repeater signals necessary to prevent muting from the proposed WCS emissions levels.

- Exhibit 3 is a report prepared by SWRI, detailing the results of road tests to assess the sensitivity of Sirius XM receivers to interference generated in the WCS band. This is similar to the video depiction of WCS interference to satellite radio receivers that Sirius XM filed with the Commission in February.

- Exhibit 4 is a report prepared by Motorola, providing additional path loss measurements for 2.3 GHz WCS user terminal operated in a variety of circumstances including free field, in the presence of a user, and at various locations inside and outside a vehicle. The purpose of this report is to provide new data in the record with detailed information on local attenuation levels on WCS user terminal emissions.

Exhibits 5 and 6 provide the declarations and certifications of the two test houses.

Sirius XM's intention in filing this new data is not to raise new issues or broaden the record. Rather, these studies should remove any controversy about path loss and receiver sensitivity data that currently exists in the record. Understanding these key parameters is critical if the Commission is to establish new WCS service rules based on technical facts and the laws of physics rather than policy. To further this end, Sirius XM draws the Commission's attention to the following conclusions that can be derived from a review of these reports:

***Path Losses Between WCS Transmitters and Satellite Radio Receivers Cannot Be Expected To Mitigate Satellite Radio Muting.*** In Exhibit 1, SWRI measures outdoor path losses where the WCS transmitter had a clear line-of-sight to the satellite radio receive antenna at 3 dB greater than the theoretical free space path loss. This further validates data previously submitted by Sirius XM and shows much less attenuation than the information submitted into the record by WCS interests.[3] The enclosed data supports Sirius XM's position that stringent limits on WCS mobile transmitter power and out-of-band emissions are needed to prevent interference to satellite radio consumers even when

[3] Reply Comments of Sirius Satellite Radio Inc, IB Docket No. 95-91, WT Docket No. 07-293, Exhibit B at 6 (filed March 17, 2008) (detailing a study that confirmed "a 'Free Space + 3 dB' methodology for estimating path loss between WCS transmitters and nearby SDARS receivers."). *See also* Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91, WT Docket No. 07-293, Section 2.3.9 and Exhibit C (filed February 14, 2008). *See also* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 2 (filed May 9, 2008).

the two devices are physically separated by more than 3 meters, which is the compatibility distance mutually agreed upon by both parties.[4]

Results submitted by both SWRI (Exhibit 1) and Motorola (Exhibit 4) provide similar conclusions for the path loss from a WCS transmitter operating from various locations inside the passenger compartment of one vehicle to a satellite radio antenna mounted on another vehicle. In Exhibit 1, SWRI shows that propagation from inside one vehicle to an adjacent vehicle will vary depending upon the position of the transmitter, with attenuation values ranging between 6 and 15 dB greater than free-space loss. In Exhibit 4, Motorola shows that placing a WCS transmitter in a vehicle in the presence of one or two users will result in a reduction of average gain (or signal level transmitted outside the vehicle) by 4 to 7.5 dB, depending on the scenario. Data and analysis filed by the WCS Coalition suggests much greater attenuation from in-vehicle devices.[5]

***Satellite Radio Receivers Will Experience Interference from Mobile WCS Operations, Regardless of Whether Terrestrial Repeaters are Available.*** SWRI conducted RF testing relating to the muting of satellite radio receivers from WCS in-band signal overload and OOBE. In completing these tests, the results of which are attached as Exhibit 2, SWRI found that, without significant reinforcement from terrestrial repeaters, satellite radio receivers would always experience muting from WCS overload at a simulated range of 3 meters, even if there were no OOBE. The addition of OOBE would increase the required attenuation even further. As a result, terrestrial reinforcement levels from -81 dBm to -46 dBm were required to overcome muting from WCS overload and OOBE at an interferer range of 3 to 10 meters. This result is consistent with Sirius XM's prior conclusions regarding the path loss necessary to protect against muting and its related explanation that its terrestrial repeater network cannot ameliorate the interference caused by WCS.[6]

***WCS Transmitters Will Cause Muting to Occur in Satellite Radio Receivers Up to At Least 20 Meters Away.*** SWRI conducted RF testing regarding the muting of satellite radio receivers in a moving vehicle from WCS adjacent channel overload and OOBE while driving in traffic. The tests, the results of which are attached as Exhibit 3, concluded that despite vehicle-to-vehicle propagation losses, WCS signals still caused muting in satellite radio receivers up to at least 20 meters away. This result is wholly

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[4] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 and WT Docket No. 07-293, at 2 (filed May 19, 2008).

[5] *See* Letter from Mary N. O'Connor, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, *Path Loss Between WCS Transmitters and SDARS Receivers in Typical Vehicle Usage Scenarios* (filed Aug. 1, 2008).

[6] *See* Letter from James S. Blitz, Sirius XM Radio Inc., to Marlene H. Dortch, Secretary, FCC, at 4-15 & Exhibits A, B (filed Sep. 8, 2008). *See also,* Reply Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91, at 9 of Exhibit A (filed March 17, 2008).

consistent with Sirius XM's own vehicle tests, the results of which were submitted to the Commission earlier this month.[7]

As indicated above, the data provided herein by independent testing organizations confirms the Commission's original decision in 1997 and what Sirius XM has been telling the Commission ever since: the relaxation of OOBE limits applicable to mobile WCS devices will cause irreparable harm to Sirius XM's service, resulting in the loss of satellite radio service to millions of consumers at unpredictable times and locations. Sirius XM asks the Commission to take this information into account when deciding the outcome of these proceedings.

Respectfully submitted,

*/s/ Terrence R. Smith*
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New York, NY 10020

*/s/ James S. Blitz*
James S. Blitz
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CC:

| | |
|---|---|
| Paul Murray | Jim Schlichting |
| Renee Crittenden | Roger Noel |
| Angela Giancarlo | John Guisti |
| Julius Knapp | Steven Duall |
| Ron Repasi | |

[7] *See* Letter from Robert L. Pettit, Counsel to Sirius XM Radio, Inc., to Marlene H. Dortch, FCC, IB Docket No. 95-91, WT Docket No. 07-293, Attachment 2 at 8 (filed Feb. 13, 2009) ("Satellite radio signal reception is highly susceptible to interference from WCS mobile devices . . . Interference occurs in all manners of WCS in-vehicle orientations that were tested . . . Even in areas near Princeton, NJ where repeater coverage was encountered, WCS mobile devices caused interference to satellite reception.").

# EXHIBITS

1. Southwest Research Institute, Test Report for Project 16-14708: 2.3 GHz Outdoor Path Loss Testing at Southwest Research

2. Southwest Research Institute, Test Report for Project 16-14708: Laboratory Testing of Sirius XM Receiver Sensitivity to Interference from WCS Band

3. Southwest Research Institute, Test Report for Project 16-14708: Road Testing of Sirius XM Receiver Sensitivity to Interference from WCS Band

4. Motorola, Inc., Measurements of Signal Attenuation at 2.3 GHz from Inside-to-Outside of a Vehicle

5. Certification of Michael Pilcher, Southwest Research Institute

6. Certification of Nicholas E. Buris, Motorola, Inc.

# EXHIBIT 1

## SOUTHWEST RESEARCH INSTITUTE

## 2.3 GHZ OUTDOOR PATH LOSS TESTING AT SOUTHWEST RESEARCH

S O U T H W E S T R E S E A R C H I N S T I T U T E ®
6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS 78228-0510, USA • (210) 684-5111 • WWW.SWRI.ORG
SIGNAL EXPLOITATION AND GEOLOCATION DIVISION (16)
FAX: (210) 522-2709

February 26, 2009

Sirius XM Radio
989 Lenox Drive
Lawrenceville, New Jersey 08648

Attention: Mr. Stefano DiPierro, Senior Systems Engineer

Subject: Test Report for Project 16-14708
2.3 GHz Outdoor Path Loss Testing at SwRI

Dear Mr. DiPierro:

This report describes the tests conducted and results obtained during the outdoor propagation testing conducted on January 28 and 29, 2009 at SwRI in San Antonio, TX.

## 1.0 Executive Summary

Sirius XM Satellite Radio has commissioned SwRI to conduct independent RF testing related to signal propagation at 2.3 GHz. There were two main sets of tests described in this report.

During the first set of tests, CW signals were transmitted from a cart to the Satellite Digital Audio Receiver service (SDARS) receiver antenna mounted on top of a sedan from in front and from the side at ranges from 1 to 50 meters. The tests showed that propagation to the mounted antenna generally follows the standard free-space (range-squared) loss equations from most textbooks. Attenuation levels were, in all cases from 1 to 25 meters of range, between 40 and 75 dB.

During the second set of tests, CW signals were transmitted from 14 different locations inside the passenger compartment of one sedan and received by the SDARS receiver antenna mounted on the top of a second sedan. Measurements were conducted side by side at 3 and 6 meter (center to center) spacing. Measurements were also conducted with the cars in a front to back configuration at 3, 6, 9, and 12 meters (bumper to bumper). The transmitter was located in the front vehicle, and then the test was repeated with the transmitter in the rear vehicle.

The tests show that propagation from inside one vehicle to an adjacent vehicle varied significantly depending upon the position of the transmitter. Median values across positions for each orientation and range, varied from 62 to 78 dB. Attenuation levels were, in all cases, between 55 and 90 dB.

Table 1 – Summary Table for Median Attenuation Values (in dB)

| | Side-to-Side | | WCS Transmitter in Front | | | | SDARS Receiver in Front | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Range | 3 m | 6 m | 7.3 m | 10.3 m | 13.3 m | 16.3 m | 7.3 m | 10.3 m | 13.3 m | 16.3 m |
| Atten | 62.9 | 65.2 | 66.5 | 68.8 | 70.3 | 77.7 | 70.4 | 74.6 | 75.6 | 77.5 |

The median attenuation values among positions tended to be between 6 and 15 dB greater than free-space loss (i.e. n = 2), with effective propagation loss coefficients (n's) between 3.15 and

3.90, which is consistent with SwRI experience in microwave signal propagation through and around vehicles.

## 2.0 Background

Southwest Research Institute (SwRI®) is an independent, not-for-profit research and development organization, founded over 60 years ago for the purpose of applying science and technology for the betterment of mankind. The Institute has no shareholders. Our nonprofit status provides for objectivity on projects where other companies might have a conflict of interest.

SwRI is nationally recognized as a technology leader. The Institute has earned 30 R&D 100 Awards from R&D Magazine. In 2004, Popular Science magazine names two of our staff to the top 10 most brilliant young scientists in America today. SwRI has been inducted into the U.S. Space Foundation's Space Technology Hall of Fame and has received two DOD James S. Cogswell Outstanding Industrial Security Achievement Awards. In 2003, we received NASA's Software of the Year Award. Since our founding in 1947 we have been awarded 818 patents.

SwRI has world-class laboratory facilities located on our 1,200-acre property in San Antonio, Texas, with 2 million square feet of laboratories housing over $90 million of equipment. Our combined facility and equipment resources include both general-purpose facilities that may be used to support analysis, design, and fabrication activities as well as a number of specialized fabrication and testing facilities

The Signal Exploitation and Geolocation Division, which is conducting this project, is ISO 9001 certified and has supported commercial and government clients in radio signal research for decades. Facilities include anechoic chambers, screen rooms, and more than 160 acres of antenna test ranges.

## 3.0 Path Loss to Vehicle-Mounted Antenna

The purpose for this set of tests was to measure the path loss from a relatively omni-directional antenna simulating WCS transmitter power emissions to a typical, vehicle-mounted satellite radio antenna. The tests were conducted on January 28, 2009. There was no precipitation. The target vehicle was a Toyota Corolla Sedan with a standard production XM Satellite Radio antenna mounted on the roof.

### 3.1 Test Setup

For these tests, a continuous wave (CW) signal with +5 dBm (3 mW) of effective radiated power was produced at 2344.75 MHz from a dipole antenna placed at the same height as the roof of the vehicle. The transmitter cart was pulled away from the vehicle in one meter steps to 20 meters and 5 meter steps thereafter to 50 meters. Range was measured (1) with tape measure up to 10 meters and (2) a laser range-finder thereafter.

Figure 1, on the next page, is a diagram of the test setup. It shows the vehicle, antenna placement, specifics of distance of interest, and test equipment. The signal generator and spectrum analyzer are further described in section 3.2. The SDARS Receive antenna with integrated LNA has an effective gain of +21 dB, which is factored into the measurements taken. The WCS antenna has an effective gain of about 0 dB and the pattern measured at SwRI is included as Figure 2.

Tests were conducted with the transmitter both in front of the vehicle and to the side (perpendicular), as shown in Figures 3 (front) and 4 and 5 (perpendicular).

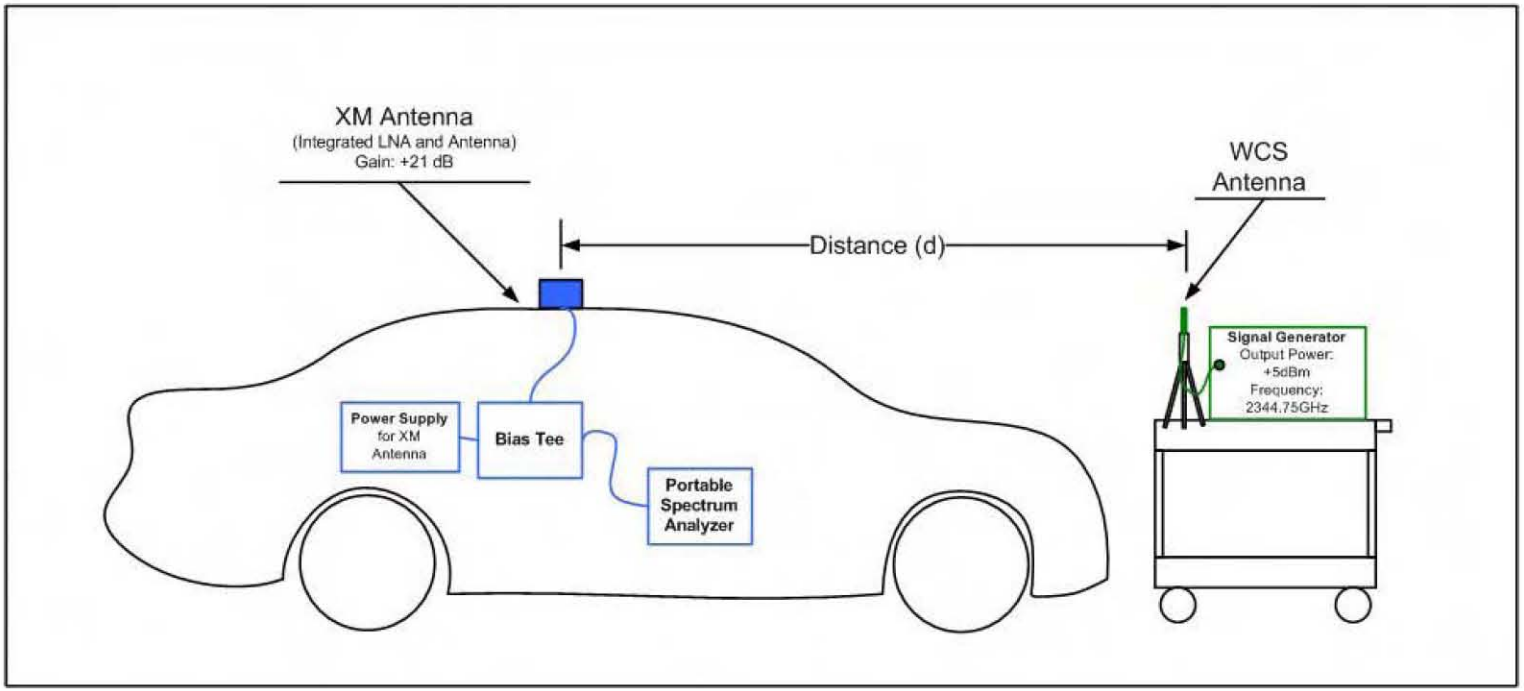



Figure 1 – Diagram of Path Loss to Vehicle Mounted Antenna

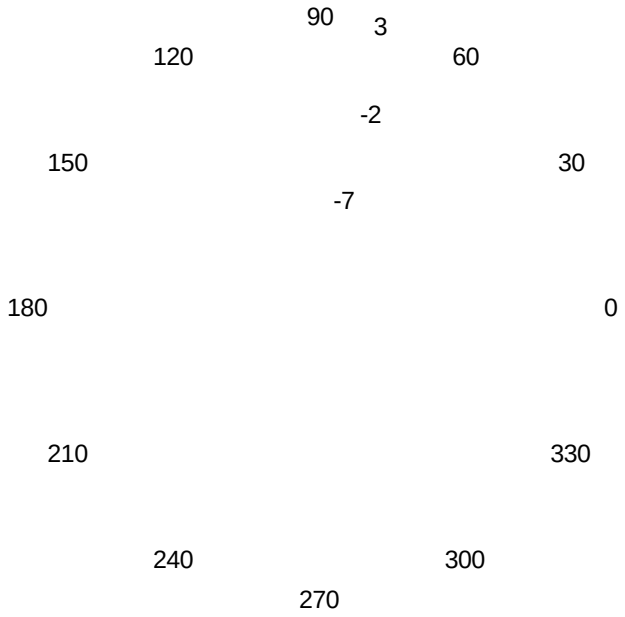



Figure 2 - WCS Antenna Pattern

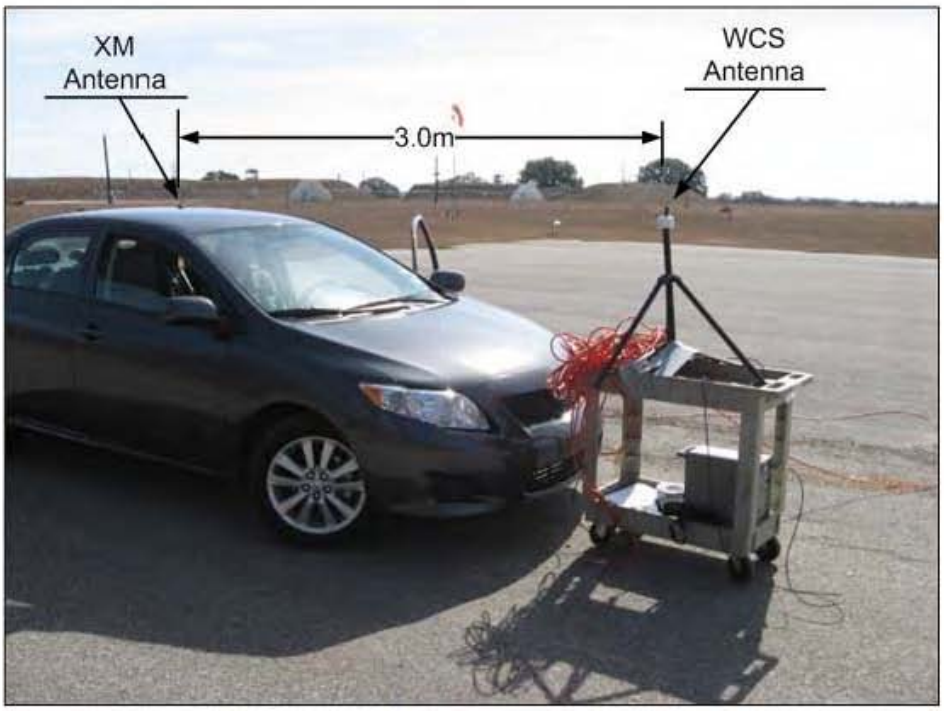



Figure 3 -Transmitter in Front of Vehicle

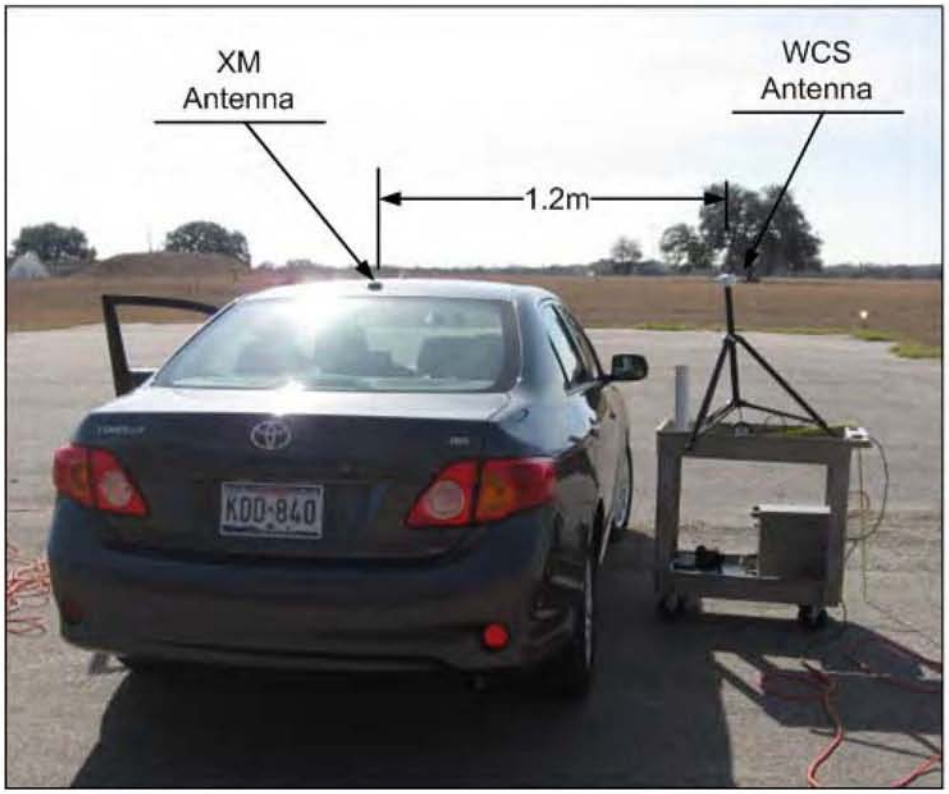



Figure 4 - Transmitter to the Side of Vehicle (Initial Position)

Figure 5 - Transmitter to the Side of Vehicle

### 3.2 Test Equipment Used

Electronic test and measurement equipment included:

Table 2 – Electronic Test and Measurement Equipment

| | P/N | S/N | Calibration |
|---|---|---|---|
| Signal Generator | Agilent 8648D | 3847M00124 | Due November 2009 |
| Spectrum Analyzer | Rhode & Schwarz FSH6 | 100814 | Due October 2009 |

### 3.3 Test Results

The raw test results are reported in the following table. The closest position possible for the side testing was about 1.2 meters, and the closest position possible for the in-front testing was 3.0 meters. Also included is the theoretical free space path loss (negative gain) based on omni-directional (0 dB gain) antennas and range-squared free-space attenuation. The path loss results reflect the 21 dB offset from the Sirius Antenna and LNA gain.

Table 3 - Path Loss to Vehicle-Mounted Antenna Results

| range (meters) | gain (dB) | | |
|---|---|---|---|
| | side | head-on | Theoretical |
| 1.2 | -41.0 | | -41.2 |
| 2.0 | -47.0 | | -45.9 |
| 3.0 | -51.5 | -52.4 | -49.4 |
| 4.0 | -54.7 | -57.3 | -51.9 |
| 5.0 | -55.4 | -58.4 | -53.8 |
| 6.0 | -60.6 | -58.7 | -55.4 |
| 7.0 | -59.0 | -59.4 | -56.7 |
| 8.0 | -63.9 | -60.5 | -57.9 |
| 9.0 | -63.2 | -62.7 | -58.9 |
| 10.0 | -62.9 | -61.0 | -59.8 |
| 11.0 | -65.6 | -63.2 | -60.7 |
| 12.0 | -64.0 | -66.0 | -61.4 |
| 13.0 | -64.6 | -63.9 | -62.1 |
| 14.0 | -68.9 | -65.4 | -62.8 |
| 15.0 | -66.5 | -65.7 | -63.4 |
| 16.0 | -66.3 | -69.7 | -63.9 |
| 17.0 | -67.4 | -68.3 | -64.5 |
| 18.0 | -71.9 | -70.5 | -64.9 |
| 19.0 | -66.2 | -69.2 | -65.4 |
| 20.0 | -68.0 | -68.0 | -65.9 |
| 25.0 | -68.7 | -69.0 | -67.8 |

Figures 6 and 7 show the measured (black) and theoretical (red) path losses on a logarithmic scale. Note that the side-view data corresponds more perfectly with the theoretical loss. This is most likely because the hood of the car produces a less ideal (less free-space) path between antennas.

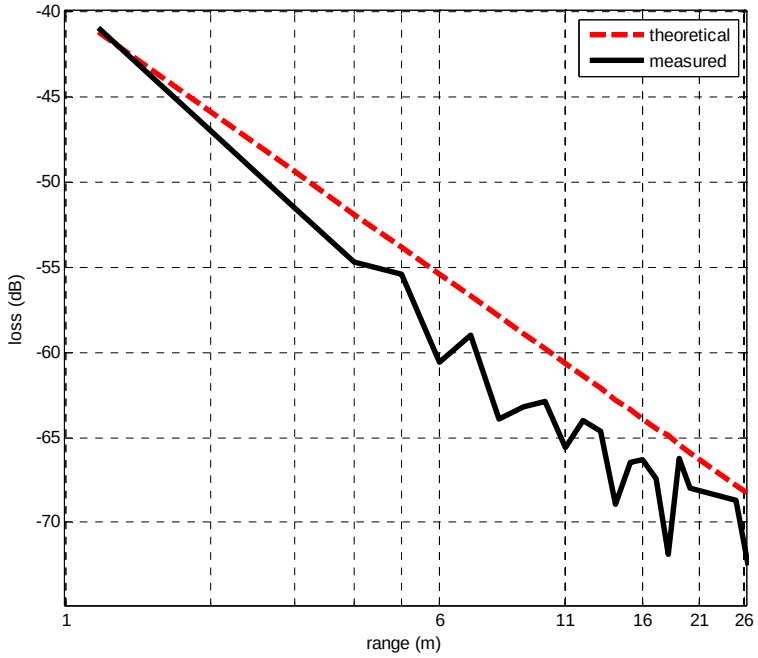



Figure 6 - Path Loss for Transmitter to the Side of the Vehicle

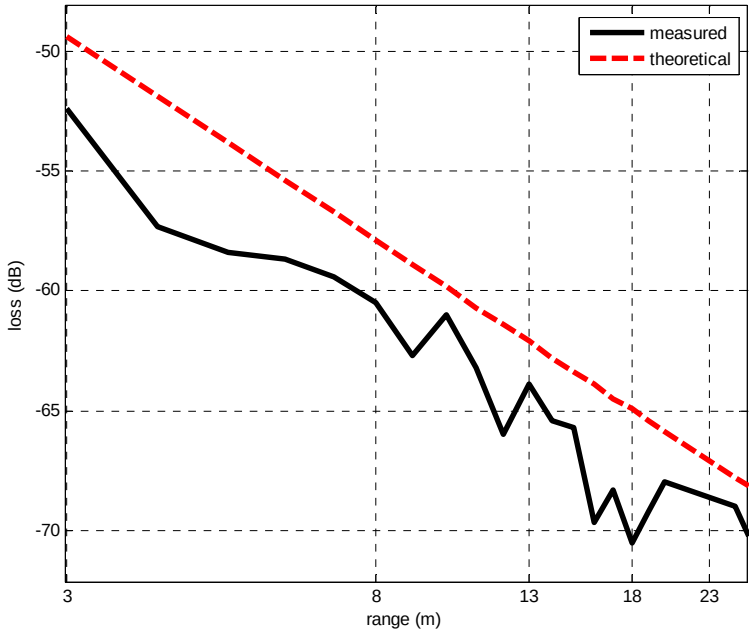



Figure 7 - Path Loss for Transmitter in Front of the Vehicle

## 4.0 Path Loss Between Vehicles

The purpose for this set of tests was to measure the path loss from a WCS transmitter located at various locations inside the passenger compartment of one vehicle to a satellite radio antenna mounted on another vehicle. The tests were conducted on the afternoon of January 28 and the morning of January 29, 2009. There was no precipitation.

## 4.1 Test Setup

For these tests a CW signal with +5 dBm (3 mW) of effective radiated power was produced at 2344.75 MHz from a dipole antenna placed in 14 potential positions inside a Nissan Altima Sedan. The satellite receiver antenna was once again mounted on a Toyota Corolla Sedan. The cars were spaced 3 and 6 meters apart in a side by side configuration. Then they were spaced 3, 6, 9, and 12 meters apart (bumper-to-bumper distance) in front to back configurations with the Sirius XM receiver antenna both in front and behind the WCS transmitter.

Figures 8 and 9 show the two vehicles in side by side and front to back configurations. Figures 10, 11, and 12 show three of the WCS transmitter positions.

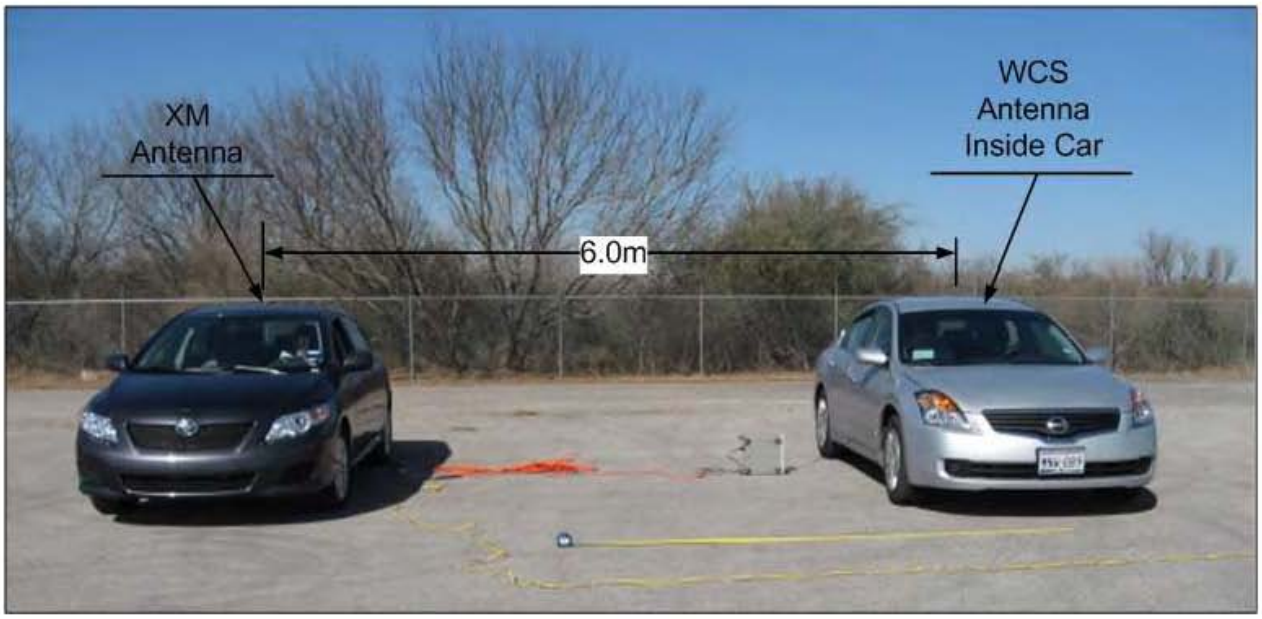



Figure 8 - Side by Side Configuration, 6 Meter Separation

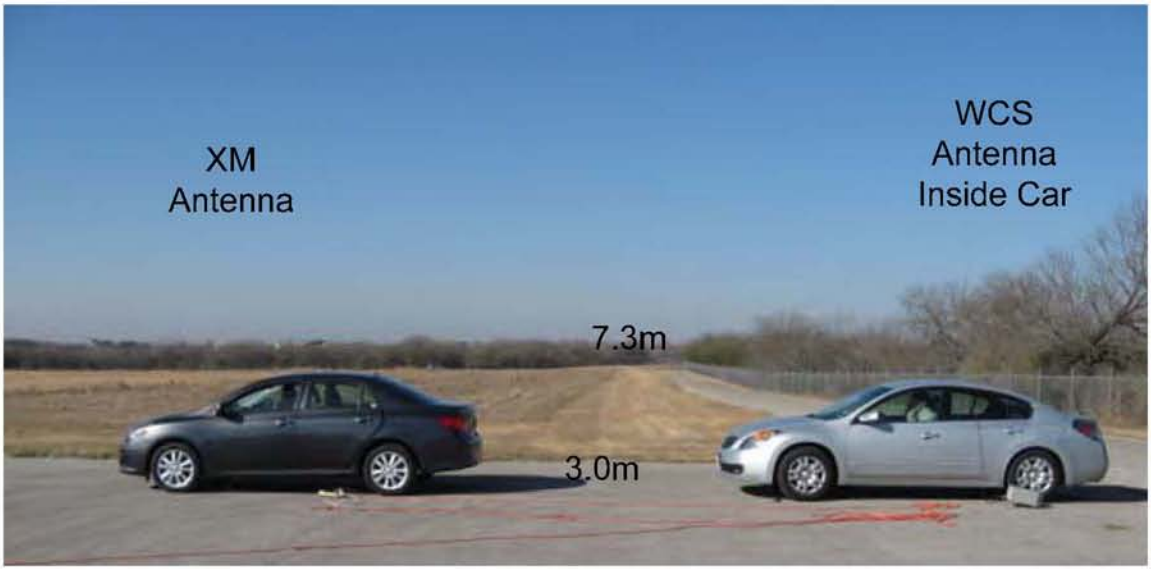



Figure 9 - SDARS Receiver antenna in Front, 3 Meter (Bumper-to-Bumper) Separation

Figure 10 - Left Rear Left (Cell Phone) Position

Figure 11 - Passenger Laptop Position

Figure 12 - Dashboard Position

### 4.2 Test Results

The raw test results are reported in the following tables and figures. Table 4 contains the side by side path loss data.

Table 4 – Path Loss Measurements between Vehicles (Side by Side)

| Position | Loss with 3 m range (dB) | Loss with 6 m range (dB) |
|---|---|---|
| Driver Left | -66.1 | -75.9 |
| Driver Right | -64.4 | -67.0 |
| Passenger Left | -72.5 | -81.0 |
| Passenger Right | -66.5 | -61.3 |
| Passenger Laptop | -59.0 | -61.9 |
| Dashboard | -58.5 | -67.0 |
| Left Rear Left | -73.0 | -73.4 |
| Left Rear Right | -64.8 | -66.5 |
| Left Rear Laptop | -56.0 | -63.9 |
| Right Rear Left | -71.0 | -75.3 |
| Right Rear Right | -56.4 | -59.9 |
| Right Rear Laptop | -56.7 | -63.9 |
| Center | -57.0 | -62.5 |
| Rear Window | -61.3 | -63.5 |
| Median for 14 Positions | -62.9 | -65.2 |

Figure 13 shows the complementary cumulative distribution function (CCDF) for vehicle positions as a function of path loss.

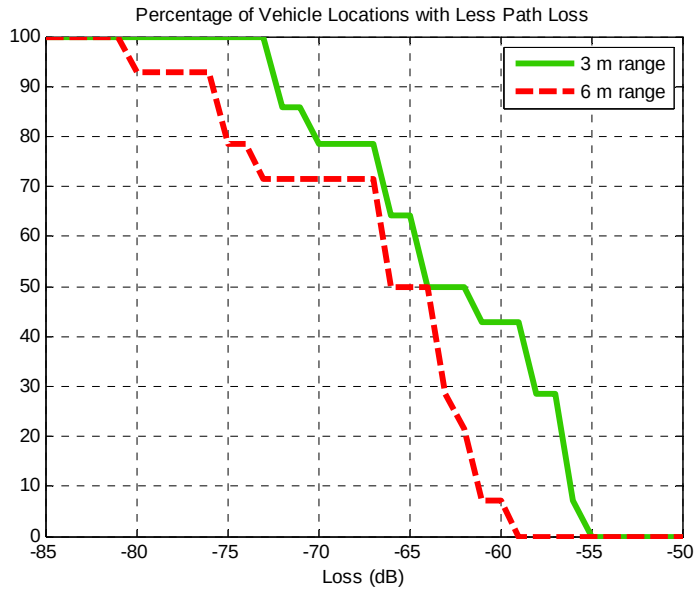



Figure 13 - CCDF of Automobile Positions vs. Path Loss

Table 5 contains the path loss measurements for the front-to-back automobile testing.

Table 5 – Path Loss Measurements (Front to Back Orientation) in dB

| | WCS Transmitter in Front | | | | Satellite Receiver in Front | | | |
|---|---|---|---|---|---|---|---|---|
| Bumper-to-Bumper Distance | 3.0 m | 6.0 m | 9.0 m | 12.0 m | 3.0 m | 6.0 m | 9.0 m | 12.0 m |
| Rooftop Center to Rooftop Center Distance | 7.3 m | 10.3 m | 13.3 m | 16.3 m | 7.3 m | 10.3 m | 13.3 m | 16.3 m |
| Driver Left | -73.2 | -74.3 | -83.4 | -77.3 | -68.1 | -81.8 | -70.7 | -77.5 |
| Driver Right | -63.3 | -67.6 | -70.7 | -74.5 | -71.0 | -71.8 | -86.0 | -77.7 |
| Passenger Left | -67.8 | -72.7 | -74.6 | -85.0 | -64.9 | -70.2 | -71.8 | -75.5 |
| Passenger Right | -69.0 | -69.1 | -73.7 | -81.5 | -66.9 | -74.3 | -75.7 | -75.3 |
| Passenger Laptop | -71.9 | -65.1 | -76.5 | -87.0 | -72.2 | -72.9 | -73.4 | -77.4 |
| Dashboard | -69.6 | -77.2 | -69.9 | -78.2 | -63.9 | -65.9 | -68.5 | -72.8 |
| Left Rear Left | -66.6 | -82.5 | -74.0 | -79.0 | -79.9 | -82.8 | -76.5 | -88.2 |
| Left Rear Right | -61.5 | -68.4 | -66.5 | -72.2 | -70.9 | -75.5 | -80.5 | -81.2 |
| Left Rear Laptop | -67.6 | -79.0 | -71.3 | -78.0 | -66.1 | -67.4 | -75.5 | -79.1 |
| Right Rear Left | -58.7 | -68.2 | -65.5 | -71.2 | -69.9 | -77.0 | -74.8 | -77.0 |
| Right Rear Right | -63.9 | -66.9 | -66.1 | -73.4 | -75.9 | -77.1 | -87.2 | -81.7 |
| Right Rear Laptop | -66.3 | -70.0 | -69.6 | -80.6 | -72.7 | -74.9 | -79.5 | -75.7 |
| Center | -61.0 | -64.7 | -68.7 | -73.8 | -67.3 | -67.4 | -69.0 | -70.9 |
| Rear Window | -61.5 | -65.7 | -65.9 | -70.5 | -72.3 | -77.7 | -80.2 | -81.6 |
| Median | -66.5 | -68.8 | -70.3 | -77.7 | -70.4 | -74.6 | -75.6 | -77.5 |

Figures 14 and 15 show the CCDFs for the front-to-back configurations.

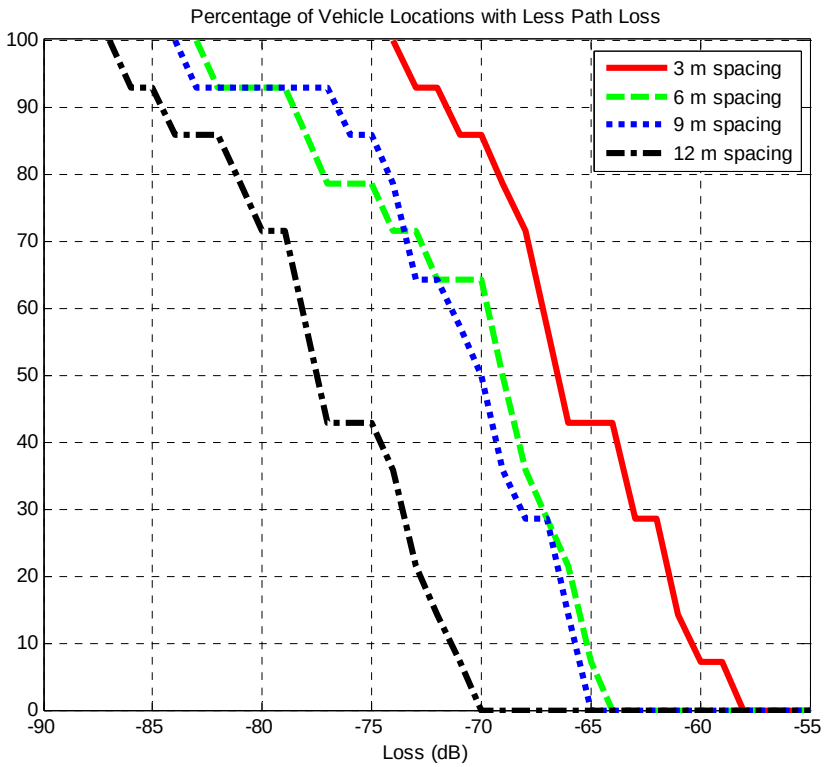



Figure 14 - CCDF for WCS Transmitter in Front

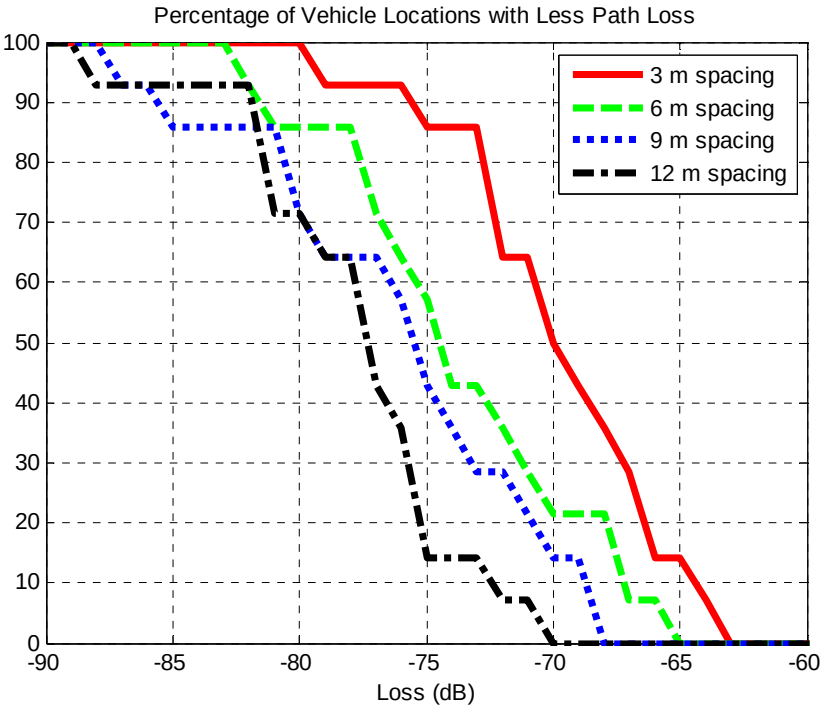



Figure 15 - CCDF for Satellite Receiver in Front

## 5.0 Conclusion

The first set of tests showed that propagation to the vehicle-mounted antenna generally follows the standard free-space (range-squared) loss equations from most textbooks. Attenuation levels were, in all cases from 1 to 25 meters of range, between 40 and 75 dB.

The vehicle-to-vehicle measurements in the second set of experiments show that propagation from inside one vehicle to an adjacent vehicle varied significantly depending upon the position of the transmitter. Median values across positions for each orientation and range, varied from 62 to 78 dB. Attenuation levels were, in all cases, between 55 and 90 dB.

The median attenuation values among positions tended to be between 6 and 15 dB greater than free-space loss (i.e. n = 2), with effective propagation loss coefficients (n's) between 3.15 and 3.90, which is consistent with SwRI experience in microwave signal propagation through and around vehicles.

If you have any questions concerning this report, you can contact Mike Pilcher at 210-522-2083 or via email at mpilcher@swri.org.

Sincerely,

Barbara Pilbin

Barbara Pilbin, Research Engineer
Surveillance Systems Section

**APPROVED:**

Michael E. Pilcher, Manager
Surveillance Systems Section

MEP/rl

c: Mr. Riza Akturan (rakturan@siriusradio.com)
Mr. Douglas Ayerst (Douglas.Ayerst@xmradio.com)

# EXHIBIT 2

## SOUTHWEST RESEARCH INSTITUTE

## LABORATORY TESTING OF SIRIUS XM RECEIVER SENSITIVITY TO INTERFERENCE FROM WCS BAND

S O U T H W E S T  R E S E A R C H  I N S T I T U T E ®

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS 78228-0510, USA • (210) 684-5111 • WWW.SWRI.ORG

SIGNAL EXPLOITATION AND GEOLOCATION DIVISION (16)
FAX: (210) 522-2709

February 26, 2009

Sirius XM Radio
989 Lenox Drive
Lawrenceville, New Jersey 08648

Attention: Mr. Stefano DiPierro, Senior Systems Engineer

Subject: Test Report for Project 16-14708
Laboratory Testing of SiriusXM Receiver Sensitivity to interference from WCS Band

Dear Mr. DiPierro:

This report describes the tests conducted and results obtained during the laboratory testing conducted on February 4, 5, and 6, 2009.

## 1.0 Executive Summary

Sirius XM Satellite Radio has commissioned SwRI to conduct independent RF testing related to muting of satellite receivers from adjacent channel overload and out-of-band emissions (OOBE). This report covers four sets of tests including:

- Muting Levels with WCS Signals and OOBE
- Muting Levels with WCS Signals Only
- Required Terrestrial Repeater Levels to Overcome Muting

Terrestrial reinforcement levels of -81 to -46 dBm were required to overcome muting from WCS overload and OOBE at 3 and 10 meters. Without such reinforcement from terrestrial repeaters, muting always occurred from WCS overload (at +22 or +24 dBm channel power) in any of the adjacent blocks at a simulated range of 3 meters, even with no OOBE. Addition and amplification of OOBE significantly increased the interference range.

Then the expected interference ranges were calculated based on free-space loss, thus representing conservative figures considering vehicle to vehicle measurements presented in past reports.

These ranges were in generally over 21 meters even for +12 or +14 dBm levels for the adjacent (C and D) block transmissions with OOBE, and generally over 67 meters for +22 and +24 dBm transmission levels. Measurements of interference sensitivity in the B-Lower and A-Upper blocks generally resulted in interference ranges from 4 to 75 meters (conservatively), depending upon the tested WCS carrier power and mask levels; +14 dBm with a 90 + 10 log( P ) mask and +24 dBm with a 60 + 10 log( P ) mask, respectively.

## 2.0 Background

Southwest Research Institute (SwRI®) is an independent, not-for-profit research and development organization, founded over 60 years ago for the purpose of applying science and technology for the betterment of mankind. The Institute has no shareholders. Our nonprofit status provides for objectivity on projects where other companies might have a conflict of interest.

SwRI is nationally recognized as a technology leader. The Institute has earned 30 R&D 100 Awards from R&D Magazine. In 2004, Popular Science magazine names two of our staff to the top 10 most brilliant young scientists in America today. SwRI has been inducted into the U.S. Space Foundation's Space Technology Hall of Fame and has received two DOD James S. Cogswell Outstanding Industrial Security Achievement Awards. In 2003, we received NASA's Software of the Year Award. Since our founding in 1947 we have been awarded 818 patents.

SwRI has world-class laboratory facilities located on our 1,200-acre property in San Antonio, Texas, with 2 million square feet of laboratories housing over $90 million of equipment. Our combined facility and equipment resources include both general-purpose facilities that may be used to support analysis, design, and fabrication activities as well as a number of specialized fabrication and testing facilities

The Signal Exploitation and Geolocation Division, which is conducting this project, is ISO 9001 certified and has supported commercial and government clients in radio signal research for decades. Facilities include anechoic chambers, screen rooms, and more than 160 acres of antenna test ranges.

Sirius XM Satellite Radio has commissioned SwRI to conduct independent RF testing related to muting of satellite receivers from adjacent channel overload and out-of-band emissions (OOBE).

## 3.0 Muting Levels with WCS Signal and Frequency Masks

The purpose for this set of tests was to measure the WCS signal levels required to mute a satellite radio receiver in various combinations of frequency bands and emission masks.

### 3.1 Test Setup

For these tests satellite signals were generated at levels of -100 dBm per satellite. For tests with the XM system, each carrier of the ensemble was set to -103 dBm, resulting in a composite ensemble power of -100 dBm. The radio under test received both satellite streams at all times for these tests. WCS and white (Gaussian) noise signals were also generated, attenuated, and coupled into the satellite signal. All signal frequencies and power levels were verified using a calibrated spectrum analyzer. Attenuation was adjusted in order to determine the minimum attenuation setting (maximum signal power) that the satellite receiver could tolerate without muting for at least one minute. For Sirius signals, an audio channel with a 1 kHz test tone was played on a speaker, and for XM signals, a laptop was setup to record mutes caused by the bit errors exceeding an error threshold. Figure 1 shows the basic test setup.

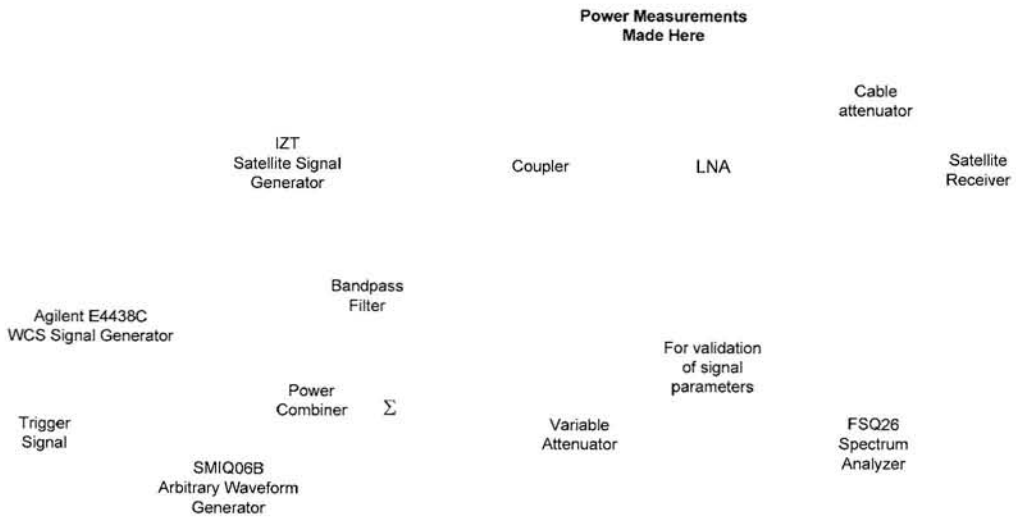



Figure 1 – Laboratory Setup, Frequency Masks

Tests were run with initial WCS output power levels of -40 and -30 dBm (for A and B blocks) and -38 dBm and -28 dBm (for C and D blocks), representing expected WCS output powers of +12, +14, +22, and +24 dBm (depending upon the band) with 52 dB of path loss (based on the path loss measured at 3 m separation distance between the WCS transmit and SiriusXM receive antennas). These values represent average power during a burst, thus the peak power is higher due to the crest factor of the WCS signal, and the overall average power is lower due to the 25% duty cycle.

The SMIQ06B was used to generate white noise outside of the WCS band in the Satellite Radio bands to represent the tested WCSA OOBE (Out-of-Band Emissions) mask. Bandpass filters were used to ensure that the WCS signal generator did not add any further noise in these bands. The noise level was set to -77, -82, or -112 dBm per 1 MHz bandwidth, corresponding to -25, -30, or -60 dBm per 1 MHz with 52 dB of path loss. Note that these also correspond to 55 + 10 log( P ), 60 + 10 log( P ), and 90 + 10 log ( P ) spectral masks (where P is in Watts).

These figures are also average power during a burst (again with higher peak and lower average from crest factor and duty cycle). The noise signals were triggered to align with the WCS signals (verified using the spectrum analyzer), but the SMIQ noise generator could not match the 25% duty cycle precisely, thus a duty cycle of 30% was used instead.

WCS signals were generated in the WCS B Lower, WCS C, WCS D, and WCS A Upper bands, while noise was generated in the SDARS Sirius and SDARS XM bands. See Table 1 for relevant frequency allocations.

Table 1 – Relevant Frequency Allocations

| Service | Frequency (MHz) | Power Levels Tested | OOBE Masks Tested |
|---|---|---|---|
| WCS A Lower | 2305 to 2310 | - | - |
| WCS B Lower | 2310 to 2315 | +14, +24 dBm | 60, 90 |
| WCS C | 2315 to 2320 | +12, +22 dBm | 60, 90 |
| SDARS Sirius | 2320 to 2332.5 | -100 dBm | - |
| SDARS XM | 2332.5 to 2345 | -103 dBm x 2 | - |
| WCS D | 2345 to 2350 | +12, +22 dBm | 55, 90 |
| WCS A Upper | 2350 to 2355 | +14, +24 dBm | 55, 90 |
| WCS B Upper | 2355 to 2360 | - | - |

For each of these four bands, and under each power level and spectral mask the minimum attenuation (maximum WCS signal power) level which would allow un-muted transmission for at least one minute was recorded.

## 3.2 Test Equipment

Electronic test and measurement equipment with calibration dates are recorded in Table 2. Radios used are included in Table 3.

Table 2 – Major Electronic Test and Measurement Equipment

| | P/N | S/N | Calibration |
|---|---|---|---|
| Signal Generator | Agilent E4438C | US41461299 | Due April 2009 |
| Signal Generator | Rhode & Schwarz SMIQ03B | DE27480 | Due August 2010 |
| Spectrum Analyzer | Rhode & Schwarz FSQ26 | 100060 | Due November 2009 |

Table 3 – Receiver Radios

| Service | Model | S/N |
|---|---|---|
| Sirius | Starmate | 008663733365 |
| XM | RoadyXT | 6L3KT088 |

## 3.3 Test Results

Prior to each test the input signals were verified on the calibrated spectrum analyzer. Figure 2 shows the WCS and noise signals with 100% duty cycle, measured at 1 MHz resolution bandwidth. Note the 5 MHz WCS signal has a reading of -35.5 dBm per 1 MHz. Adding 52 dB for 3 meters of path loss and 7 dB for the 5 MHz actual bandwidth (versus 1 MHz measured) yields a signal level of +23.5 dBm, which is just under the 250 mW simulated transmit level. Note that the noise measurement is -82.7 dBm per 1 MHz. Adding the 52 dB of simulated path loss gives an effective transmit power of -30 dBm per 1 MHz, thus simulating the 60 + 10 log( P ) mask. A similar procedure was used to verify the 55 + 10 log( P ) mask.

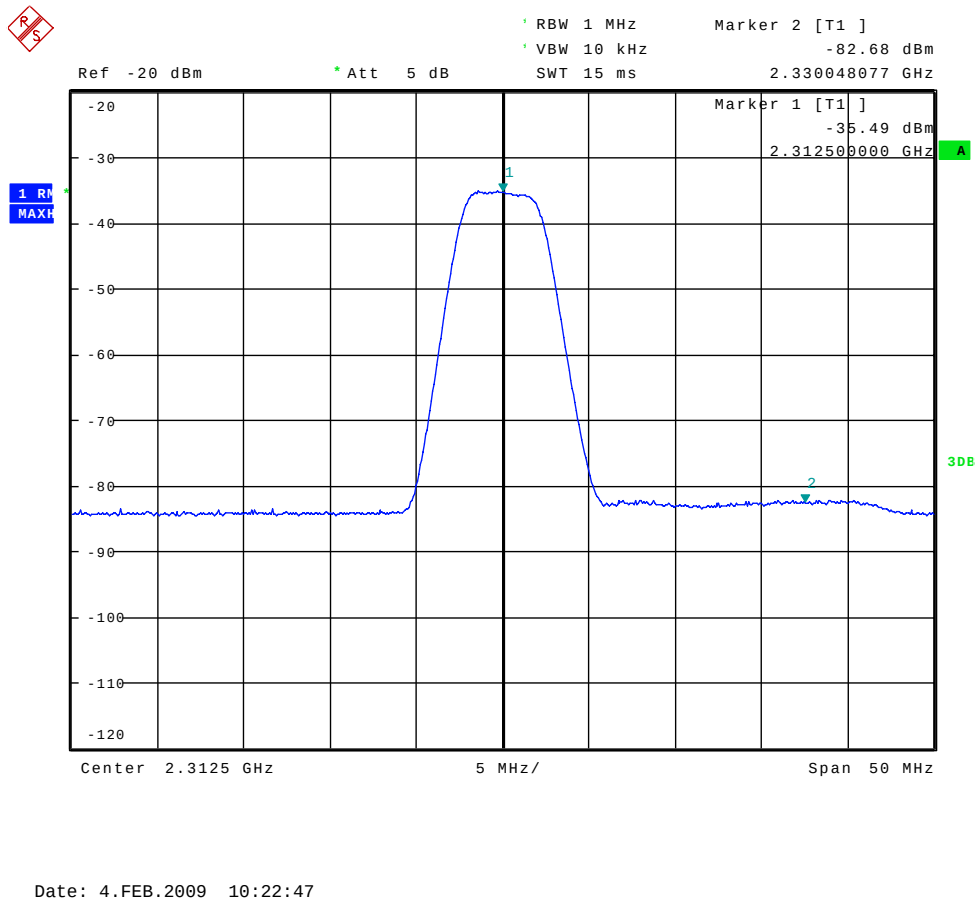



Figure 2 – Output from FSQ26 Spectrum Analyzer – WCS and Noise Signals

Results for the muting in the SDARS Sirius band from WCS transmission in the B-Lower block are recorded in Table 4. Corresponding power levels are calculated by subtracting the required attenuation required from the power level (in addition to the 52 dB for 3 meters). Because 52 dB of path loss for 3 meters is already included, the additional attenuation represents additional free space (range-squared) loss, thus range is calculated by multiplying 3 meters by the square root of the required loss.

Table 4 – Muting Levels from WCS B-Lower Block

| WCS Signal Power (dBm) | Out-of-Band Mask (dB) | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|---|
| +14 | 60 + 10 log( P ) | 27 | -65 | 67 |
| +14 | 90 + 10 log( P ) | 3 | -41 | 4 |
| +24 | 60 + 10 log( P ) | 28 | -56 | 75 |
| +24 | 90 + 10 log( P ) | 15 | -43 | 17 |

Results for the muting in the SDARS Sirius band from WCS transmission in the C block are recorded in Table 5. Corresponding WCS power levels of less than -57 dBm were not recorded, and attenuation experimentation was halted in each case, once that point was reached.

Table 5 – Muting Levels from WCS C Block

| WCS Signal Power (dBm) | Out-of-Band Mask (dB) | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|---|
| +12 | 60 + 10 log( P ) | > 17 | < -57 | > 21 |
| +12 | 90 + 10 log( P ) | > 17 | < -57 | > 21 |
| +22 | 60 + 10 log( P ) | > 27 | < -57 | > 67 |
| +22 | 90 + 10 log( P ) | > 27 | < -57 | > 67 |

Results for the muting in the SDARS XM band from WCS transmission in the D block are recorded in Table 6.

Table 6 – Muting Levels from WCS D Block

| WCS Signal Power (dBm) | Out-of-Band Mask (dB) | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|---|
| +12 | 55 + 10 log( P ) | > 17 | < -57 | > 21 |
| +12 | 90 + 10 log( P ) | > 17 | < -57 | > 21 |
| +22 | 55 + 10 log( P ) | > 27 | < -57 | > 67 |
| +22 | 90 + 10 log( P ) | > 27 | < -57 | > 67 |

Results for the muting in the SDARS XM band from WCS transmission in the A Upper block are recorded in Table 7.

Table 7 – Muting Levels from A Upper Band

| WCS Signal Power (dBm) | Out-of-Band Mask (dB) | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|---|
| +14 | 55 + 10 log( P ) | 20 | -58 | 30 |
| +14 | 90 + 10 log( P ) | 2 | -40 | 4 |
| +24 | 55 + 10 log( P ) | 20 | -48 | 30 |
| +24 | 90 + 10 log( P ) | 11 | -39 | 11 |

## 4.0 Muting Levels from WCS Signal Overload

The purpose for this set of tests was to measure the WCS signal levels required to mute a satellite radio receiver in different frequency bands with essentially no out-of-band signals.

### 4.1 Test Setup

For these tests satellite signals were generated at levels of -100 dBm per satellite. For tests with the XM system, each carrier of the ensemble was set to -103 dBm, resulting in a composite ensemble power of -100 dBm. The performance of the satellite radio when receiving both satellite signals, as well as individual satellite signals was tested. WCS signals were also generated, attenuated, and coupled into the satellite signal. All signal frequencies and power levels were verified using a calibrated spectrum analyzer. Attenuation was adjusted in order to determine the minimum attenuation setting (maximum signal power) that the satellite receiver could tolerate without muting for at least one minute. For Sirius signals, a 1 kHz tone was played on a speaker, and for XM signals, a laptop was setup to record mutes caused by too many bit errors. Figure 3 shows the basic test setup.

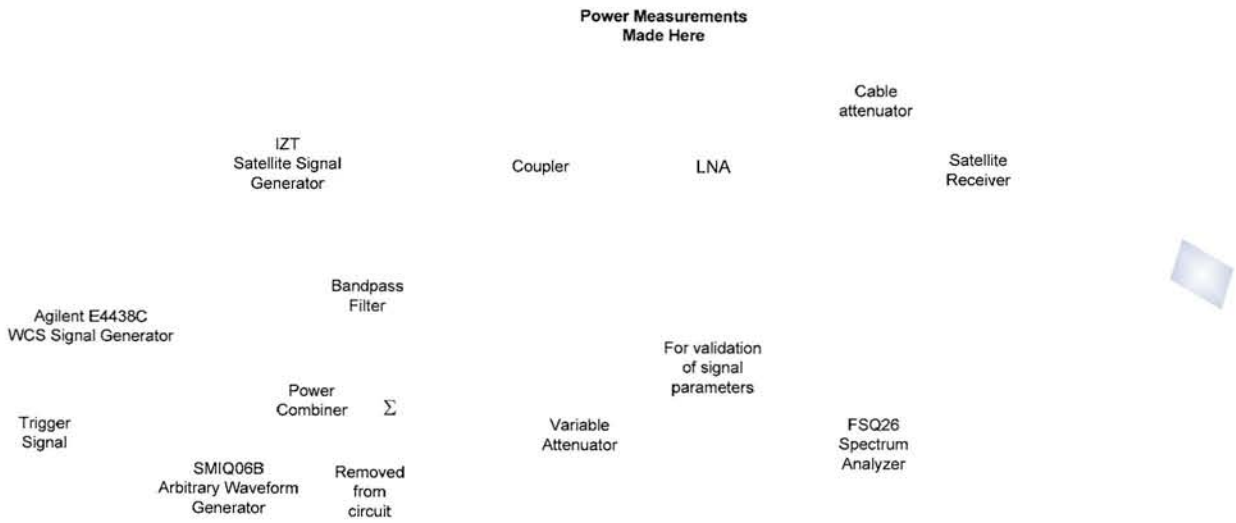



Figure 3 – Laboratory Setup, WCS Signal Overload

Tests were run with WCS output power levels of -40 and -28 dBm, representing expected WCS output powers of +22 and +24 dBm (depending upon the block) with 52 or 62 dB of path loss (based on a 3 m and 10 m measurement). These figures are average power during a burst, thus the peak power is higher due to the crest factor of the WCS signal, and the long-period average power is lower than the burst average power due to the duty cycle of 25%. The SMIQ, used previously to generate noise in the Satellite Radio bands, was electrically removed from the circuit, and second combiner input was loaded with a 30 dB attenuator.

## 4.2 Test Equipment

Electronic test and measurement equipment with calibration dates are recorded in Table 8.

Table 8 – Major Electronic Test and Measurement Equipment

| | P/N | S/N | Calibration |
|---|---|---|---|
| Signal Generator | Agilent E4438C | US41461299 | Due April 2009 |
| Signal Generator | Rhode & Schwarz SMIQ06B | DE27480 | Due August 2010 |
| Spectrum Analyzer | Rhode & Schwarz FSQ26 | 100060 | Due November 2009 |

## 4.3 Test Results

Prior to each test the input signals were verified on the calibrated spectrum analyzer. Results for the muting in the SDARS Sirius band from WCS transmission in the B Lower block are recorded in Table 9. Corresponding power levels are calculated by subtracting the attenuation required from -28 dBm (+24 dBm minus 52 dB for 3 meters). Range is calculated by determining range for additional free-space loss at each attenuation level and multiplying by 3 meters.

Test combinations included each satellite individually (at a power level of -100 dBm), both satellites together, and the terrestrial repeater signal (at a power level of -95 dBm).

Table 9 – Muting Levels from B Lower Block, WCS Overload

| Satellite Transmitters Active | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|
| Satellite 1 Only | 21 | -49 | 34 |
| Satellite 2 Only | 14 | -42 | 15 |
| Both Satellites | 13 | -41 | 13 |
| Terrestrial Repeater | 12 | -40 | 12 |

Results for the muting in the SDARS Sirius band from WCS transmission in the C block are recorded in Table 10 Corresponding power levels are calculated by subtracting the attenuation required from -40 dBm (+22 dBm minus 62 dB for 10 meters). Range is calculated by determining range for additional free-space loss at each attenuation and multiplying by 10 meters. Test combinations included each satellite individually (at a power level of -100 dBm), both satellites together, and the terrestrial repeater signal (at -95 dBm).

Table 10 – Muting Levels from C Block, WCS Overload

| Satellite Transmitters Active | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|
| Satellite 1 Only | > 27 | < -67 | >224 |
| Satellite 2 Only | 22 | -62 | 126 |
| Both Satellites | 22 | -62 | 126 |
| Terrestrial Repeater | 7 | -47 | 22 |

Results for the muting in the SDARS XM band from WCS transmission in the D block are

recorded in Table 11. Corresponding power levels are calculated by subtracting the attenuation required from -40 dBm (+22 dBm minus 62 dB for 10 meters). Range is calculated by determining range for additional free-space loss at each attenuation and multiplying by 10 meters. Test combinations included each satellite individually (at a power level of -100 dBm), both satellites together, and the terrestrial repeater signal (at -95 dBm).

Table 11 – Muting Levels from D Block, WCS Overload

| Satellite Transmitters Active | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|
| Satellite 1 Only | 24 | -64 | 158 |
| Satellite 2 Only | 23 | -63 | 141 |
| Both Satellites | 19 | -59 | 89 |
| Terrestrial Repeater | 26 | -66 | 200 |

Results for the muting in the SDARS XM band from WCS transmission in the A Upper block are recorded in Table 12. Corresponding power levels are calculated by subtracting the attenuation required from -28 dBm (+24 dBm minus 52 dB for 3 meters). Range is calculated by determining range for additional free-space loss at each attenuation and multiplying by 3 meters. Test combinations included each satellite individually (at a power level of -100 dBm), both satellites together, and the terrestrial repeater signal (at a power level of -95 dBm).

Table 12 – Muting Levels from A Upper Block, WCS Overload

| Satellite Transmitters Active | Attenuation (dB) | Corresponding WCS Power (dBm) | Corresponding Range (m) |
|---|---|---|---|
| Satellite 1 Only | 16 | -44 | 19 |
| Satellite 2 Only | 15 | -43 | 17 |
| Both Satellites | 11 | -39 | 11 |
| Terrestrial Repeater | 12 | -40 | 12 |

## 5.0 Terrestrial Repeater Levels Required to Overcome Muting

The purpose for this set of tests was to measure the required terrestrial repeater level to overcome muting from WCS interference with duty cycle of 25% at ranges of 3 m and 6 m.

### 5.1 Test Setup

For these tests satellite signals were generated at levels of -100 dBm per satellite. For tests with the XM system, each carrier of the ensemble was set to -103 dBm, resulting in a composite ensemble power of -100 dBm. Terrestrial repeater signals began at -95 dBm and were increased in order to overcome the interference. WCS and white (Gaussian) noise signals were also generated, attenuated, and coupled into the satellite signal. All signal frequencies and power levels were verified using a calibrated spectrum analyzer. For Sirius signals, an audio test channel with a 1 kHz tone was played on a speaker, and for XM signals, a laptop was setup to record mutes caused by excessive bit errors. Figure 4 shows the basic test setup.

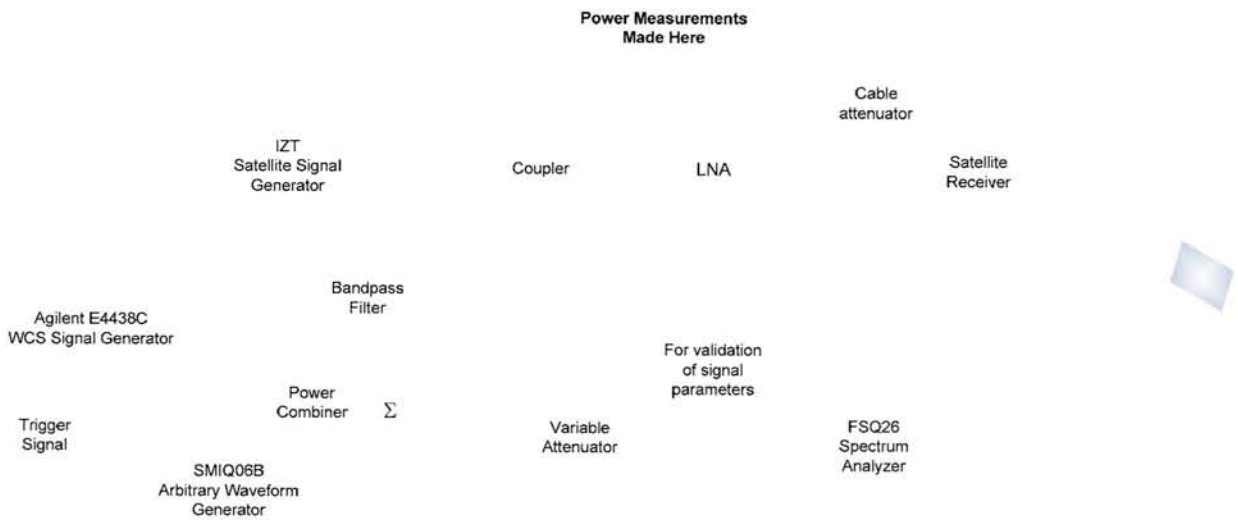



Figure 4 – Laboratory Setup, Frequency Masks

Tests were run with WCS output power levels of -40, -38, -30, and -28 dBm, representing expected WCS output powers of +22 and +24 dBm (depending upon the block) with 52 and 62 dB of path loss (based on a 3 m and a 6 m measurement). These figures are average power during a burst, thus the peak power is higher due to the crest factor of the WCS signal, and the average power is lower due to the 25% duty cycle.

The SMIQ was used to generate white noise outside of the WCS band in the Satellite Radio bands to represent the spectral mask. Bandpass filters were used to ensure that the WCS signal generator did not add any noise in these bands. The noise level was set to -77, -82, -87, or -92 dBm per 1 MHz bandwidth, corresponding to -25 or -30 dBm per 1 MHz with 52 or 62 dB of path loss.

These figures are also average power during a burst (again with higher peak and lower average from crest factor and duty cycle). The noise signals were triggered to align with the WCS signals (verified using the spectrum analyzer), but the SMIQ could not match the duty cycle precisely, so 30% was used instead of 25%.

## 5.2 Test Equipment

Electronic test and measurement equipment with calibration dates are recorded in Table 13.

Table 13 – Major Electronic Test and Measurement Equipment

| | P/N | S/N | Calibration |
|---|---|---|---|
| Signal Generator | Agilent E4438C | US41461299 | Due April 2009 |
| Signal Generator | Rhode & Schwarz SMIQ06B | DE27480 | Due August 2010 |
| Spectrum Analyzer | Rhode & Schwarz FSQ26 | 100060 | Due November 2009 |

## 5.3 Test Results

Prior to each test the input signals were verified on the calibrated spectrum analyzer. Results for the muting in the SDARS Sirius band from WCS transmission in the WCS B Lower block are recorded in Table 14. In each case the WCS transmit power is +24 dBm and noise power level is -30 dBm per 1 MHz, both prior to path loss

Table 14 – Terrestrial Recovery Levels for Interference from WCS B Lower Block

| Path Loss Attenuation | Simulated Distance | Muting Observed | Required Terrestrial Repeater Signal Power |
|---|---|---|---|
| 52 dB | 3 m | Yes | -51 dBm |
| 62 dB | 10 m | Yes | -81 dBm |

Results for the muting in the SDARS Sirius band from WCS transmission in the WCS C block are recorded in Table 15. In each case the WCS transmit power is +22 dBm and noise power level is -25 dBm per 1 MHz, both prior to path loss

Table 15 – Terrestrial Recovery Levels for Interference from WCS C Block

| Path Loss Attenuation | Simulated Distance | Muting Observed | Required Terrestrial Repeater Signal Power |
|---|---|---|---|
| 52 dB | 3 m | Yes | -46 dBm |
| 62 dB | 10 m | Yes | -80 dBm |

Results for the muting in the SDARS XM band from WCS transmission in the WCS D block are recorded in Table 16. In each case the WCS transmit power is +22 dBm and noise power level is -25 dBm per 1 MHz, both prior to path loss

Table 16 – Terrestrial Recovery Levels for Interference from WCS D Block

| Path Loss Attenuation | Simulated Distance | Muting Observed | Required Terrestrial Repeater Signal Power |
|---|---|---|---|
| 52 dB | 3 m | Yes | -53 dBm |
| 62 dB | 10 m | Yes | -64 dBm |

Results for the muting in the SDARS XM band from WCS transmission in the WCS A Upper block are recorded in Table 17. In each case the WCS transmit power is +24 dBm and noise power level is -30 dBm per 1 MHz, both prior to path loss

Table 17 – Terrestrial Recovery Levels for Interference from WCS A Upper Block

| Path Loss Attenuation | Simulated Distance | Muting Observed | Required Terrestrial Repeater Signal Power |
|---|---|---|---|
| 52 dB | 3 m | Yes | -69 dBm |
| 62 dB | 10 m | Yes | -78 dBm |

## 6.0 Conclusion

Terrestrial reinformcement levels of -81 to -46 dBm were required to overcome muting from WCS overload and OOBE at 3 and 10 meters. Without such reinforcement from terrestrial repeaters, muting always occurred from WCS overload (at +22 or +24 dBm channel power) in any of the adjacent blocks at a simulated range of 3 meters, even with no OOBE. Addition and amplification of OOBE significantly increased the interference range.

Then the expected interference ranges were calculated based on free-space loss, thus representing conservative figures considering vehicle to vehicle measurements presented in past reports.

These ranges were in generally over 21 meters even for +12 or +14 dBm levels for the adjacent (C and D) block transmissions with OOBE, and generally over 67 meters for +22 and +24 dBm transmission levels. Measurements of interference sensitivity in the B-Lower and A-Upper blocks generally resulted in interference ranges from 4 to 75 meters (conservatively), depending upon the tested WCS carrier power and mask levels; +14 dBm with a 90 + 10 log( P ) mask and +24 dBm with a 60 + 10 log( P ) mask, respectively.

If you have any questions concerning you can contact Mike Pilcher at 210-522-2083 or via email at mpilcher@swri.org.

Sincerely,

Barbara Pilbin, Research Engineer
Surveillance Systems Section

**APPROVED:**

Michael E. Pilcher, Manager
Surveillance Systems Section

MEP/rl

c: Mr. Riza Akturan (rakturan@siriusradio.com)
Mrs. Barbara Pilbin (bpilbin@swri.org)

**EXHIBIT 3**

**SOUTHWEST RESEARCH INSTITUTE**

# ROAD TESTING OF SIRIUS XM RECEIVER SENSITIVITY TO INTERFERENCE FROM WCS BAND

S O U T H W E S T  R E S E A R C H  I N S T I T U T E ®

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS 78228-0510, USA • (210) 684-5111 • WWW.SWRI.ORG

SIGNAL EXPLOITATION AND GEOLOCATION DIVISION (16)
FAX: (210) 522-2709

February 26, 2009

Sirius XM Radio
989 Lenox Drive
Lawrenceville, New Jersey 08648

Attention: Mr. Stefano DiPierro, Senior Systems Engineer

Subject: Test Report for Project 16-14708
Road Testing of SiriusXM Receiver Sensitivity to interference from WCS Band

Dear Mr. DiPierro:

This report describes the tests conducted and results obtained during the road testing conducted on February 6, 2009.

## 1.0 Executive Summary

Sirius XM Satellite Radio has commissioned SwRI to conduct independent RF testing related to muting of satellite receivers from adjacent channel overload and out-of-band emissions (OOBE). This report covers the tests conducted in vehicles, while driving in traffic.

The tests demonstrate that despite vehicle to vehicle propagation losses, WCS signals generally cause muting to occur with SDARS receivers up to at least 20 meters away. Tests were conducted in both C block (at 150 mW transmit power) and B-Lower block (at 250 mW transmit power), and observations were made with the receiver both leading and lagging the transmitter.

## 2.0 Background

Southwest Research Institute® (SwRI®) is an independent, not-for-profit research and development organization, founded over 60 years ago for the purpose of applying science and technology for the betterment of mankind. The Institute has no shareholders. Our nonprofit status provides for objectivity on projects, where other companies might have a conflict of interest.

SwRI is nationally recognized as a technology leader. The Institute has earned 30 R&D 100 Awards from R&D Magazine. In 2004, Popular Science magazine names two of our staff to the top 10 most brilliant young scientists in America today. SwRI has been inducted into the U.S. Space Foundation's Space Technology Hall of Fame and has received two DOD James S. Cogswell Outstanding Industrial Security Achievement Awards. In 2003, we received NASA's Software of the Year Award. Since our founding in 1947 we have been awarded 818 patents.

SwRI has world-class laboratory facilities located on our 1,200-acre property in San Antonio, Texas, with 2 million square feet of laboratories housing over $90 million of equipment. Our

combined facility and equipment resources include both general-purpose facilities that may be used to support analysis, design, and fabrication activities as well as a number of specialized fabrication and testing facilities

The Signal Exploitation and Geolocation Division, which is conducting this project, is ISO 9001 certified and has supported commercial and government clients in radio signal research for decades. Facilities include anechoic chambers, screen rooms, and more than 160 acres of antenna test ranges.

Sirius XM Satellite Radio has commissioned SwRI to conduct independent RF testing related to muting of satellite receivers from adjacent channel overload and out-of-band emissions (OOBE).

## 3.0 Testing

The purpose for this set of tests was to determine muting ranges while driving in traffic and to record any observed traffic-specific phenomena.

### 3.1 Test Setup

For these test, WCS and white (Gaussian) noise signals were generated and transmitted from a standard dipole antenna in one vehicle. Signal frequencies and power levels were verified using a calibrated spectrum analyzer.

A second vehicle, equipped with an SDARS receiver, was driven in front, behind, and to the side of the other vehicle, and muting results were recorded.

Figure 1 shows a diagram of the transmitter setup.

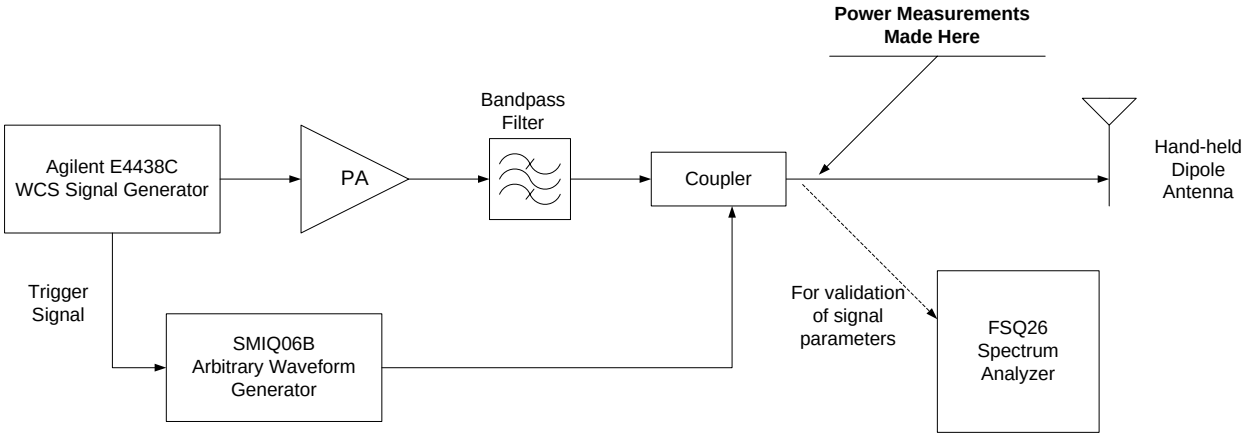



Figure 1 – Diagram of Transmitter Setup

Tests were run with WCS output power levels of +22 dBm (150 mW) average power during a burst for the C block and +24 dBm (250 mW) for B-Lower block. The peak power is higher due to the crest factor of the WCS signal, and the long-term average power is lower due to the 25% duty cycle. A 25 W (+44 dBm capable) Power Amplifier was used to ensure linear amplification for the 150 to 250 mW output, thus limiting harmonic signals generated. A band-pass filter was also used to further ensure no material harmonic signal leakage into the SDARS band.

The SMIQ06B was used to generate white noise outside of the WCS band in the Satellite Radio band to represent the spectral mask. The noise level was set to -30 dBm per 1 MHz bandwidth, corresponding to a spectral mask of 60 + 10 log( P ) for B-Lower. The SMIQ06B was set for a

30% duty cycle, and the noise signals were coupled into the output chain after the Bandpass filter.

Figures 2 and 3 show pictures of the transmitter setup.

Figure 2 – Picture of Transmitter Equipment in Vehicle

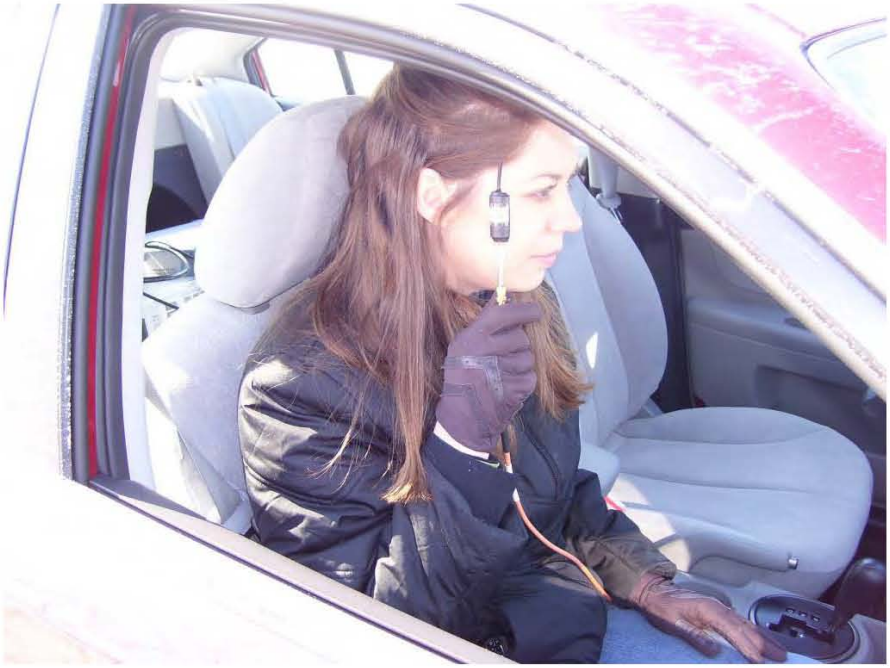


Figure 3 – Simulating Use of Mobile WiMAX Cellular Phone

## 3.2 Test Equipment

Electronic test and measurement equipment with calibration dates are recorded in Table 1.

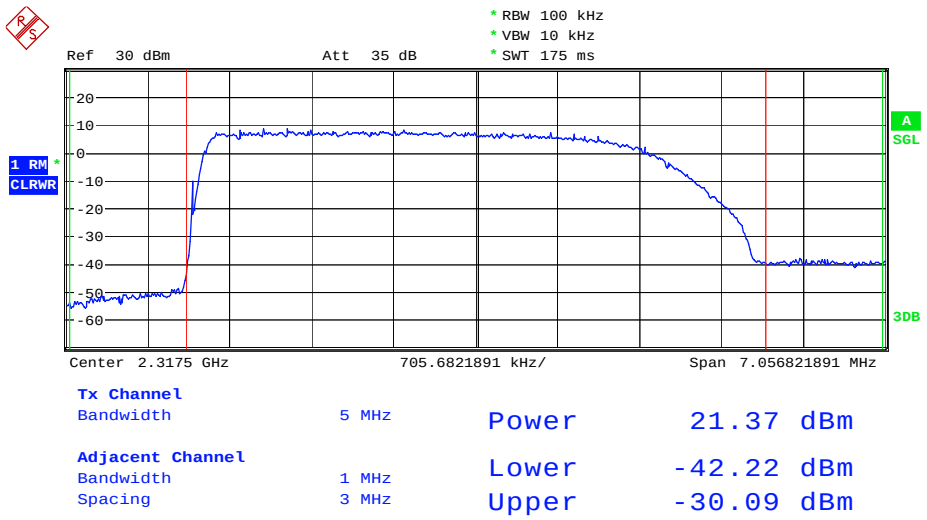
Table 1 – Major Test and Measurement Equipment

| | P/N | S/N | Calibration |
|---|---|---|---|
| Signal Generator | Agilent E4438C | US41461299 | Due April 2009 |
| Signal Generator | Rhode & Schwarz SMIQ06B | DE27480 | Due August 2010 |
| Spectrum Analyzer | Rhode & Schwarz FSQ26 | 100060 | Due November 2009 |
| Laser Range-Finder | Leupold RX-III | R304714T | Purchased in previous month |

The SDARS receiver was a Sirius Starmate model, S/N 008663733365.

## 3.3 Test Results

Immediately before testing, the input signals were verified on the calibrated spectrum analyzer. Figure 4 shows the WCS and noise signals with 100% duty cycle, measured at 1 MHz resolution bandwidth. The measured channel power is, indeed below +22 dBm, and the noise in the above band is just below -30 dBm per 1 MHz.




Date: 6.FEB.2009 11:18:57

Figure 4 – Verification of WCS C-Block and Noise Signals

The first set of tests were run with the WCS C-block signal. Traffic conditions prevented measurement from being taken at particular ranges. Therefore the team captured as many ranges and resulting muted or not conditions as practical, but could not always get exact transition points.

Figure 5 – Both Vehicles Prior to Testing

With the SDARS vehicle in front, the receiver was muted at close range and did not come out of mute until a range of 27 meters was achieved. Specific ranges of muting included 17, 21, and 25 meters. Once re-acquired, the SDARS receiver was able to get as close as 23 meters without muting, but was again muted at a range of 18 meters. Muting occurred with the WCS vehicle two lanes over (measured at 5 to 6 meters), even with a car and even a van in between the transmitter and receiver vehicles. Adjacent muting (two lanes over and ahead) was observed at 15 meters.

Figure 6 – Picture of WCS Transmit Vehicle taken from SDARS Receiver Vehicle during Mute

The WCS transmitter vehicle was permitted to pass. With the WCS transmitter vehicle in front, muting continued at 13, 14, and 15 meters. Clear reception was once again observed at 24, 26, 27, 30, and 31 meters.

Figure 7 – Pictures of WCS Transmit Vehicle about to pass SDARS Receiver Vehicle

The next set of test were run with the WCS B-Lower signal. Traffic conditions prevented measurement from being taken at particular ranges. Therefore the team captured as many ranges and resulting muted or not conditions as practical, but could not always get exact transition points.

With the SDARS receiver in front, muting was observed at ranges up to 31 meters, and muting ceased at 38 meters. Once re-acquired, the SDARS receiver was able to get as close as 23 meters, re-muting at 22 meters.

With the WCS vehicle in front, the SDRAS receiver was muted at close range and did not come out of mute until a range of over 27 meters was achieved. Once re-acquired, ranges as short as 16 meters were achievable, without muting. Once muting occurred, the SDARS vehicle was allowed to pass, and muting continued until a range of over 23 meters.

Figure 8 – Pictures of WCS Transmitter Vehicle from SDARS Vehicle

Table 2 contains a summary of the muting results during the road testing.

Table 2 – Muting Ranges from Road Testing

| | Muting Ranges (m) | Non-muting Ranges (m) |
|---|---|---|
| C Block, SDARS Leading | 17, 18, 21, 25 | 23, 27, 30 |
| C Block, WCS Leading | 13, 14, 15 | 26, 27, 30, 31 |
| B Lower, SDARS Leading | 22, 23, 27, 31 | 16, 21, 22, 25, 27, 38 |
| B Lower, WCS Leading | 15 | 23 |

## 4.0 Conclusion

The tests demonstrate that despite vehicle to vehicle propagation losses, WCS signals generally cause muting to occur with SDARS receivers up to at least 20 meters away.

If you have any questions concerning you can contact Mike Pilcher at 210-522-2083 or via email at mpilcher@swri.org.

Sincerely,

Barbara Pilbin

Barbara Pilbin, Research Engineer
Surveillance Systems Section

**APPROVED:**

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MEP/rl

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# EXHIBIT 4

## MOTOROLA, INC.

## MEASUREMENTS OF SIGNAL ATTENUATION AT 2.3 GHZ FROM INSIDE-TO-OUTSIDE OF A VEHICLE

Date: February 19, 2009

To: Sirius XM Satellite Radio

# Measurements of Signal Attenuation at 2.3 GHz from Inside-to-Outside of a Vehicle

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## 1. EXECUTIVE SUMMARY

This document describes measurements of 2.3 GHz signal attenuation (path loss) when transmitting from a WCS user terminal in a variety of circumstances (including free field, in the presence of a user, and at various locations inside a vehicle). A sleeve dipole tuned to WCS frequencies was used to simulate a WCS cellular wireless service terminal antenna.. The measurements were performed at five frequencies, namely: 2332.5MHz, 2336.0MHz, 2338.0MHz, 2342.0MHz and 2345.0MHz.

Table 1 in section 2 lists the maximum, average and minimum gains and ripple of the WCS sleeved dipole in various positions as measured relative to the reference antenna (standard gain horn). Polar plots for each configuration are shown in Section 2.

Referring to the horizontal gain measurements of the WCS dipole antenna, the following observations can be made at 2.3GHz:

- The presence of the user affects the ripple of the antenna pattern at 2.3GHz.
- Positioning the antenna inside a sedan vehicle increases the ripple of the antenna pattern.
- The user "blocks" radiation from the dipole in a direction consistent with his/her shadowing effect.
- The effect of a vehicle on the gain pattern of the dipole is more complex than that of the user effect because of the metallic structure of the vehicle.
- The average gain of a dipole antenna when held by a user compared to its gain in free space is about 2dB lower.
- The average gain of a dipole antenna when placed inside a vehicle is about 2dB lower than its gain in free space.
- The combination of placing the WCS antenna in a vehicle in the presence of one, or two users, results in a reduction of average gain by 4 to 7.5dB, depending on the scenario.

## 2. MEASUREMENTS AND RESULTS

The tests were performed at the Motorola Labs Outdoor Antenna Range on January 27th, 2009. The weather was clear but cold, the high was about 15℉ and there was about 6 inches of snow on the surrounding ground. The area used for testing is an asphalt area which was cleared of snow. The turntable consists of metal rails mounted to a Scientific Atlanta heavy duty positioner such that the rails are even with the surrounding surface level.

Power measurements were taken using an HP 8753C Vector Network Analyzer (VNA). The VNA is housed in the control building and is connected to the turntable by means of 240 feet long cables and amplifiers which are used to ensure good quality of the signals sent to and received from the Antenna Under Test (AUT).

One port of the VNA drove the WCS sleeved dipole source antenna (AUT) which was mounted in various configurations on the turntable. The other port measured the power received by a Rhode & Schwarz HL-024 1-18GHz Log Periodic antenna mounted on a dielectric tripod at 48 inch elevation at a fixed distance of 27 feet from the Antenna Under Test (AUT).

Figure 1. The turn table loaded with the test vehicle.

*Calibration method*

The calibration method used was the antenna substitution method. The calibration antenna was a Seavey SGA-20 standard gain horn. This antenna was placed on the turntable and mounted at a height of 48 inches above ground to approximate the height of the testing to be done. With the source antenna fixed, the power received by the calibration antenna was measured, $P_{cal}$. This power contains, of course, the gain(loss) of the entire measurement path (i.e. cables, amplifiers and free space). Then, the power received by the AUT is also measured, say $P_{AUT}$. Since the VNA keeps the power constant during the measurements and since the environment pathloss is the same (the calibration antenna and the AUT are at the same position while the source antenna remains fixed), the gain of the AUT expressed in decibels (dBs) is

$$G_{AUT} = (P_{AUT} - P_{CAL}) + G_{CAL}$$

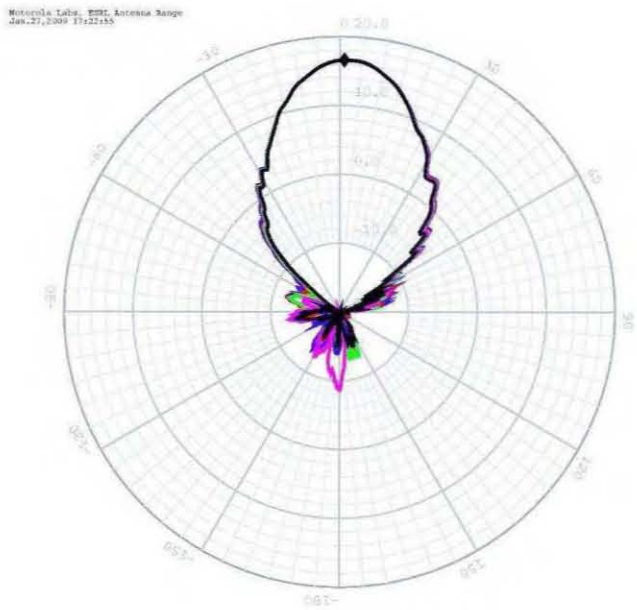
For the frequencies of these tests, the precise gain of the standard gain horn is indicated in Figure 2a below and, on average, it is $G_{CAL}$ = 16.6dB.

*Table 1: Summary of Results*

| WCS Sleeved Dipole Position Inside Car with Occupant(s) | 2345 MHz WCS Sleeved Dipole Gain Measurements (dB) | | | |
|---|---|---|---|---|
| | **Max** | **Average** | **Min** | **Ripple** |
| Driver's left ear | 4.34 | -4.91 | -31.55 | 35.89 |
| Driver's right ear | 3.40 | -4.57 | -30.32 | 33.72 |
| Front passenger's left ear | 2.34 | -7.90 | -39.84 | 42.18 |
| Front passenger's right ear | 0.55 | -8.40 | -50.28 | 50.83 |
| Front passenger's laptop | -0.95 | -8.46 | -33.70 | 32.75 |
| Right rear passenger's left ear | 3.68 | -5.66 | -31.57 | 35.25 |
| Right rear passenger's right ear | 1.21 | -6.65 | -34.15 | 35.36 |
| Right rear passenger's laptop | -0.18 | -8.22 | -49.20 | 49.02 |
| Left rear passenger's left ear | 1.32 | -7.33 | -51.28 | 52.60 |
| Left rear passenger's right ear | 1.80 | -6.40 | -35.26 | 37.06 |
| Left rear passenger's laptop | 2.26 | -6.56 | -34.31 | 36.57 |
| Left rear passenger, on shelf of rear window | 4.46 | -3.08 | -36.40 | 41.26 |
| Driver in car, on dashboard near windshield | 5.61 | -2.74 | -27.53 | 33.14 |
| **Composite of all in-car positions** | **5.61** | **-5.80** | | |

| WCS Sleeved Dipole Positon (no car or no occupants inside car) | 2345 MHz WCS Sleeved Dipole Gain Measurements (dB) | | | |
|---|---|---|---|---|
| | **Max** | **Average** | **Min** | **Ripple** |
| On 48 inch dielectric support | 1.30 | -0.83 | -4.39 | 5.69 |
| Between front seats, no occupants | 5.77 | -3.25 | -48.47 | 54.24 |
| Through sunroof opening, top of car | 4.49 | -0.28 | -17.90 | 22.39 |

| WCS Sleeved Dipole Pedestrian | 2345 MHz WCS Sleeved Dipole Gain Measurements (dB) | | | |
|---|---|---|---|---|
| | **Max** | **Average** | **Min** | **Ripple** |
| Right ear, free standing person 1 | 4.39 | -3.26 | -36.99 | 41.38 |
| Chest position, free standing person 1 | 5.30 | -2.88 | -35.91 | 41.21 |
| Right ear, free standing person 2 | 3.27 | -2.45 | -24.43 | 27.70 |
| Chest position, free standing person 2 | 4.36 | -2.85 | -39.37 | 43.73 |
| **Composite Pedestrian Postions** | **5.30** | **-2.85** | | |




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 16.58 | -0.75 | -45.75 | 62.33 |
| 2336 MHz | 16.59 | -0.84 | -44.75 | 61.34 |
| 2338 MHz | 16.59 | -0.94 | -41.43 | 58.04 |
| 2342 MHz | 16.60 | -0.87 | -40.26 | 56.86 |
| 2345 MHz | 16.61 | -1.07 | -48.20 | 64.81 |

SGH V cal ant 00, 01/27/09

Seavey Standard Gain Horn calibration Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel- Magnitude
Tx:RS log p v on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.5 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

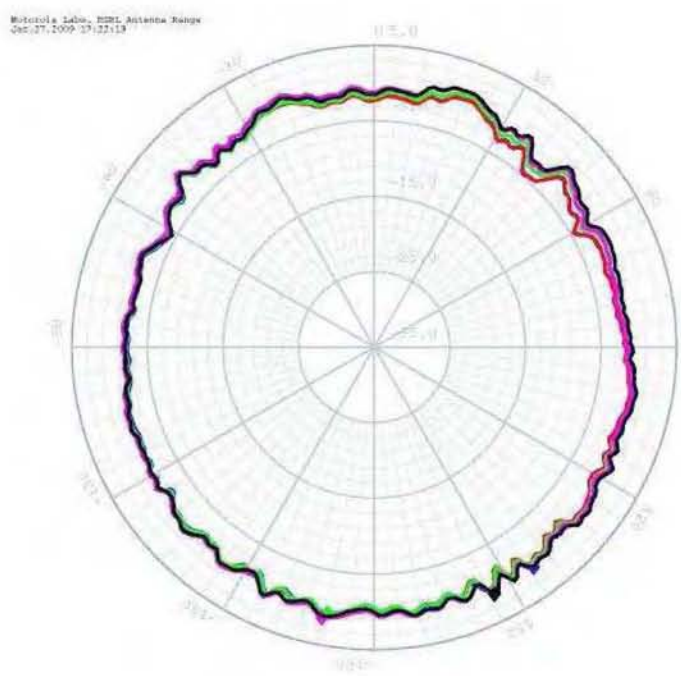
Figure 2a. Power Gain of the Standard Gain Horn vs. azimuthal angle

Source antenna on the turntable, Calibration antenna on the tripod, separation distance 27 feet. Both antennas 48" above ground.

Figure 2b. Measurement set-up.

*Power gain pattern measurements*

The power gain measurements started with measuring the gain of the WCS dipole antenna in free field. The results are shown below.



| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 0.89 | -1.41 | -4.75 | 5.64 |
| 2336 MHz | 0.74 | -1.39 | -4.61 | 5.35 |
| 2339 MHz | 0.48 | -1.27 | -4.28 | 4.95 |
| 2342 MHz | 1.38 | -0.80 | -3.78 | 5.16 |
| 2345 MHz | 1.30 | -0.83 | -4.39 | 5.69 |

WCS diople 01 ref ant 00, 01/27/09

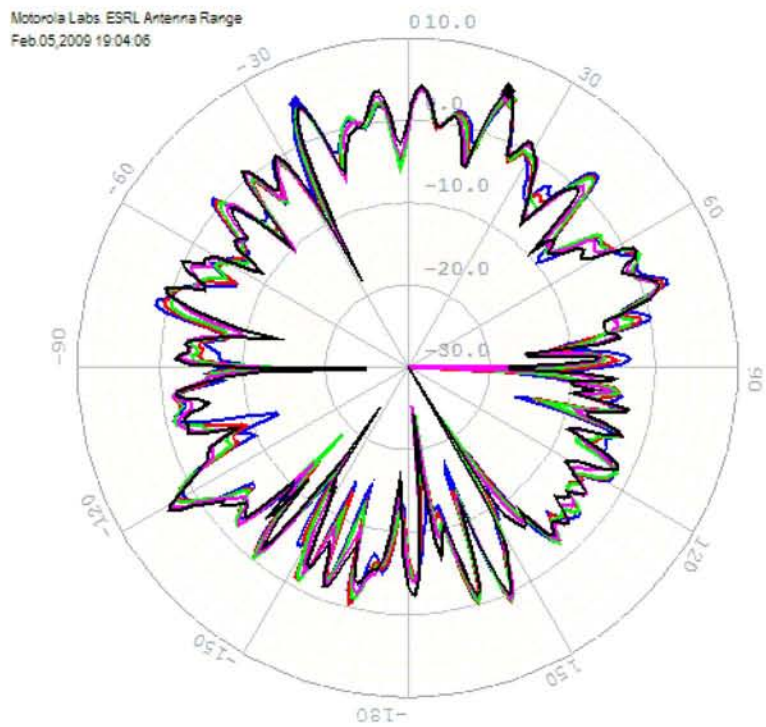
WCS reference antenna 01 Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-83 deg=00 Units= dB
Cal.: 83H V cal ant 00.TXT(M= 16.6 16.6 16.6 16.6 16.6)
AUT offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 3a. WCS antenna power gain pattern

Figure 3b. WCS Dipole 48 inch dielectric support

*Vehicular and user loading effects to WCS gain pattern*

In order to investigate the range of the "loading" effects of the vehicle and the user to the WCS antenna, the antenna was placed in a test vehicle and measured in the following positions. Note that, in reality, the WCS product will have an additional effect on the gain through its housing and the antenna may not be a dipole. However, the results here are considered representative of what is to be expected. Also note that the mismatch losses, if any, when the WCS dipole is held by the user is also included in the gain measurement.

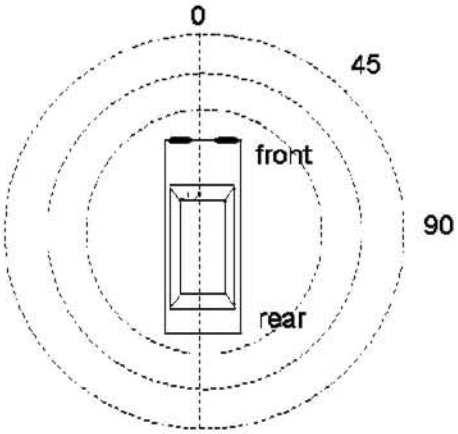



| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 4.66 | -3.02 | -18.03 | 22.69 |
| 2336 MHz | 4.77 | -3.14 | -30.21 | 34.98 |
| 2338 MHz | 4.87 | -3.21 | -24.15 | 29.02 |
| 2342 MHz | 5.35 | -3.27 | -34.93 | 40.28 |
| 2345 MHz | 5.77 | -3.25 | -48.47 | 54.24 |

WCS in veh pos1 00, 01/27/09

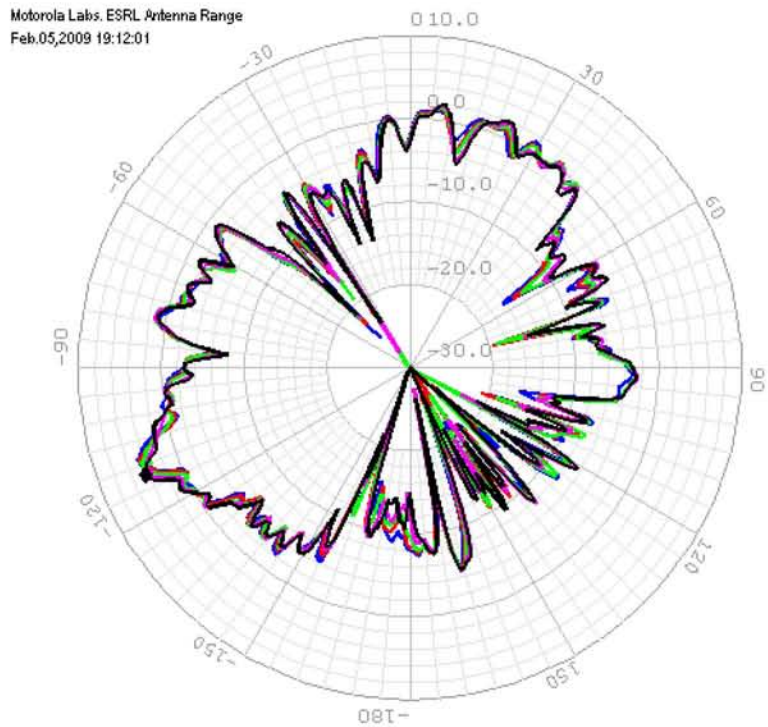
Wcs Dipole between seats head level center Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 4a. Gain pattern of WCS antenna located at the center between the front seats. No driver, no passenger in the vehicle.




All pattern polar plots follow the same convention. They are top view with the front of the vehicle pointing at zero degrees in azimuth.

Figure 4b. photo & schematic of the measurement.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 4.08 | -4.92 | -26.30 | 30.38 |
| 2336 MHz | 3.87 | -4.98 | -39.09 | 42.96 |
| 2338 MHz | 3.83 | -4.96 | -35.60 | 39.43 |
| 2342 MHz | 4.07 | -4.94 | -40.73 | 44.80 |
| 2345 MHz | 4.34 | -4.91 | -31.55 | 35.89 |

WCS in veh pos2 00, 01/27/09

Wcs Dipole driver left ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 5a. Gain pattern of WCS antenna held near the driver's left ear.

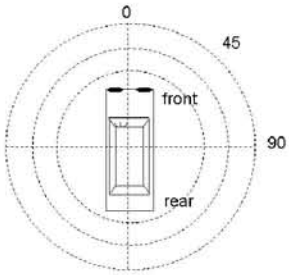
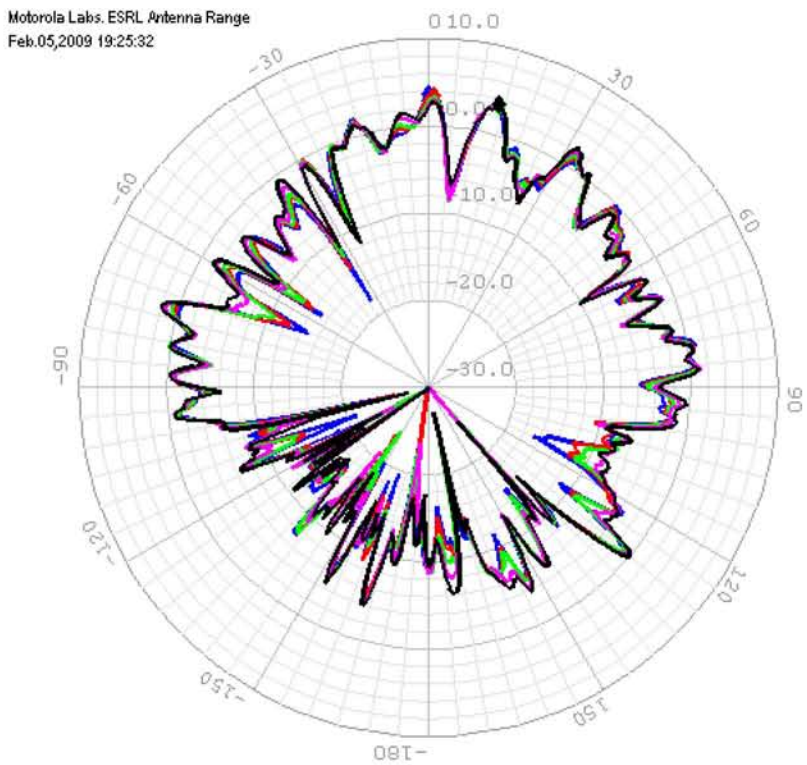



Figure 5b. Photo of antenna in position for test.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 3.71 | -5.23 | -32.23 | 35.94 |
| 2336 MHz | 3.52 | -5.16 | -40.08 | 43.60 |
| 2338 MHz | 3.37 | -5.04 | -36.91 | 40.28 |
| 2342 MHz | 3.43 | -4.80 | -39.99 | 43.42 |
| 2345 MHz | 3.40 | -4.57 | -30.32 | 33.72 |

WCS in veh pos3 00, 01/27/09

Wcs Dipole driver right ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 6a. Gain pattern of WCS antenna held near the driver's right ear

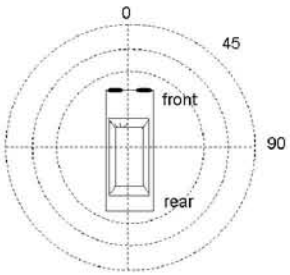



Figure 6b. Photo of antenna in position for right ear test.

The following tests use a passenger to hold the WCS antenna in three test positions. The positions tested are; the passenger right ear, the passenger left ear, and the passenger laptop position. The driver was also present during these measurements.

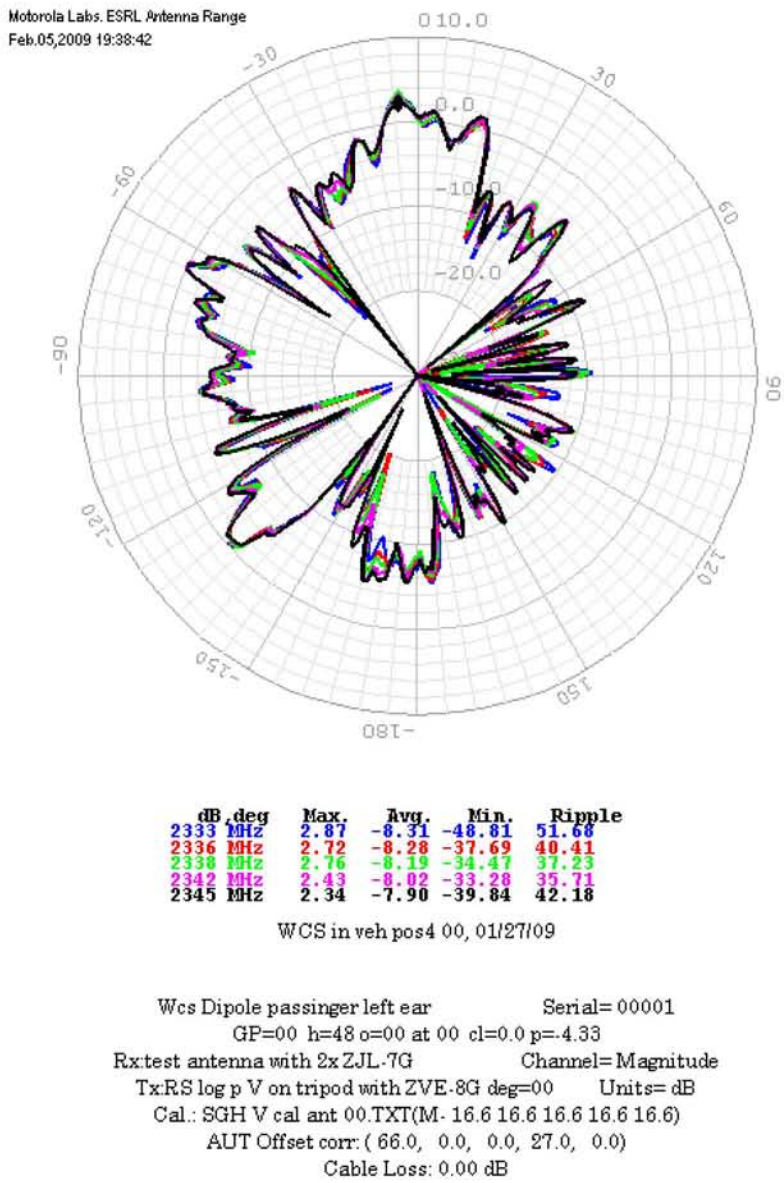



Figure 7a. Gain pattern of WCS antenna held near the passenger left ear while sitting in the front seat.

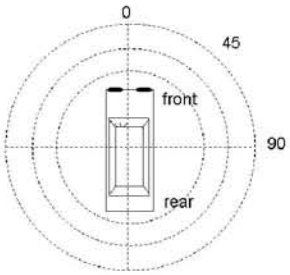
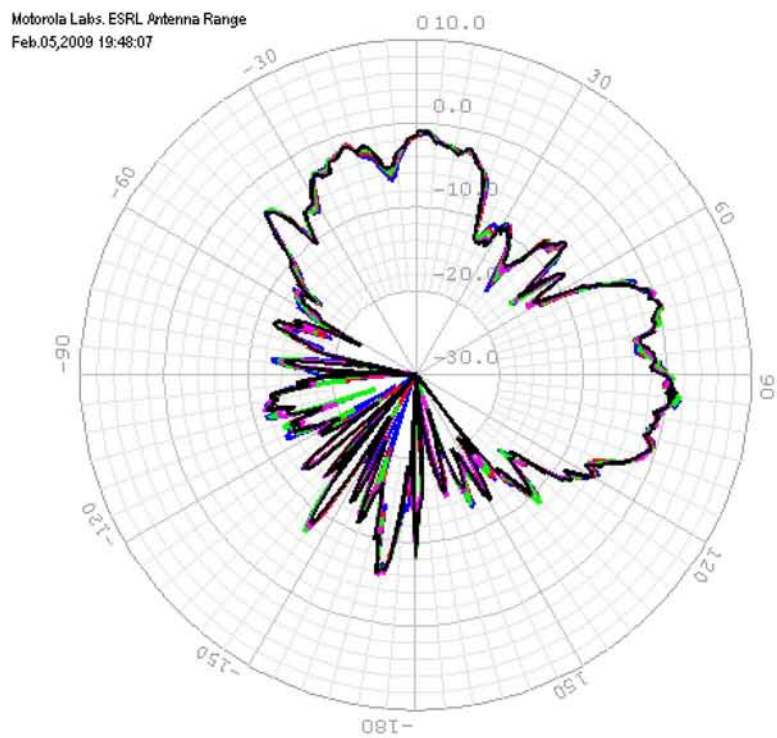



Figure 7b. Photo of antenna in position for passenger left ear test. Driver not shown.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 1.11 | -8.43 | -40.08 | 41.19 |
| 2336 MHz | 1.04 | -8.38 | -37.37 | 38.41 |
| 2338 MHz | 1.08 | -8.33 | -39.63 | 40.71 |
| 2342 MHz | 0.50 | -8.40 | -50.91 | 51.41 |
| 2345 MHz | 0.55 | -8.40 | -50.28 | 50.83 |

WCS in veh pos5 00, 01/27/09

Wcs Dipole passinger right ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 8a. Gain pattern of WCS antenna held near the passenger right ear while sitting in the front seat.

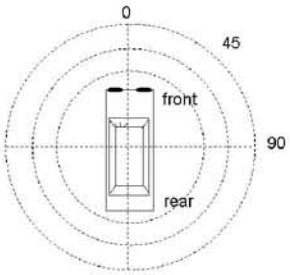
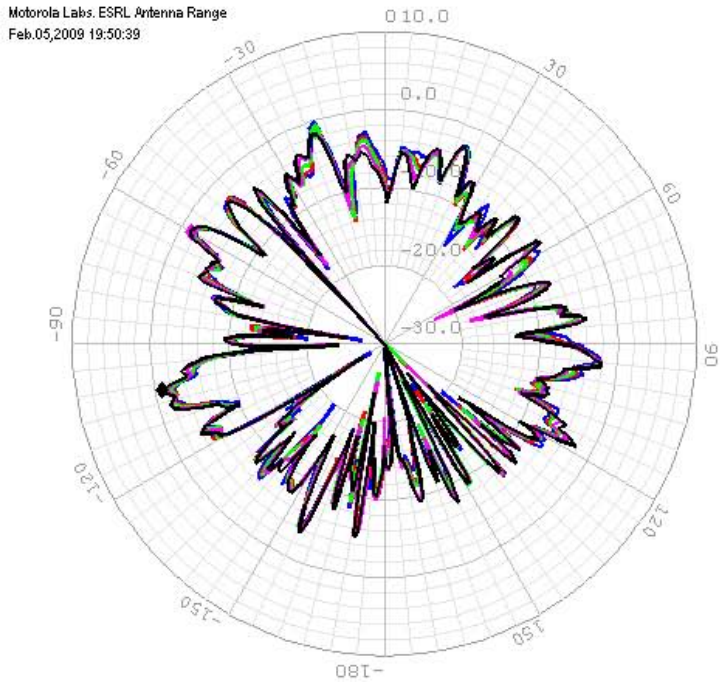



Figure 8b. Photo of antenna in position for passenger right ear test.



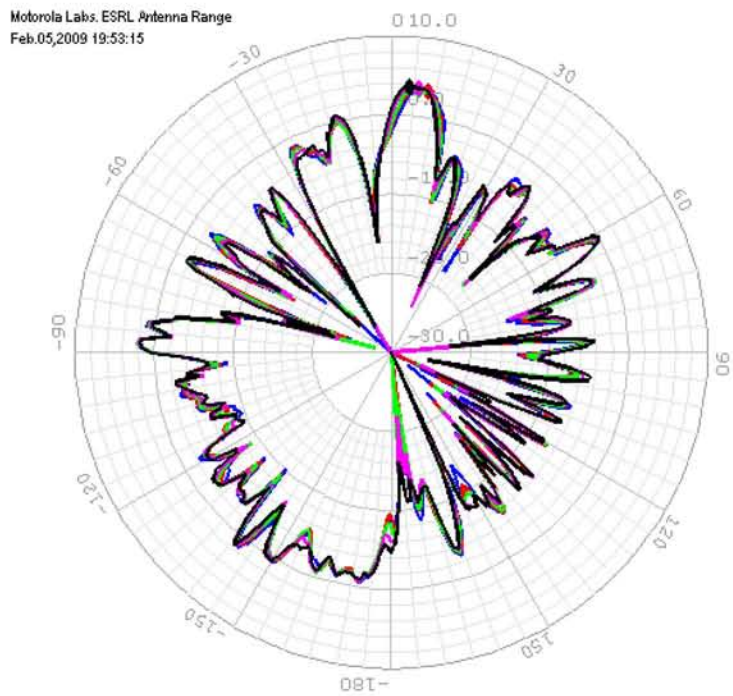

| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | -0.98 | -8.57 | -29.34 | 28.36 |
| 2336 MHz | -1.38 | -8.73 | -35.71 | 34.33 |
| 2338 MHz | -1.45 | -8.73 | -34.72 | 33.27 |
| 2342 MHz | -1.46 | -8.63 | -46.72 | 45.26 |
| 2345 MHz | -0.95 | -8.46 | -33.70 | 32.75 |

WCS in veh pos6 00, 01/27/09

Wcs Dipole passinger laptop Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 9a. Gain pattern of WCS antenna held near the passenger laptop position while sitting in the front seat.

No picture available




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 3.36 | -5.90 | -33.57 | 36.93 |
| 2336 MHz | 3.26 | -5.97 | -44.59 | 47.85 |
| 2338 MHz | 3.38 | -5.94 | -39.38 | 42.76 |
| 2342 MHz | 3.57 | -5.80 | -33.14 | 36.71 |
| 2345 MHz | 3.68 | -5.66 | -31.57 | 35.25 |

WCS in veh pos7 00, 01/27/09

Wcs Dipole passinger right rear seat left ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 10a. Gain pattern of WCS antenna held near the passenger left ear position while sitting in the right rear seat.

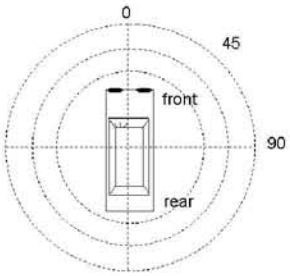
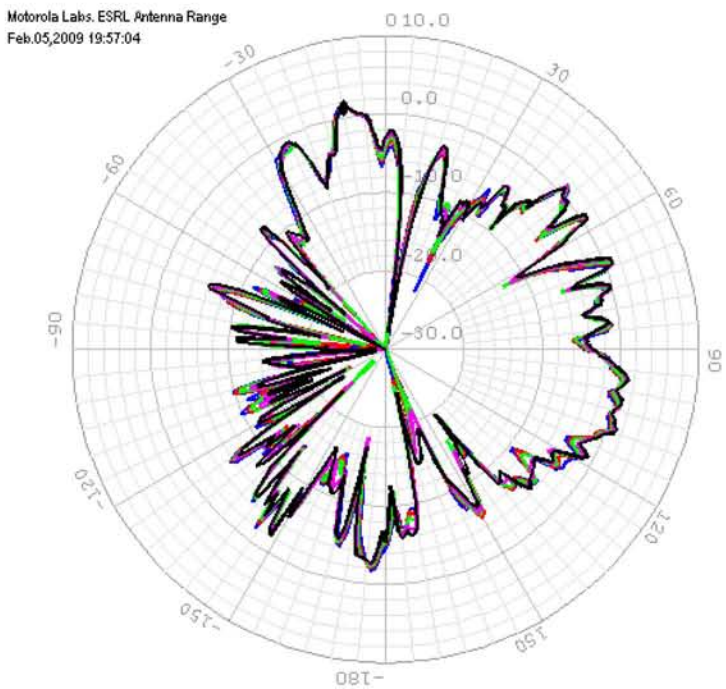



Figure 10b. Photo of the WCS antenna in the left ear position in the right rear seat.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 1.36 | -6.96 | -42.39 | 43.75 |
| 2336 MHz | 1.29 | -7.03 | -44.34 | 45.63 |
| 2338 MHz | 1.18 | -6.97 | -35.90 | 37.08 |
| 2342 MHz | 1.27 | -6.79 | -40.96 | 42.23 |
| 2345 MHz | 1.21 | -6.65 | -34.15 | 35.36 |

WCS in veh pos8 00, 01/27/09

Wcs Dipole passinger right rear seat right ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 11a. Gain pattern of WCS antenna held near the passenger right ear position while sitting in the right rear seat.

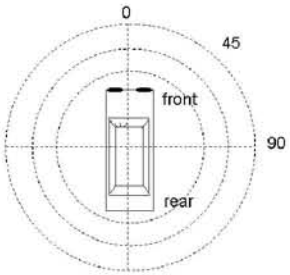



Figure 11b. Photo of the WCS antenna in the right ear position in the right rear seat.

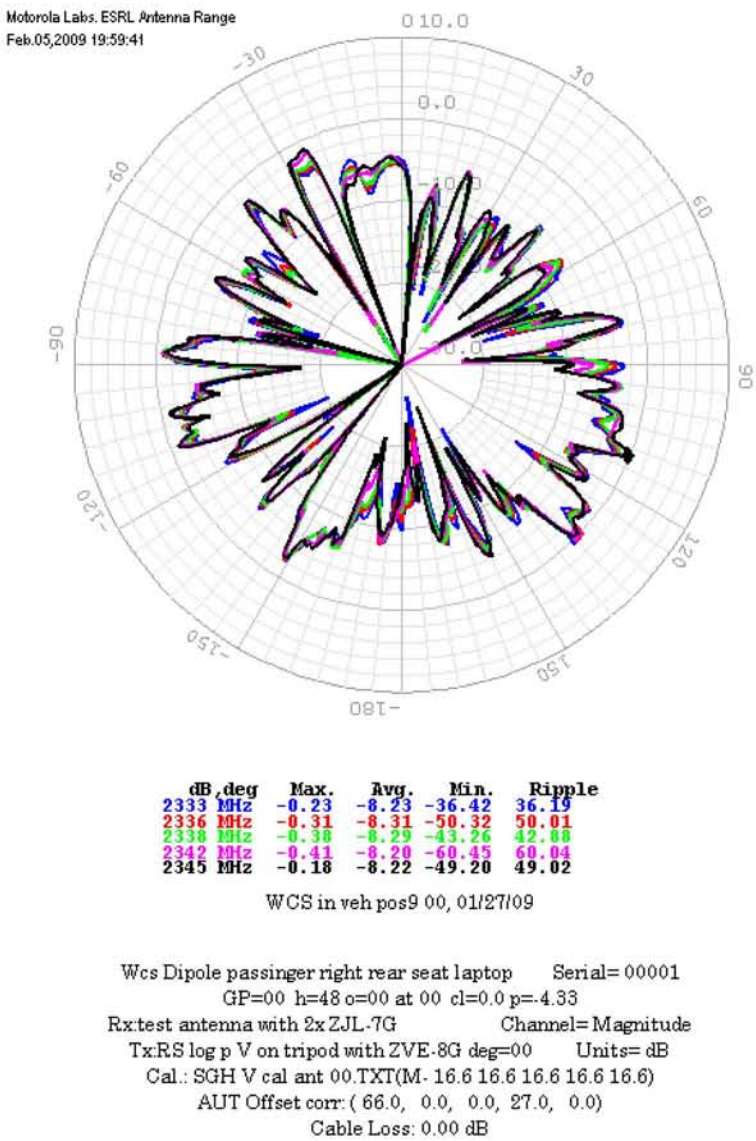



Figure 12a. Gain pattern of WCS antenna held near the passenger laptop position while sitting in the right rear seat.

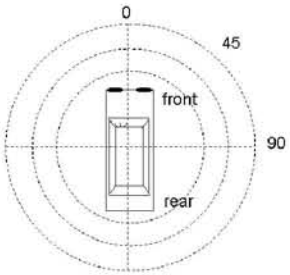
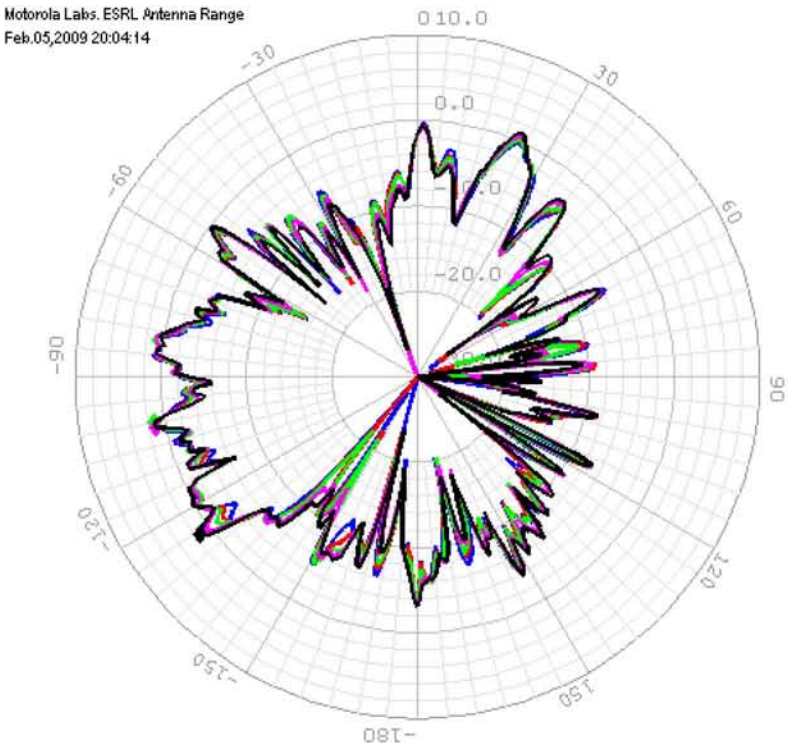



Figure 12b. Photo of the WCS antenna in the laptop position in the right rear seat.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 1.17 | -7.68 | -37.10 | 38.27 |
| 2336 MHz | 1.20 | -7.68 | -44.61 | 45.81 |
| 2338 MHz | 1.26 | -7.59 | -36.53 | 37.79 |
| 2342 MHz | 1.14 | -7.45 | -42.46 | 43.60 |
| 2345 MHz | 1.32 | -7.33 | -51.28 | 52.60 |

WCS in veh pos10 00, 01/27/09

Wcs Dipole passinger left rear seat left ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 13a. Gain pattern of WCS antenna held near the passenger left ear position while sitting in the left rear seat.

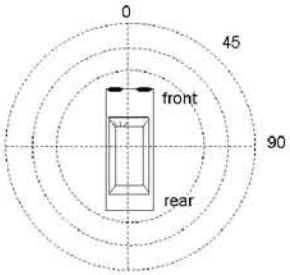
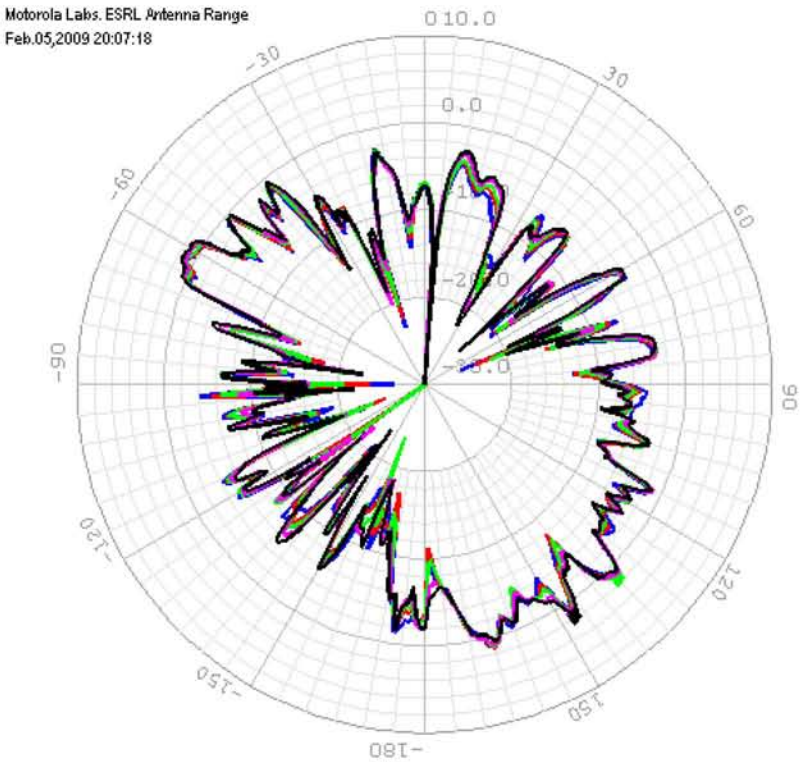



Figure 13b. Photo of WCS antenna held near the passenger left ear position while sitting in the left rear seat.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 1.46 | -6.85 | -26.47 | 27.93 |
| 2336 MHz | 1.51 | -6.86 | -28.63 | 30.14 |
| 2338 MHz | 1.41 | -6.76 | -30.03 | 31.44 |
| 2342 MHz | 1.36 | -6.53 | -27.22 | 28.58 |
| 2345 MHz | 1.80 | -6.40 | -35.26 | 37.06 |

WCS in veh pos11 00, 01/27/09

Wcs Dipole passinger left rear seat right ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 14a. Gain pattern of WCS antenna held near the passenger right ear position while sitting in the left rear seat.

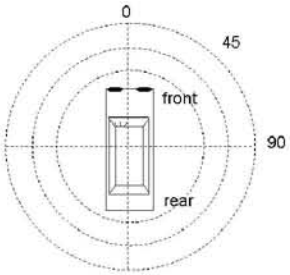
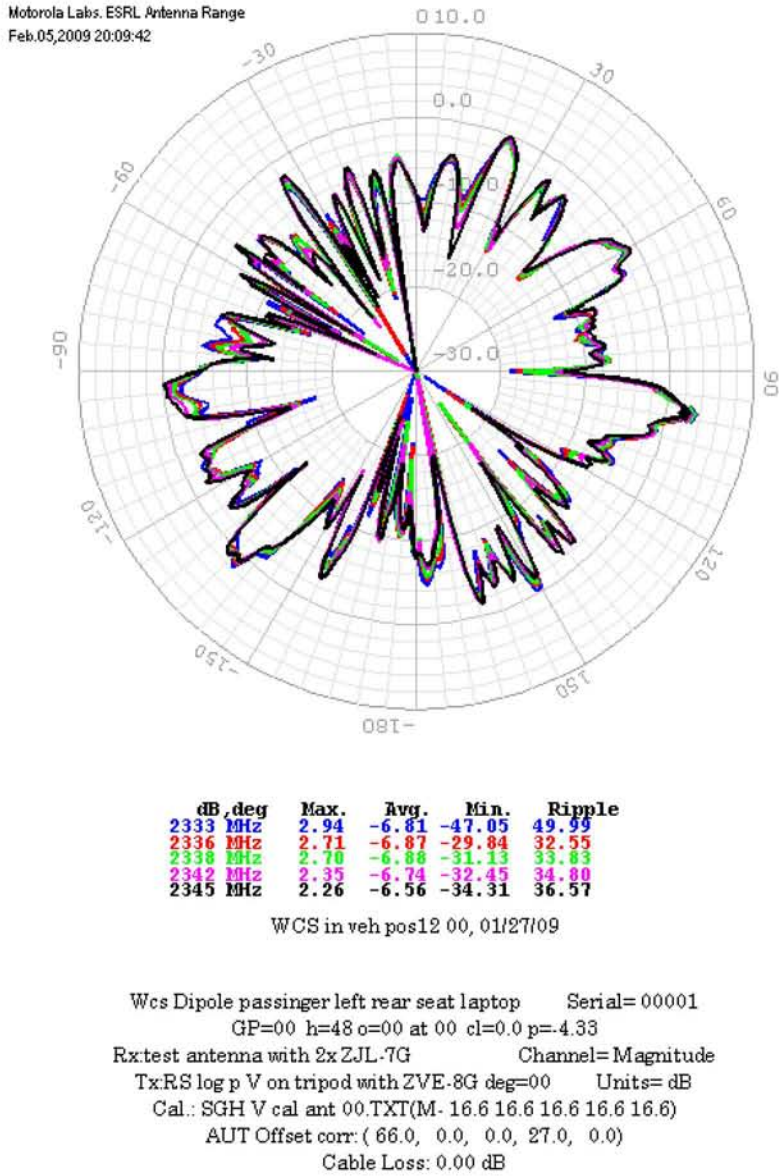



Figure 14b. Photo of WCS antenna held near the passenger right ear position while sitting in the left rear seat.



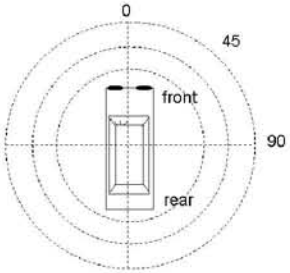
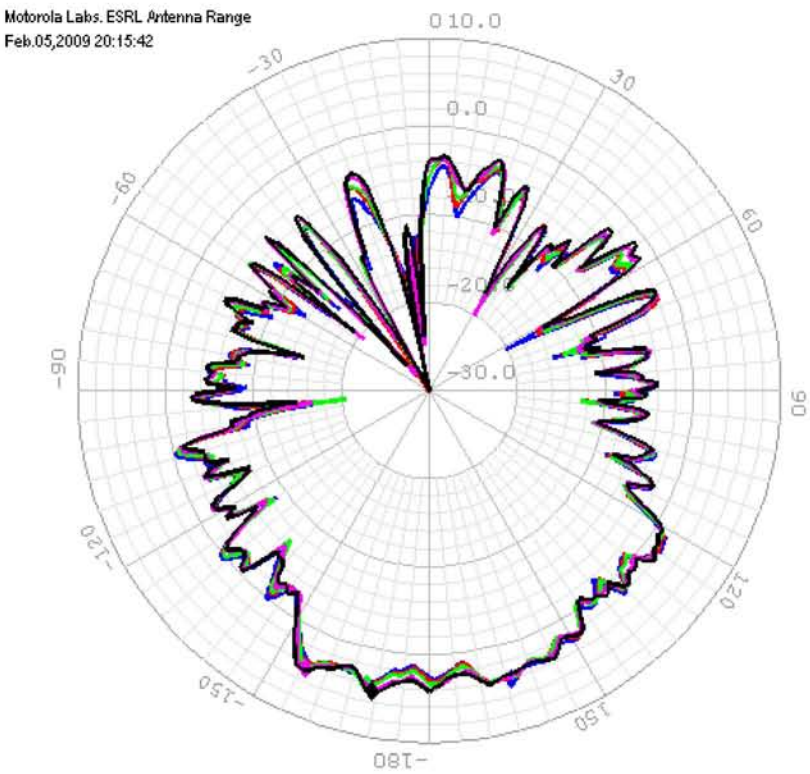



Figure 15a. Gain pattern of WCS antenna held near the passenger laptop position while sitting in the left rear seat.

Figure 15b. Gain pattern of WCS antenna held near the passenger laptop position while sitting in the left rear seat.

This test is to simulate a system installed in a vehicle with the antenna mounted on the rear package shelf area.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 4.05 | -3.61 | -44.76 | 48.81 |
| 2336 MHz | 4.00 | -3.65 | -31.57 | 35.57 |
| 2338 MHz | 4.19 | -3.56 | -35.13 | 39.32 |
| 2342 MHz | 4.57 | -3.28 | -31.12 | 35.69 |
| 2345 MHz | 4.86 | -3.08 | -36.40 | 41.26 |

WCS in veh pos13 00, 01/27/09

Wcs Dipole passinger package shelf Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 16a. Gain pattern of WCS antenna held in the package shelf position of the rear window.

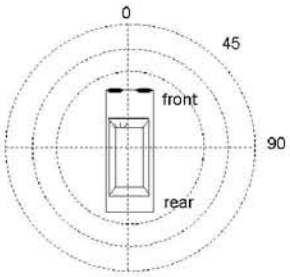
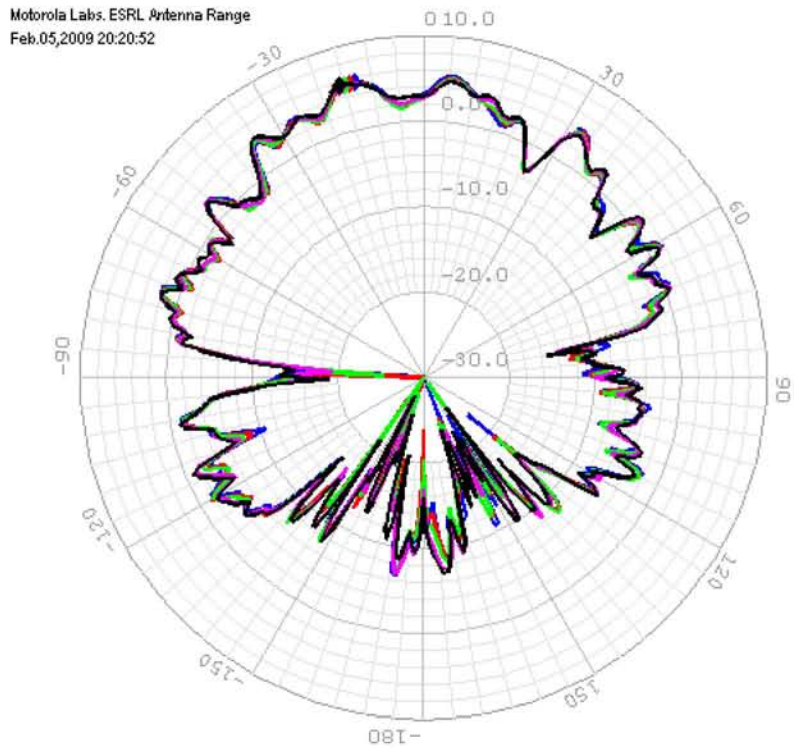



Figure 16b. Photo of WCS antenna held in the package shelf position of the rear window.

This test is to simulate a system installed in a vehicle with the antenna mounted on the dashboard area.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 5.42 | -3.01 | -42.42 | 47.84 |
| 2336 MHz | 5.36 | -3.12 | -40.20 | 45.56 |
| 2338 MHz | 5.37 | -3.08 | -38.07 | 43.44 |
| 2342 MHz | 5.42 | -2.89 | -26.95 | 32.37 |
| 2345 MHz | 5.61 | -2.74 | -27.53 | 33.14 |

WCS in veh pos14 00, 01/27/09

Wcs Dipole passinger dash board Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 17a. Gain pattern of WCS antenna held in the dashboard near the front window.

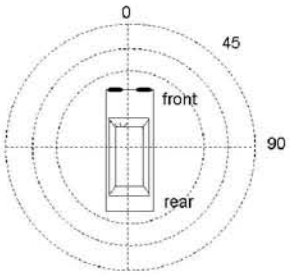
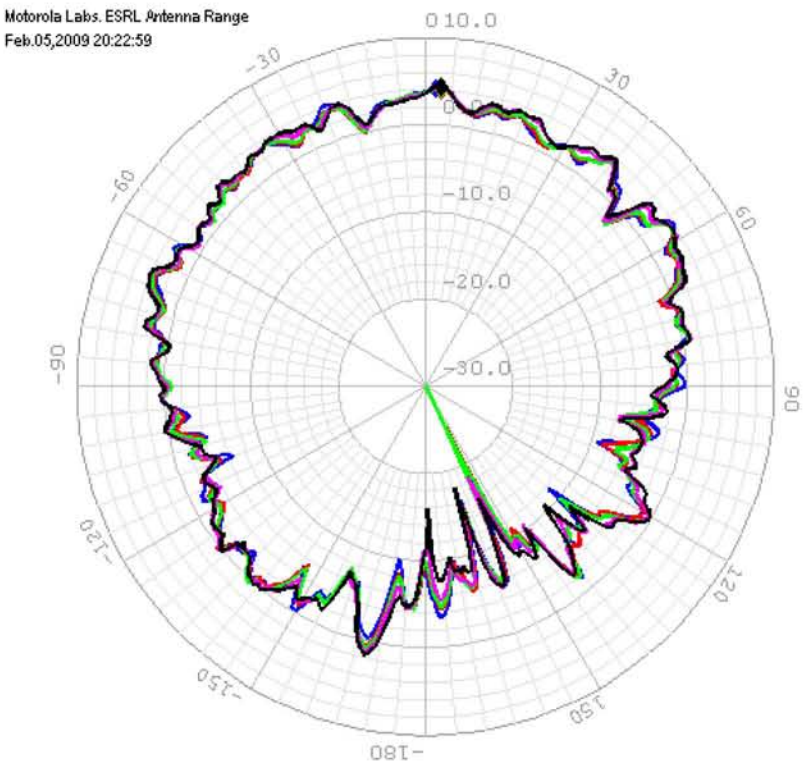



Figure 17b. Gain pattern of WCS antenna held in the dashboard near the front window.

This test simulates a roof mounted antenna.  Although the test also shows the lack of a real mounting method, the omni-directional pattern can be seen.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 4.21 | -0.67 | -19.04 | 23.25 |
| 2336 MHz | 4.10 | -0.71 | -32.59 | 36.69 |
| 2338 MHz | 4.25 | -0.63 | -33.24 | 37.49 |
| 2342 MHz | 4.42 | -0.39 | -18.38 | 22.80 |
| 2345 MHz | 4.49 | -0.28 | -17.90 | 22.39 |

WCS in veh pos15 00, 01/27/09

Wcs Dipole thru sunroof  Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G  Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00  Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 18a.  Gain pattern of WCS antenna held in the sunroof to simulate a roof mount antenna.

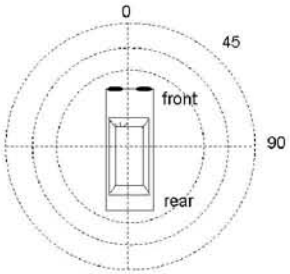
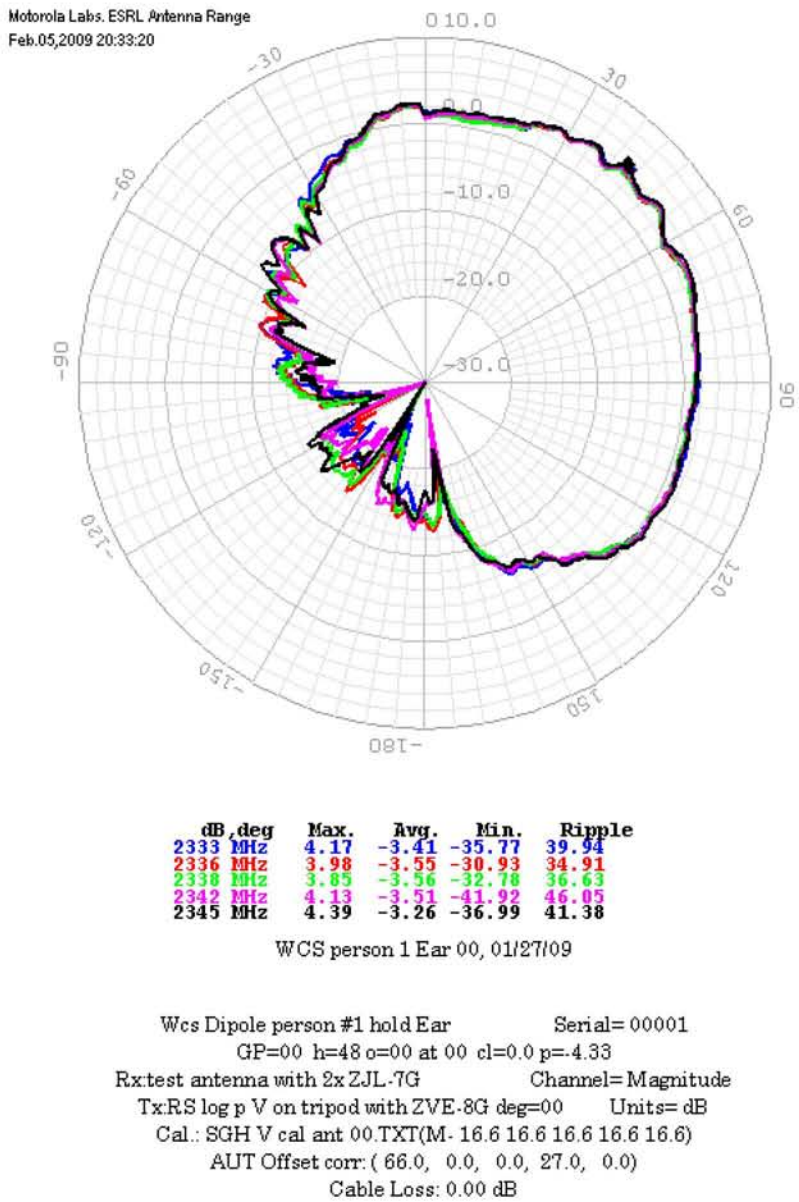
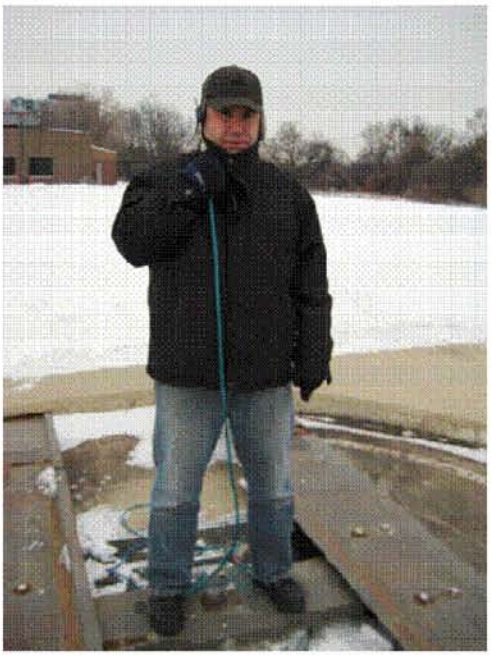



Figure 18b.  Gain pattern of WCS antenna held in the sunroof to simulate a roof mount antenna.

The following tests are designed to show the radiation patterns of a device used by a person using a handheld device.



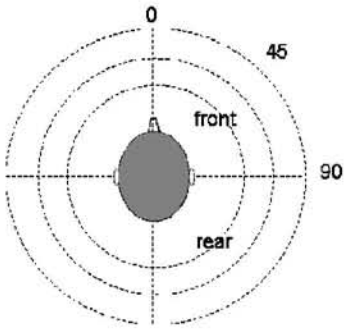
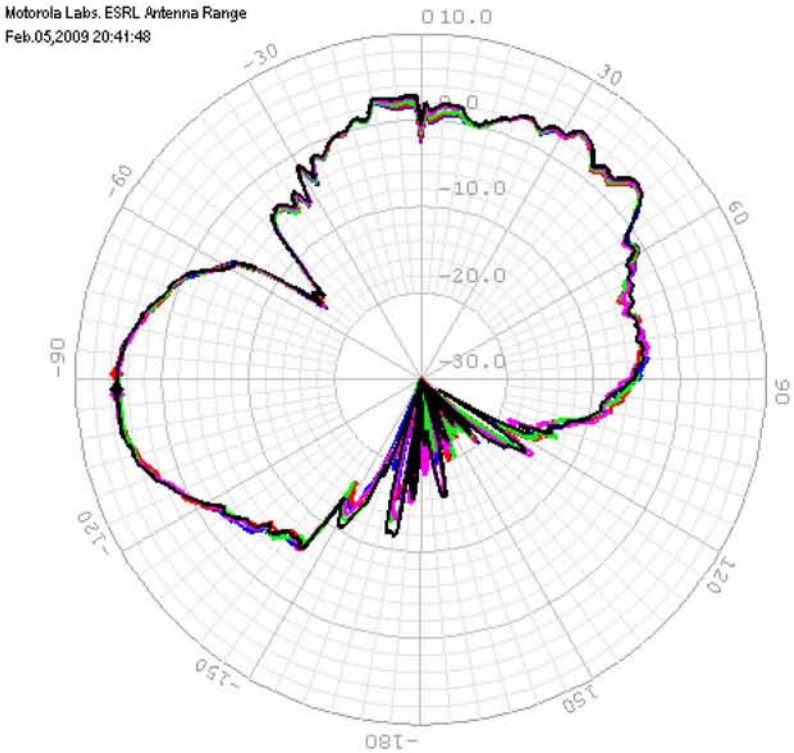



Figure 19a. WCS antenna held at right ear position of a free standing person.

Figure 19 b. All pattern polar plots follow the same convention. They are top view with the front of the person pointing at zero degrees in azimuth.

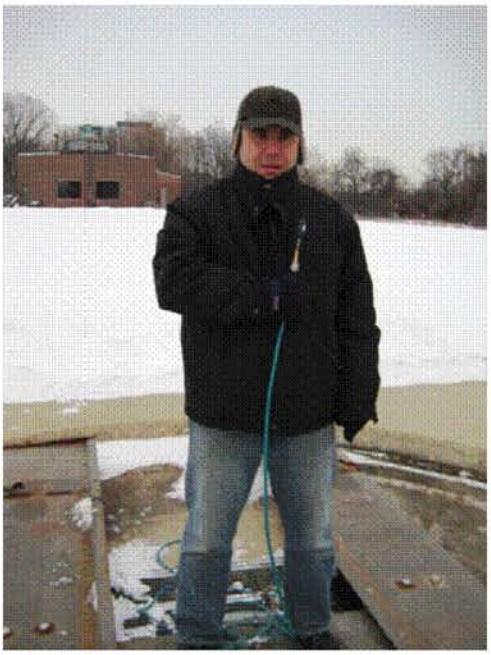



| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 5.22 | -3.14 | -34.48 | 39.70 |
| 2336 MHz | 5.19 | -3.23 | -45.20 | 50.39 |
| 2338 MHz | 5.00 | -3.16 | -38.08 | 43.08 |
| 2342 MHz | 5.28 | -3.04 | -44.19 | 49.47 |
| 2345 MHz | 5.30 | -2.88 | -35.91 | 41.21 |

WCS person 1 chest 00, 01/27/09

Wcs Dipole person #1 hold chest Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 20a. WCS antenna held at chest position of a free standing person.



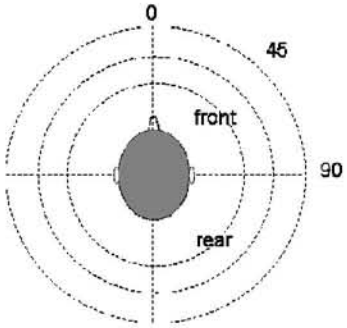
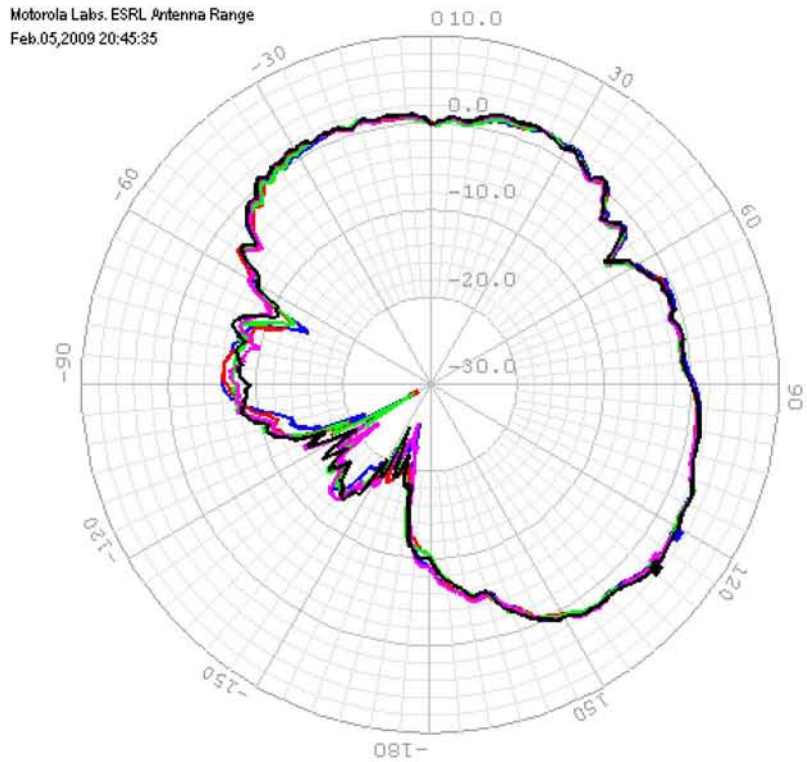



Figure 20b. WCS antenna held at chest position of a free standing person.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 2.96 | -2.64 | -28.04 | 31.00 |
| 2336 MHz | 3.05 | -2.67 | -28.37 | 31.42 |
| 2338 MHz | 3.08 | -2.68 | -27.80 | 30.88 |
| 2342 MHz | 2.99 | -2.57 | -25.26 | 28.25 |
| 2345 MHz | 3.27 | -2.45 | -24.43 | 27.70 |

WCS person 2 Ear 00, 01/27/09

Wcs Dipole person #2 hold Ear Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 21a. WCS antenna held at right ear position of a free standing person #2.

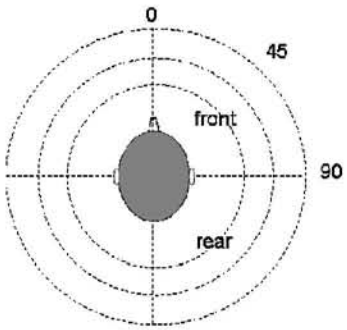
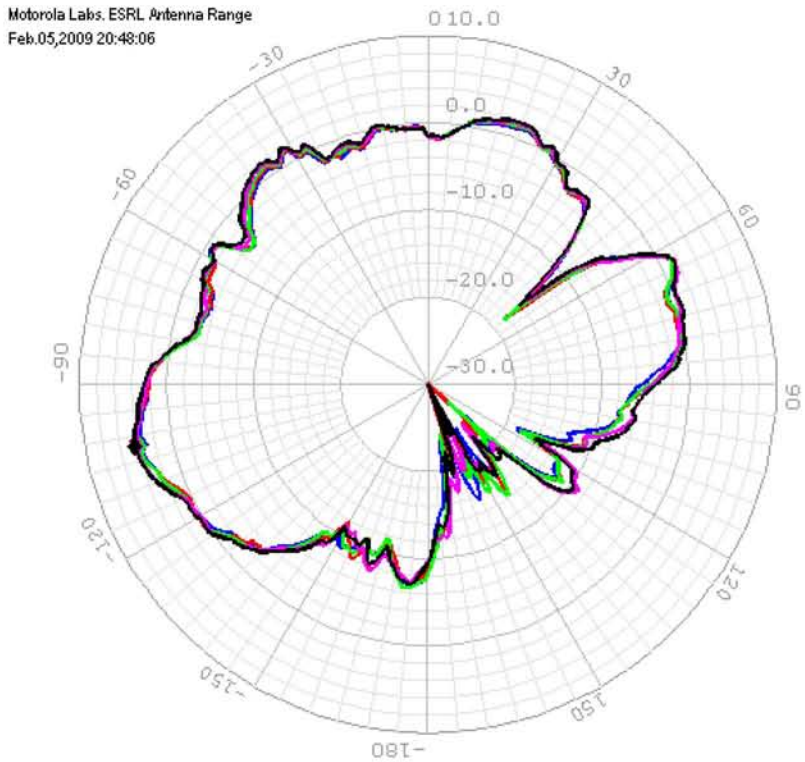



Figure 21a. WCS antenna held at right ear position of a free standing person #2.




| dB,deg | Max. | Avg. | Min. | Ripple |
|---|---|---|---|---|
| 2333 MHz | 3.66 | -3.47 | -27.00 | 30.66 |
| 2336 MHz | 4.04 | -3.35 | -34.43 | 38.47 |
| 2338 MHz | 3.88 | -3.25 | -30.80 | 34.68 |
| 2342 MHz | 4.15 | -3.03 | -31.17 | 35.32 |
| 2345 MHz | 4.36 | -2.85 | -39.37 | 43.73 |

WCS person 2 chest 00, 01/27/09

Wcs Dipole person #2 hold chest Serial= 00001
GP=00 h=48 o=00 at 00 cl=0.0 p=-4.33
Rx:test antenna with 2x ZJL-7G Channel= Magnitude
Tx:RS log p V on tripod with ZVE-8G deg=00 Units= dB
Cal.: SGH V cal ant 00.TXT(M- 16.6 16.6 16.6 16.6 16.6)
AUT Offset corr: ( 66.0, 0.0, 0.0, 27.0, 0.0)
Cable Loss: 0.00 dB

Figure 22a. WCS antenna held at chest position of a free standing person #2.

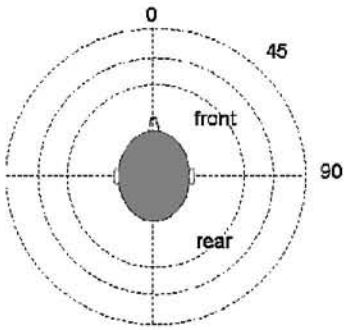



Figure 22b. WCS antenna held at chest position of a free standing person #2.

## APPENDIX A RETURN LOSS MEASUREMENTS OF WCS ANTENNA

The antenna gain measurements here include the mismatch losses, if any. Therefore, to have a complete picture of the WCS antenna, especially as held by the user, return loss measurements are recorded below for the various scenarios pertinent to the studies reported in the main body of the report. The measured S11 (return loss) of the WCS Dipole is shown in the following figures. The HP 8753 vector network analyzer was calibrated with a 3.5mm calibration kit. The test cable used was a Storm low loss cable and was included in the calibration procedure. For the free space measurement the antenna was mounted above a dielectric support in an open area. For the spacing from the head measurements, a sheet of Styrofoam of the indicated thickness was placed between the antenna and the user's head. This provides a solid reference thickness.

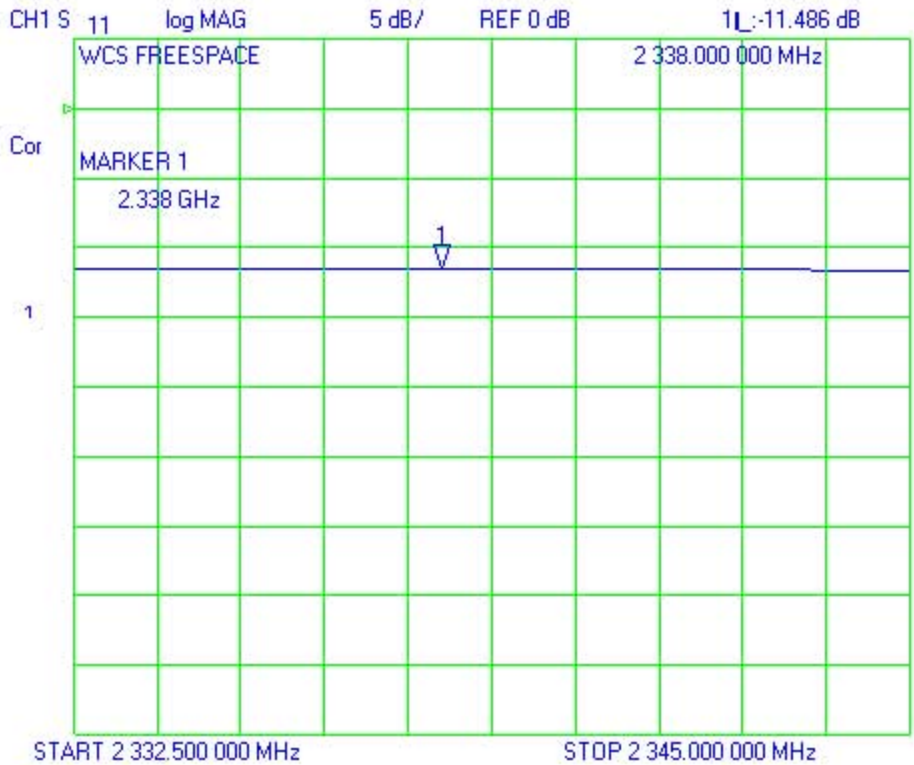



Figure A.1 WCS return loss (free space)

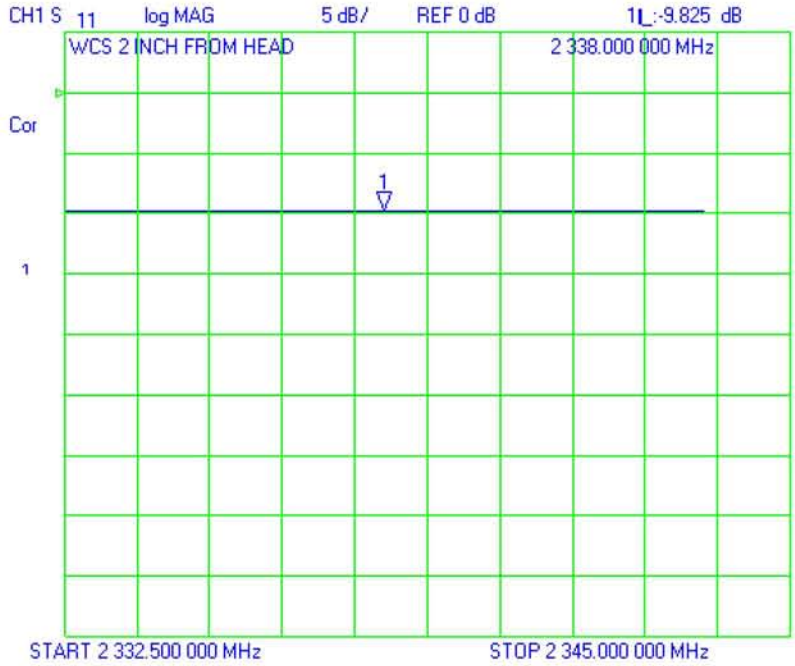



Figure A.2 WCS return loss (held two inches from the user's head)

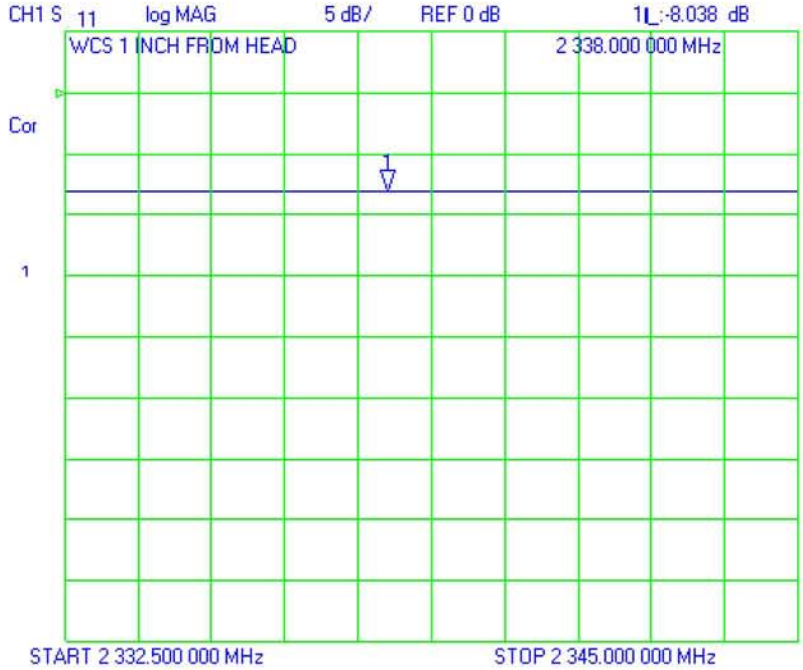



Figure A.3 WCS return loss (held one inch from the user's head)

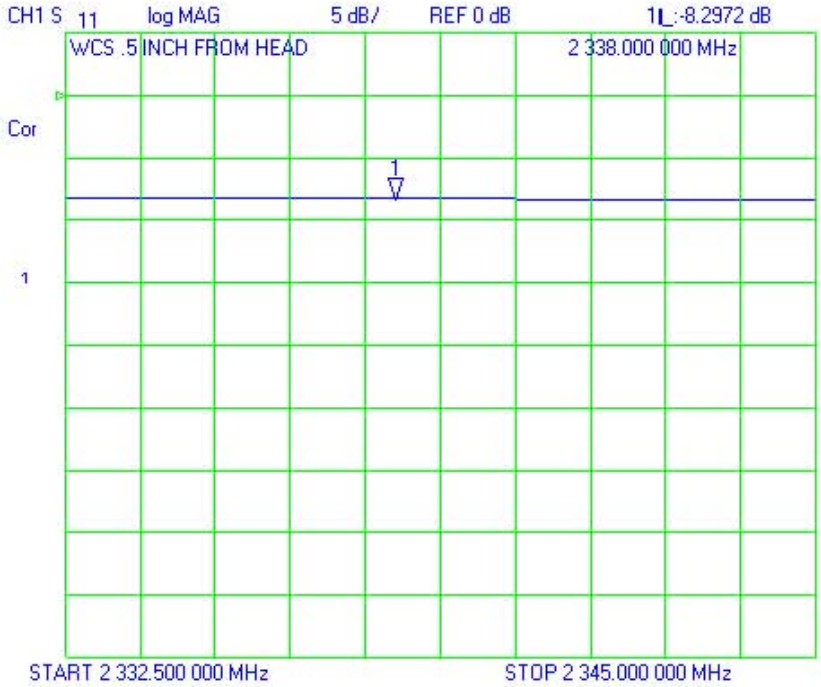



Figure A.4 WCS return loss (held 1/2 inch from the user's head)

# EXHIBIT 5

## CERTIFICATION OF MICHAEL PILCHER
## SOUTHWEST RESEARCH INSTITUTE

CERTIFICATION

Southwest Research Institute®
6220 Culebra Road
San Antonio, TX 78238

February 26, 2009

This certification is written in reference to antenna, path loss and receiver performance measurements taken Southwest Research Institute (SwRI) staff conducted at their facility in San Antonio, Texas and at the Sirius XM Lawrenceville facility. Said measurements were taken in the period of January 28 through February 6, 2009 and were commissioned by SiriusXM Radio. The results are documented in the attached reports.

I**,** Michael Pilcher, do hereby certify the following:

1. I have been the Manager of the Surveillance Systems Section (and similar sections involved in RF engineering) for the last 5 years. Over these 5 years, SwRI has conducted, among other things, UHF Antenna Measurements and Simulations for the PAVE PAWS Radar Sites (USAF Space Command through ITT-SENSOR), antenna fabrication for US Army CECOM, measured multipath phenomena for NASA (through ITT-SLRS-C), and developed wireless communication system equipment for various commercial clients whose identities are protected under non-disclosure agreements. I hold an MS degree from the University of Texas at Dallas (awarded in 2004). Prior to becoming a manager at SWRI, I was a Senior Engineer at JT3 conducting research in radar systems and in RF measurement uncertainty. Prior to that I was a Research Engineer at SwRI, conducting research and testing in RF systems and instrumentation.

2. The Path Loss setup at SwRI included all calibrated RF equipment (as required under our ISO/9001 quality plan), a rented Toyota Corolla, a typical SDARS receiver antenna (with integrated LNA), and a cart for moving the transmitter. The power provided to the WCS transmit dipole antenna was verified with a calibrated spectrum analyzer. WCS antenna integrated gain (including VSWR and efficiency) was verified in the anechoic chamber with a three-antenna test. Range between the transmitter antenna and the receiver was measured with a tape measure up to 10 meters, and measured with a Leupold RX-III Laser Range-Finder for longer distances.

3. An RF Signal Generator was used to produce a +7.5 dBm CW signal, which delivered (through a cable) a +5 dBm signal to the WCS antenna. For the free-space testing, the WCS antenna was placed atop a plastic pipe which was mounted on a four-wheel cart. The cart was moved in one meter increments away from the vehicle for 20 meters, and an additional measurement was taken at 25 meters. At each position, the received power through the integrated SDARS

antenna – LNA was measured on a calibrated spectrum analyzer with averaging enabled. The received power levels were normalized for the 20 dB SDARS receiver antenna / LNA gain/Cumulative Losses and the +5 dBm effective radiated power in order to determine the free-space loss. For the vehicle to vehicle tests, the WCS transmit antenna was removed from the plastic pipe and placed at various locations in the passenger compartment. The cars were spaced 3 and 6 meters side by side and 3, 6, 9, and 12 meters front-to-back (in both WCS-in-front and SDARS-in-front configurations. The data collection on the receive-side was identical to that used for the free-space tests.

4. All path loss measurements were performed outdoors at the SWRI San Antonio (antenna range) with an ambient temperature in the approximate range of 50-60 degrees Fahrenheit.

5. Laboratory tests to determine Sirius XM receiver performance in the presence of WCS interference were conducted at the Sirius XM facility in Lawrenceville, New Jersey.

6. An Agilent E4438C with the WiMAX waveform option was used to generate WCS signals in the B-Lower, C, D, and A-Upper blocks and to generate a trigger signal for the Rhode and Schwarz SMIQ06B. The WCS output of the E4438C was filtered in order to prevent any significant spurious or harmonic signals from being generated in the SDARS blocks. For tests required out-of-band emissions in the SDARS blocks, the SMIQ06B was used to generate white (Gaussian) noise. WCS and noise signals were combined, attenuated (via a variable RF attenuator), and then satellite radio signals were coupled in as well. Frequency, power, duty cycle, and any other relevant parameters were verified at this point with a calibrated spectrum analyzer. This combined signal was then connected to a typical SDARS receiver (an LNA and cable attenuator connecting to the remained receiver components).

7. There were four main muting tests conducted in the laboratory – muting from WCS signal overload, muting from OOBE only, muting from WCS with different OOBE masks, and minimum terrestrial power to overcome muting. OOBE only was conducted in the SDARS Sirius block and SDARS XM block. WCS signal overload, WCS with OOBE masks, and terrestrial overcome were tested in the B-Lower, C, D, and A-Upper WCS blocks. Muting levels were observed for Sirius signals from B-Lower and C block WCS signals and were observed for XM signals from the D and A-Upper WCS block signals. For each band, the satellite signals were set to -100 dBm per satellite, the WCS signals were generally tested at two different power levels (a transmit levels from +12 to +24 dBm, minus 52 dB to simulate 3 meter path loss), and OOBE masks were set at several levels as well (-25 to -60 dBm / 1 MHz minus 52 dB to simulate 3 meter path loss). Whenever frequencies or power levels changed, the power levels were re-verified with the calibrated spectrum analyzer. In almost every case, muting occurred at the simulated 3 meter distance. Therefore, to determine minimum muting levels,

the variable attenuator would be increased in (typically) 1 dB steps until the receiver came out of mute. This additional attenuation can then be used to calculate (1) additional required range, (2) reduced maximum power levels, and/or (3) increased spectral mask for non-interference.

8. The following test setup was developed for road testing. The Agilent E4438C with the WiMAX waveform option was again used to generate WCS signals in the B-Lower and C blocks and to generate a trigger signal for the Rhode and Schwarz SMIQ06B, which generated simultaneous OOBE signals. The WCS output of the E4438C was amplified with a 25-W power amplifier to ensure linear amplification to output levels of 250 mW (B-Lower Block) and 150 mW (C Block). The amplified signal was filtered to ensure no harmonic content in the Sirius block, and then the specified noise from the SMIQ06B was coupled in. The composite signal was measured on the calibrated spectrum analyzer to verify signal frequencies and power levels. Then the signal was transmitted through a WCS antenna held by a passenger.

9. While driving in traffic, muting generally occurred with ranges under 20 meters and generally did not occur for ranges over 20 meters. In one instance muting was observed at 27 meters as more range is generally required to come out of mute than to prevent muting to begin with. This is very typical of radio systems, were continuous synchronization improves receiver performance. In another case, muting was not observed at 16 meters, but in general, the transition to and from muting occurred around 20 meters.

Michael Pilcher
Manager
Surveillance Systems Section

**EXHIBIT 6**

**CERTIFICATION OF NICHOLAS E. BURIS**
**MOTOROLA, INC.**

MOTOROLA LABS

# CERTIFICATION

Motorola
Microwave Technologies Research Laboratory
1301 East Algonquin Rd.; Schaumburg, IL 60196

February 6, 2009

This certification is written in reference to antenna and path loss measurements taken at the Schaumburg Antenna Range of the Microwave Technologies Research Laboratory, a laboratory of the Applied Research and Technology Center of Motorola, Inc. Said measurements were taken in the period of January 28th-February 4th, 2009 and were commissioned by SiriusXM Radio. The results are documented in the attached reports.

I, Nicholas E. Buris, do hereby certify the following:

1. I have been the manager of the Microwave Technologies Research Laboratory (MTRL) for the last eight years. Over these eight years, this laboratory has conducted, among other things, antenna testing for more than thirty international customer companies. I hold a Ph.D. degree from the Electrical and Computer Engineering (ECE) department of the North Carolina State University (October 1986). Prior to joining Motorola in 1992, I was a professor at the ECE department of the University of Massachusetts and a summer faculty fellow at the NASA Langley Research Center in 1990. I have been elected fellow of the Institute of the Electrical and Electronics Engineers (IEEE) and have significant experience in theoretical and empirical techniques on antennas and wireless systems.

2. The antenna range at MTRL includes a turn-table at a distance of 200' from a control building. Antennas Under Test (AUT) whether in free field, or inside or on a vehicle are secured on the turn table whose axis of rotation is vertical. Radio Frequency power is provided to the AUT from the control building via 200 feet long cables. One port of a HP8753 Vector Network Analyzer (VNA) is used to power the source antenna. The other port of the VNA is connected to the AUT and measures the received power.

3. For gain measurements, the power received by the AUT is compared to the power received by "Standard Gain Antennas" under the same environmental and mounting conditions. For path loss measurements, the ratio of the received to transmitted power at the VNA ports is compared for two configurations. In the first configuration, the antennas are connected via 200' long cables to the VNA and placed in their operating environments (e.g. inside vehicles). In the second configuration, the antennas are removed and the cables are connected directly. This latter configuration provides the reference gain of the "loop" of the measurement system. The path loss from antenna port to antenna port of the first configuration is de-embedded by calibrating out reference gain of the "loop". Additional details are provided in the report.

4. While I supervised the aforementioned measurements, the actual operator was Mr. Edward Porrett, a Motorola engineer with more than 35 years experience in microwave measurements for wireless communications. Two Sirius XM Radio personnel were present during the measurements and, when needed, provided assistance to Mr. Porrett as test subjects. For example, one SiriusXM employee was used as a subject to emulate the user of a radiating device in some of the measurements.

5. All the measurements were performed outdoors with an ambient temperature in the approximate range of -8 to 2 degrees Celsius at the Motorola Antenna Test facility located in Schaumburg, IL.

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