

**RADIO FREQUENCY INTERFERENCE
(RFI)
MEASUREMENT REPORT**

Prepared For

**XM Radio
Washington, DC**

February 2002

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SECTION 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

Radio Frequency Interference (RFI) measurements were performed for XM Radio between the dates of January 16, 2001 and January 21, 2002 at various points in the surrounding Washington, DC area. The purpose of these measurements was to determine the relative RFI levels in the DARS frequency band from 2320-2345 MHz especially from systems operating in adjacent bands and other spurious emissions. These adjacent bands include the ISM band (2400-2483.5 MHz) and the WCS bands (2300-2320 and 2345-2365 MHz). Measurements were performed at eight different locations, which were classified as urban, suburban, or rural. The purpose of this report is to document the results of the measurements that were performed and to characterize the electromagnetic environment in the DARS band and to then compare the results to measurements performed by Comsearch in the DARS band previously.

The previous measurement activity and the reports is:

Survey of the XM Radio Electromagnetic Spectrum in the Northern Virginia Metropolitan Area, October 9 - October 29, 2000

- Frequency Range Considered: 2300 to 2500 MHz
- Type of Reception: Digital
- Measured Antenna Center Line: 10 Feet

1.2 Background

XM Radio contacted Comsearch to perform interference measurements in the DARS frequency band from 2320- 2345 MHz. Measurements were requested across the WCS and ISM Bands (2300-2483.5) MHz. Measurements were conducted in various settings to include urban, suburban, and rural environments.

The measured sites are identified on a portion of a map shown on the following page.



Rte 7 & Palisades Pkwy

1.3 Constraints

The analysis in this report is based upon the following assumptions and constraints.

- It is assumed that during the measurement period all of the 2.4 GHz transmitters were active and operating at full transmit power.

SECTION

TWO

SECTION 2

TEST PROCEDURE

2.1 Calibration

Figures 2.1-1, 2.1-2, and 2.1-3 are the block diagrams of the 2.4 GHz test set. All test equipment used was allowed a proper warm-up period prior to calibration. The test set was calibrated by the signal substitution method, as recommended by NSMA, utilizing a synthesized signal generator. The reference signal from the signal generator was adjusted for the frequency of test (2400 MHz) and measured with a thermal power meter for calibrated reference test level (-60 dBm). This calibrated reference signal from the signal generator was then injected into the end of the coaxial cable of the test set at the point that normally connects to the test antenna. A spectrum analyzer then measured the reference test signal level after passing through the test set. Upon completion of the calibration process, a known reference level was obtained for the measurements that corresponds to a given set of spectrum analyzer display readings.

The following formula is used to transform the measured signal level as read on the spectrum analyzer display (dBm) to an isotropic reference signal level (dBW_I) as seen at the point of test:

$$\text{dBW}_I = \text{LI} - \text{GA} - 30$$

Where: dBW_I = Isotropic level in dBW

LI = Level (dBm) of injected signal

GA = Test antenna gain (17.5 dBm at 2.4 GHz)

-30 = Conversion factor from dBm to dBW

at 2.4 GHz: dBW_I = -60 dBm – 17.5 dB - 30 dB

$$= -107.5 \text{ dBW}_I$$

In this instance, the spectrum analyzer displayed measured signal level of -60 dBm equates to an isotropic signal level of -107.5 dBW_I.

Figures 2.1-2A, 2.1-2B, and 2.1-3A display the spectrum photographs of the described calibration procedure employed during measurements using various filter arrangements.

Figure 2.1-3B shows the output of a -10 dBm signal swept across two notch filters which

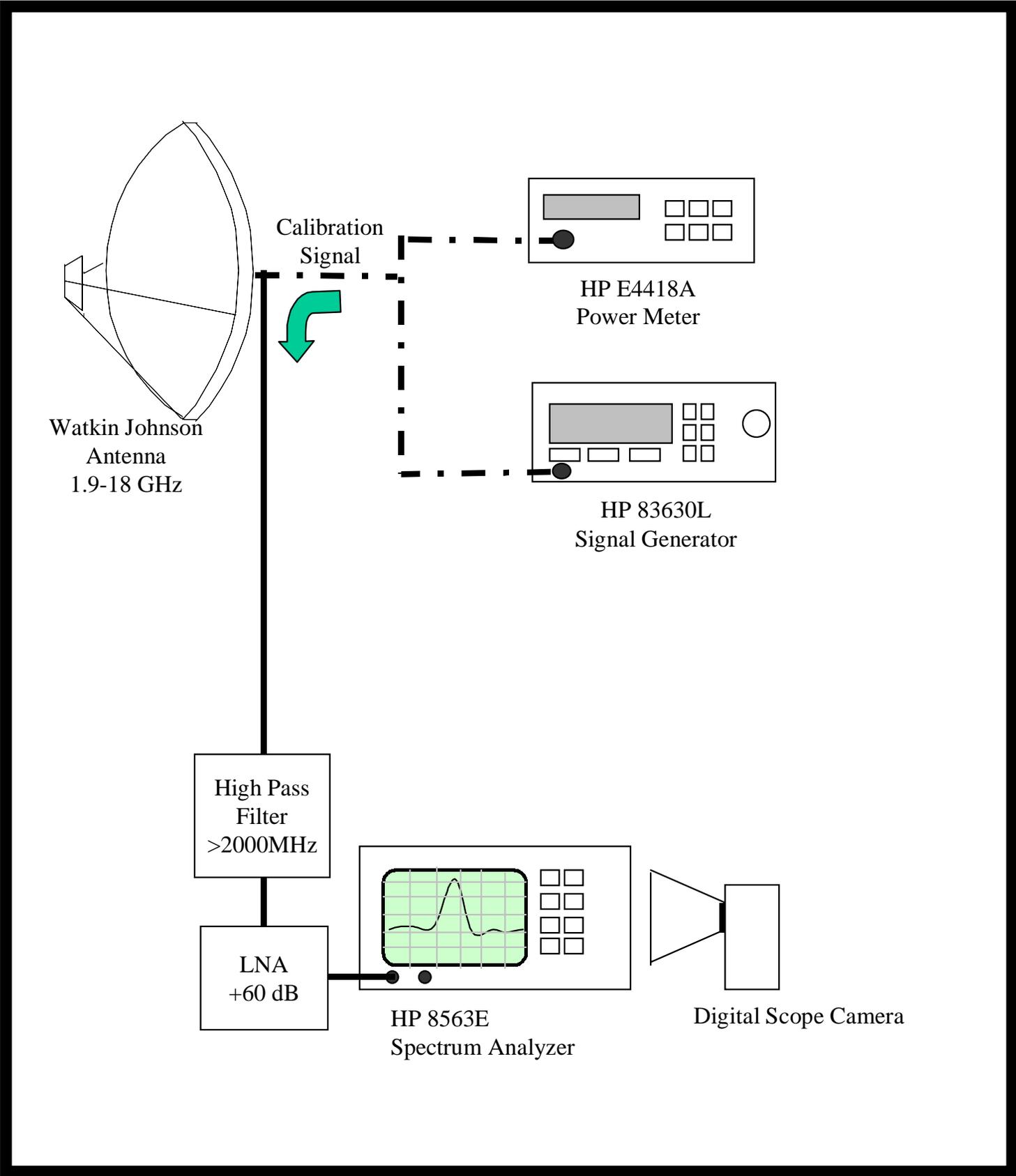


Figure 2.1-1 Test Equipment Block Diagram

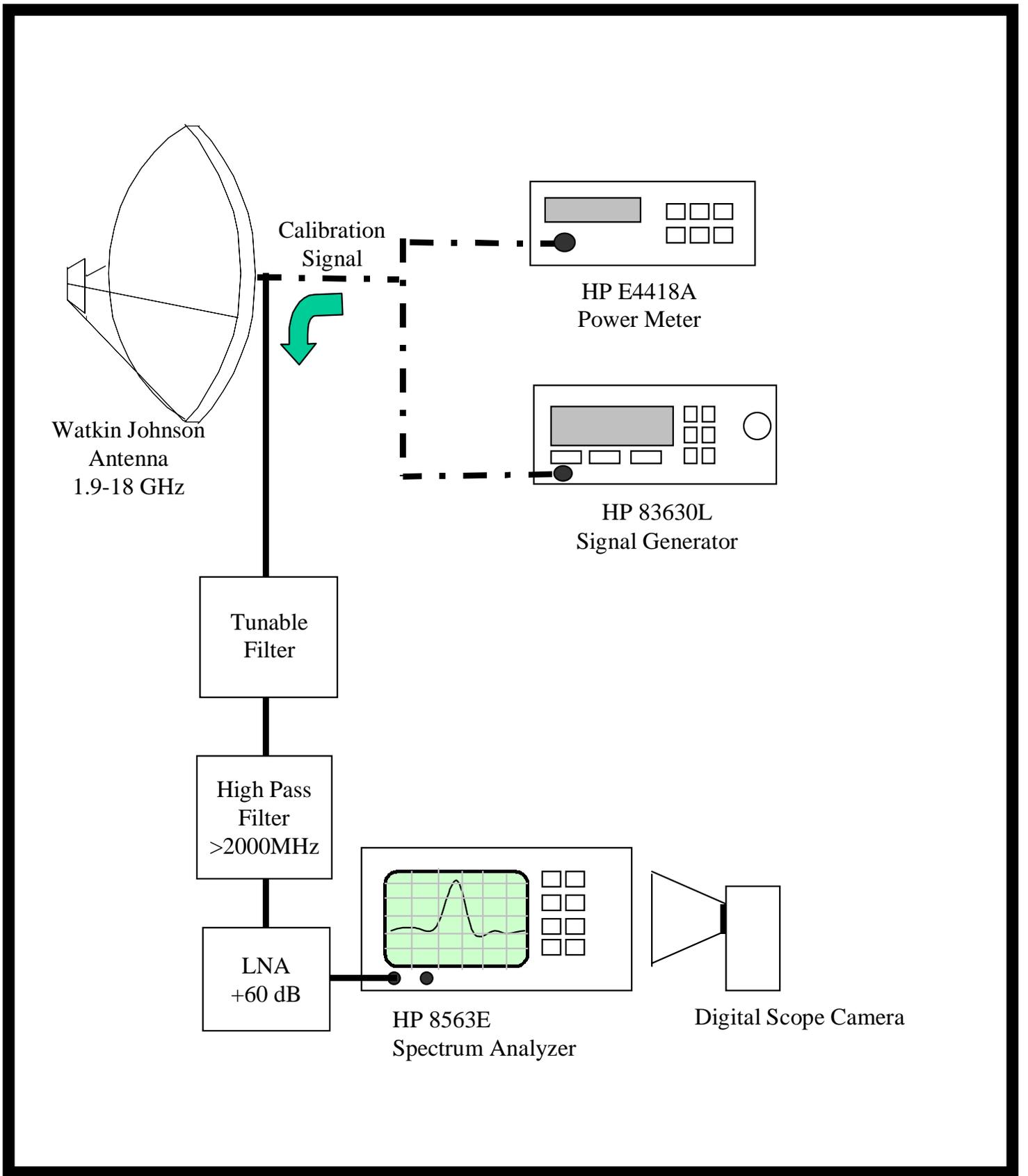


Figure 2.1-2 Test Equipment Block Diagram

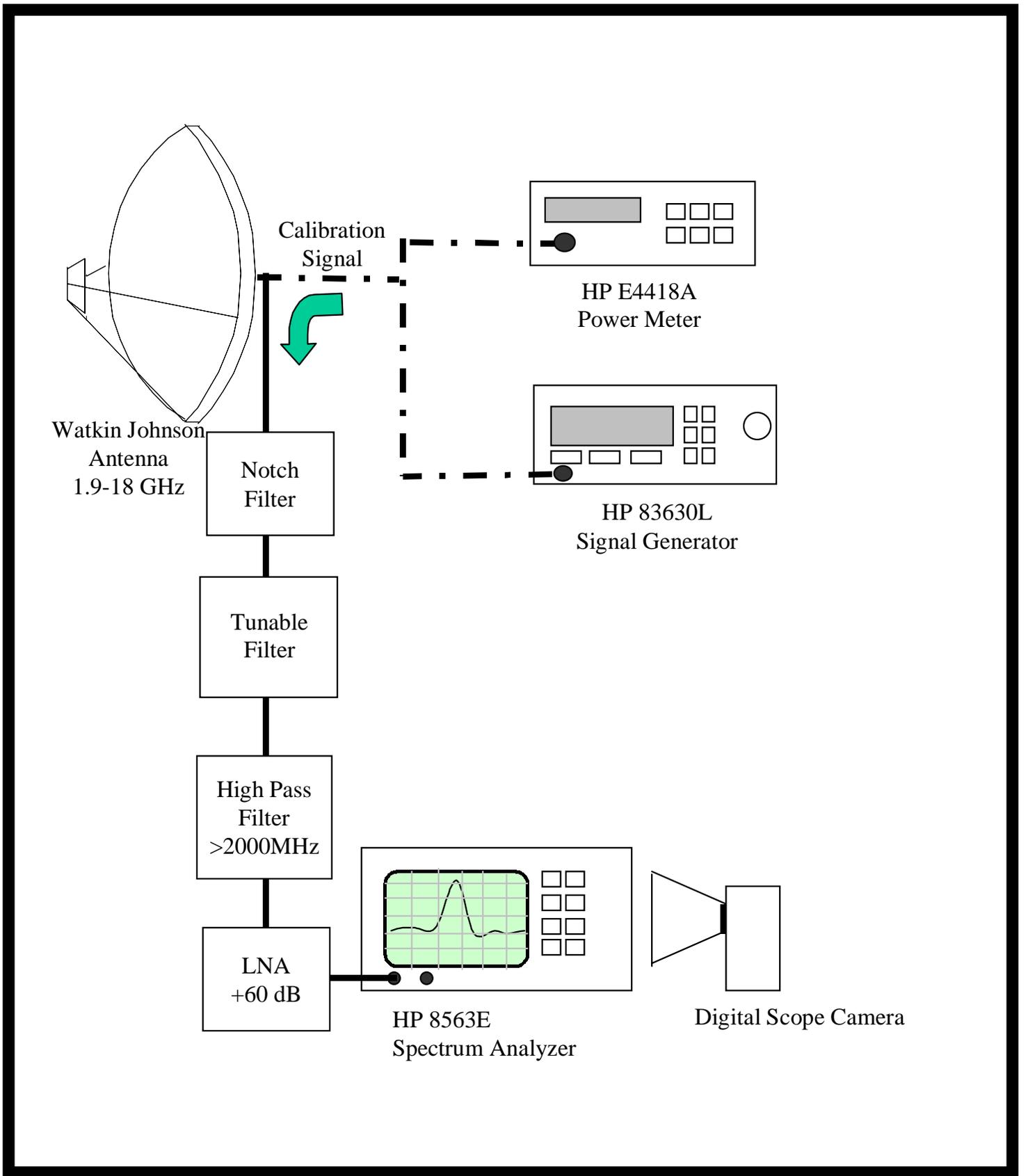
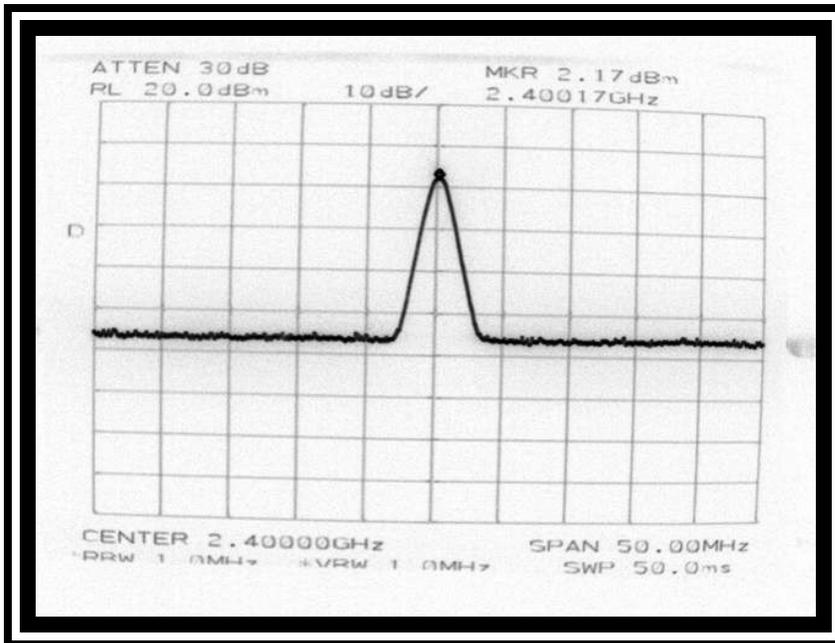


Figure 2.1-3 Test Equipment Block Diagram

Reference
Level
dBW_I

XM Radio

-89.5



High-Pass Filter

Date: January 16, 2002
Center Freq: 2400 MHz
Span/Div: 50 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 10 dB

+2.17 dBm, 2400 MHz signal indication on the spectrum photograph represents a -60 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

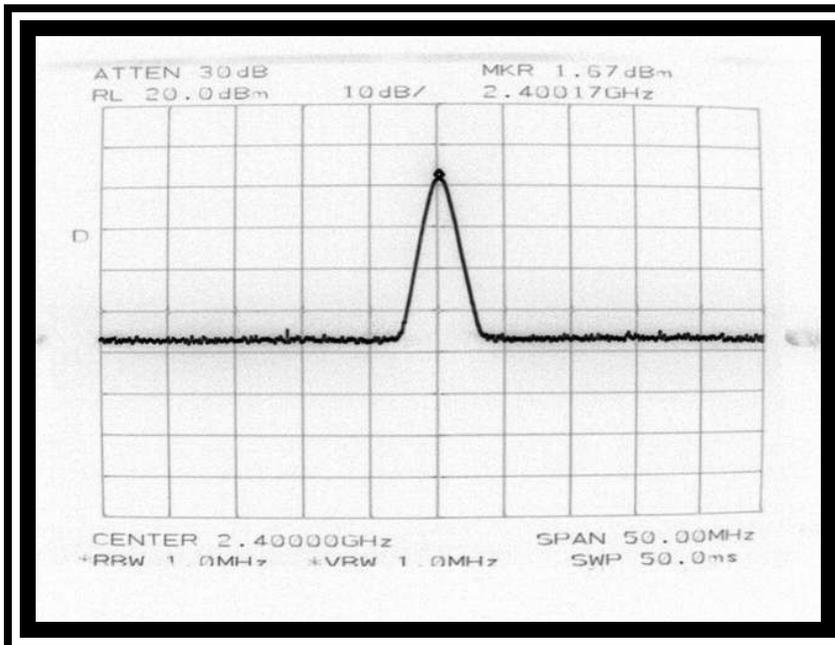
Displayed reference level is equal:

-60 dBm injected signal
-17.5 dB antenna gain
-30 dB conversion from dBm to dBW
-107.5 dBW_I; therefore, a displayed signal level of +20 dBm equals an isotropic level of -89.5 dBW_I.

Reference
Level
dBW_I

(A)

-89



High-Pass and Tunable Filters

Date: January 16, 2002
Center Freq: 2400 MHz
Span/Div: 50 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 10 dB

+1.67 dBm, 2400 MHz signal indication on the spectrum photograph represents a -60 dBm signal being injected at the point where the test cable connects to the output of the test antenna.

Displayed reference level is equal:

-60 dBm injected signal
-17.5 dB antenna gain
-30 dB conversion from dBm to dBW
-107.5 dBW_I; therefore, a displayed signal level of +20 dBm equals an isotropic level of -89 dBW_I.

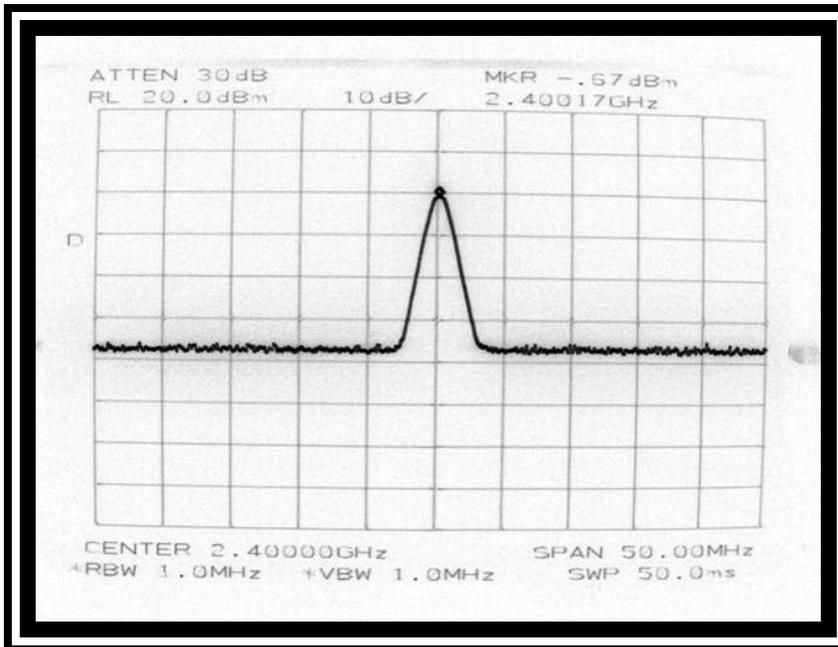
(B)

Figure 2.1-2 RF Calibration Photographs

Reference
Level
dBW_I

XM Radio

-87



High-Pass, Notch Filter and
Tunable Filter

Date: January 16, 2002
Center Freq: 2400 MHz
Span/Div: 50 MHz
Res. Bandwidth: 1 MHz
Amplitude/Div: 10 dB

-67 dBm, 2400 MHz signal indication
on the spectrum photograph represents
a -60 dBm signal being injected at the
point where the test cable connects to
the output of the test antenna.

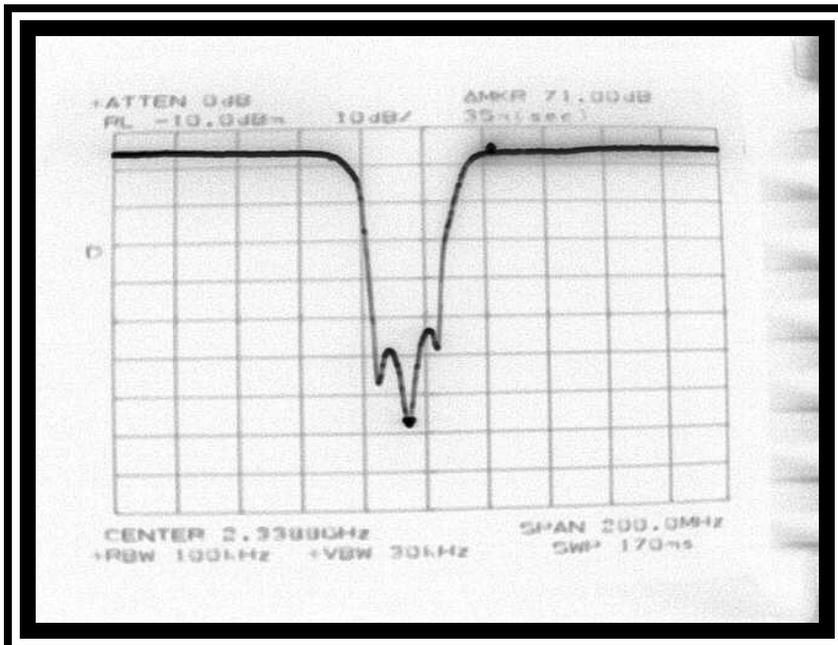
Displayed reference level is equal:

-60 dBm injected signal
-17.5 dB antenna gain
-30 dB conversion from dBm to dBW
-107.5 dBW_I; therefore, a displayed
signal level of +20 dBm equals an
isotropic level of -87 dBW_I.

Reference
Level
dBW_I

(A)

-52.5



Date: January 16, 2002
Center Freq: 2338 MHz
Span/Div: 200 MHz
Res. Bandwidth: 100 MHz
Amplitude/Div: 10 dB

-10 dBm, signal swept through entire
band. Showing 71dB of difference
from top signal to maximum
attenuation of filters

Displayed reference level is equal:

-10 dBm injected signal
-17.5 dB antenna gain
-30 dB conversion from dBm to dBW
-57.5 dBW_I

(B)

Figure 2.1-3 RF Calibration Photographs

SECTION

THREE

SECTION 3.1

Reagan National Airport

SECTION 3.1

DATA PRESENTATION

The following section contains the tables, site photos, and spectrum photos pertaining to the site location measured.

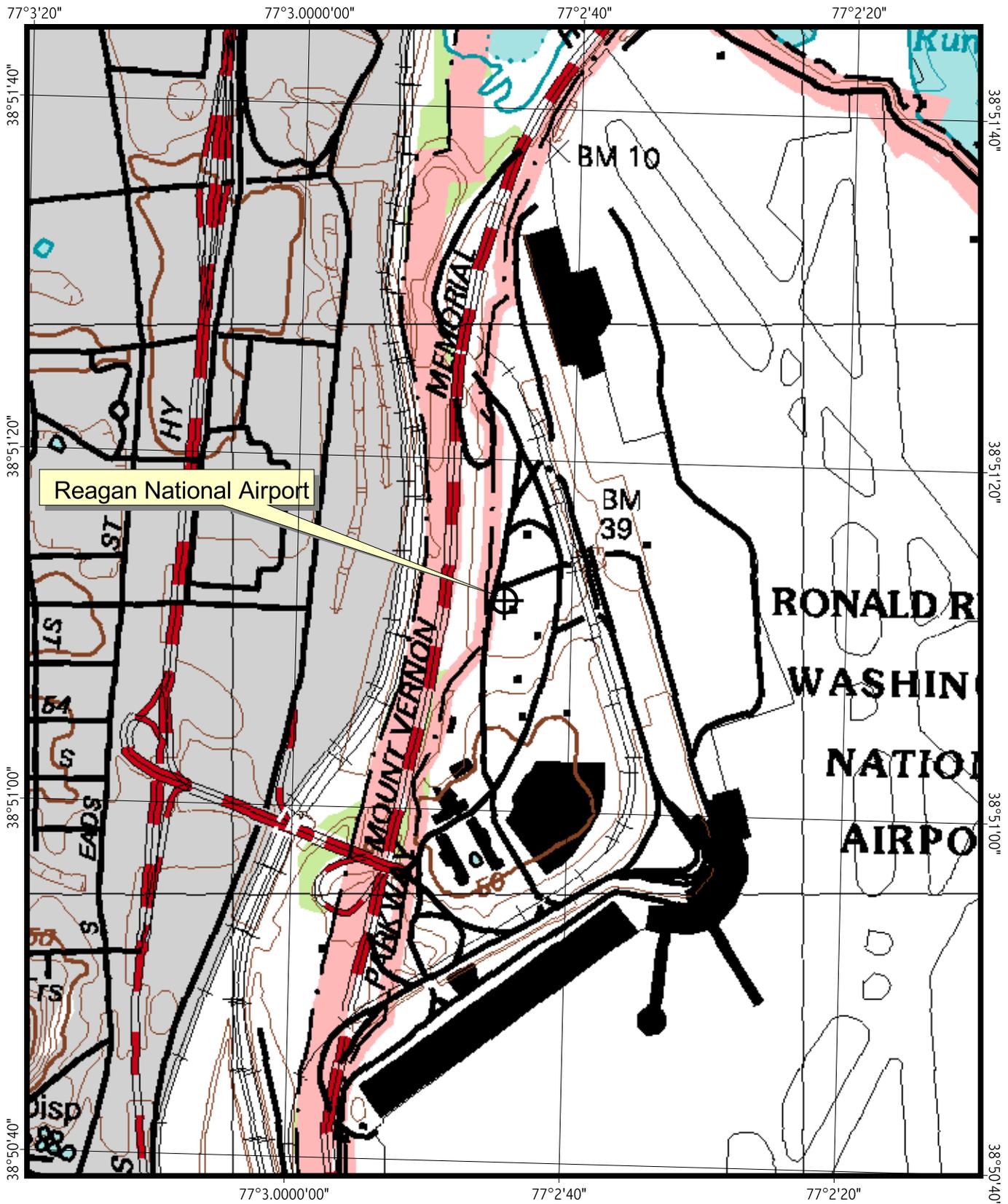
3.1 XM Radio – Reagan National Airport

- o Table 3.1-1 presents a site data sheet including all pertinent site information.
- o Figure 3.1-1 contains topographic map denoting the test location throughout the measurements.
- o Figures 3.1-2 are the photographs depicting the test site.
- o Figures 3.1-3 through 3.1-5 are the RF spectrum photographs depicting the interference environment at the test site.

TABLE 3.1-1

MEASUREMENT SITE DATA SHEET

1. SYSTEM NAME:	XM Radio
2. CITY AND STATE:	Arlington, VA
3. SITE IDENTIFICATION:	Reagan National Airport
4. COORDINATES: (NAD 1983)	LATITUDE: 38° 51' 12.6" N LONGITUDE: 77° 02' 44.8" W
5. SITE TYPE:	Urban
6. MEASUREMENT DATES & TIMES:	January 16, 2002 1300-1700 January 18, 2002 1000-1200



XM RADIO
FIGURE 3.1-1



North



East



Figure 3.1-2 Measurement Site Photographs

South



West

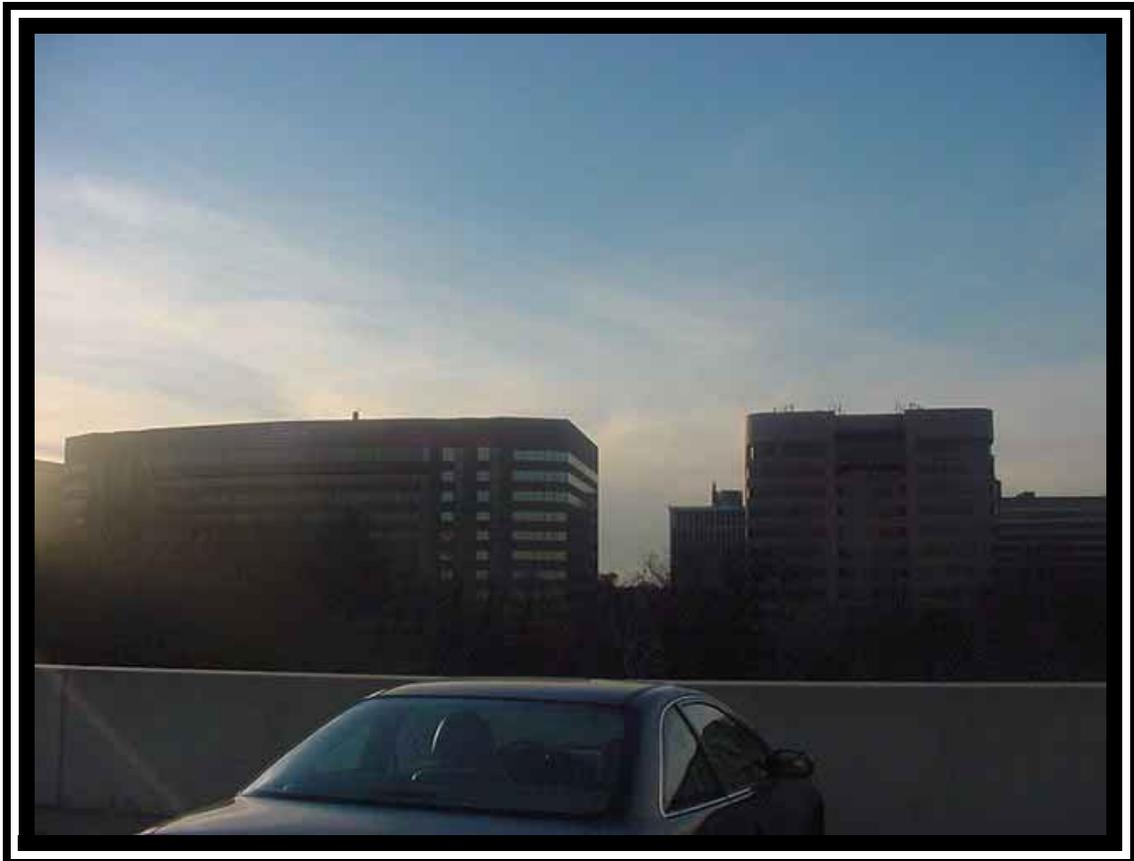


Figure 3.1-2 (cont.) Measurement Site Photographs

Az 295°



Az 358°

Az 12°

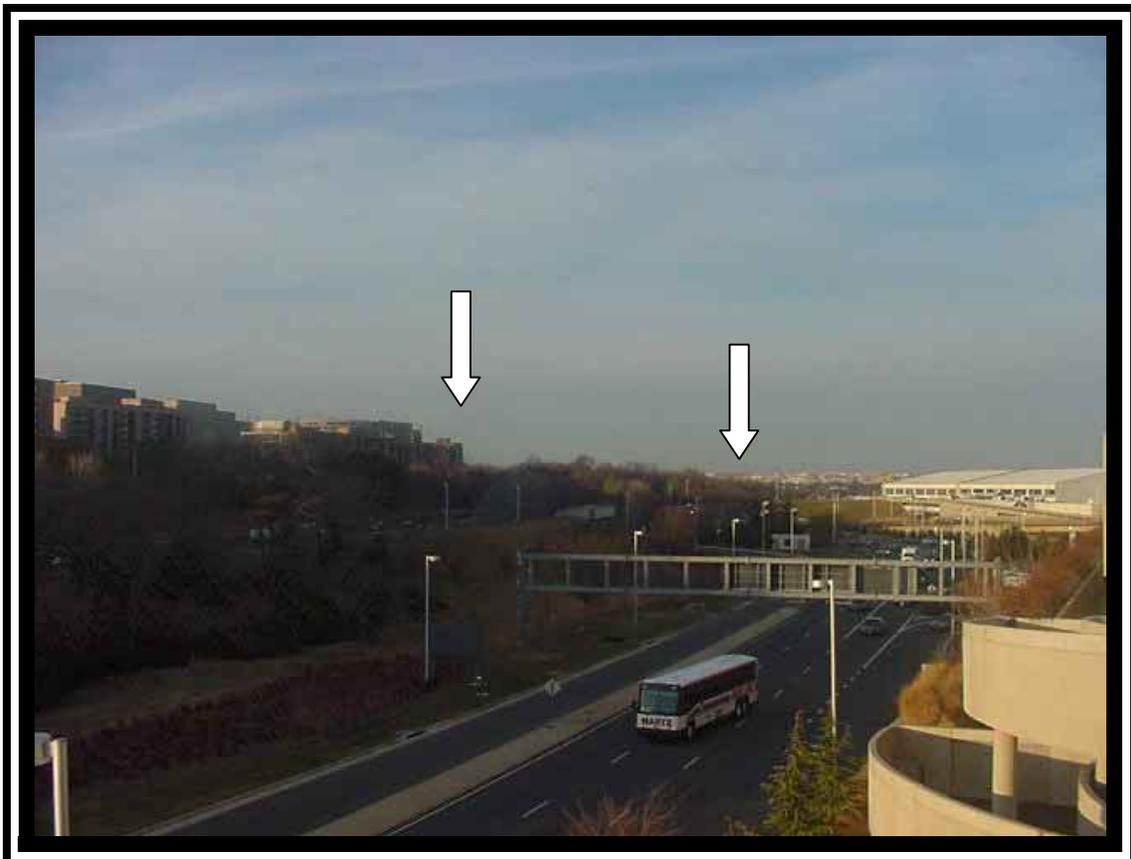


Figure 3.1- 2(cont.) Measurement Site Photographs

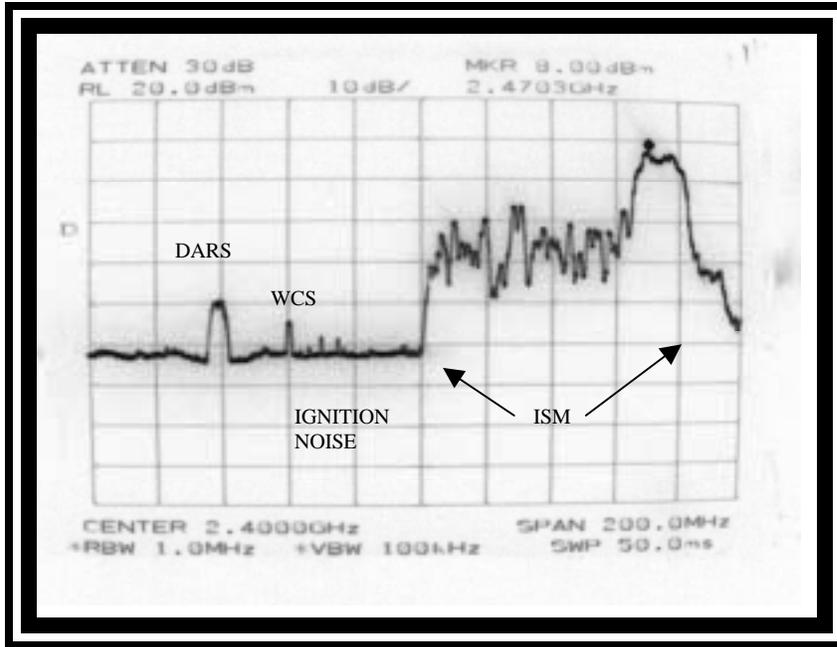
Reagan National Airport

Reference Level
dBW_I

XM Radio

Azimuth 0-360°

-87



With High-Pass, Tunable and Notch Filters

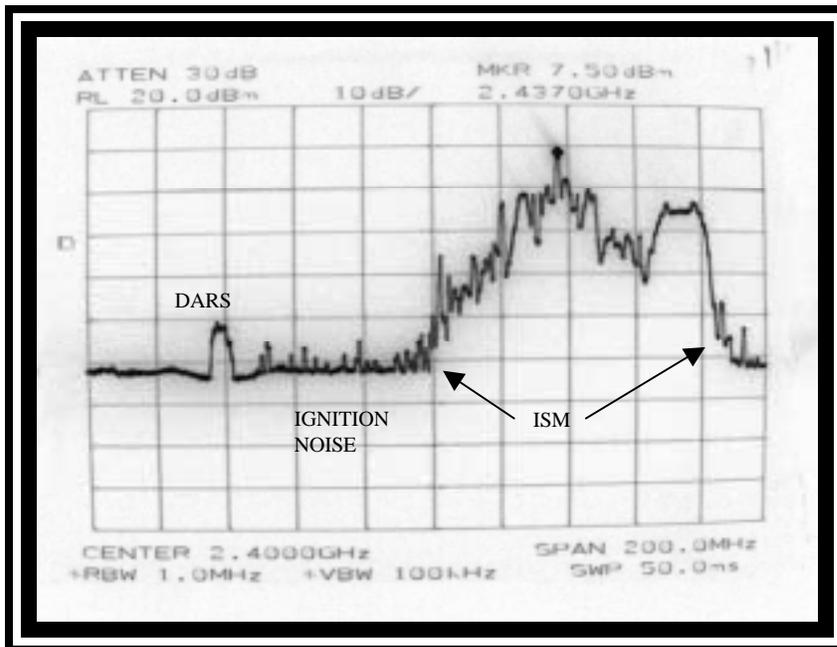
Date: January 18, 2002
Time of Day: 1100
Ant. Polarization: V
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference Level
dBW_I

-87



Date: January 18, 2002
Time of Day: 1105
Ant. Polarization: H
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.1-3 RF Spectrum Analysis

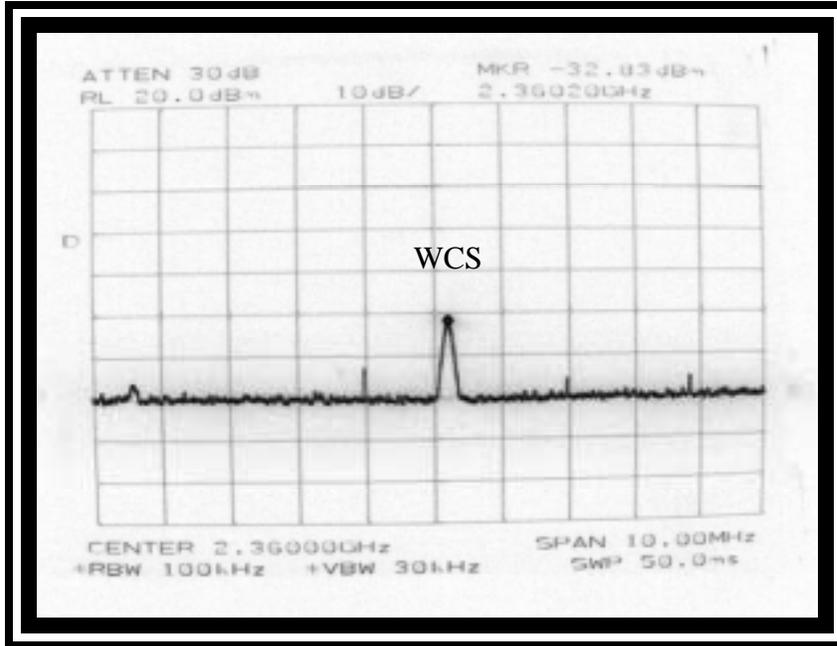
Reagan National Airport

Azimuth: 12°

Reference
Level
dBW_I

XM Radio

-87



With High-Pass, Tunable and
Notch Filters

Date: January 18, 2002

Time of Day: 1125

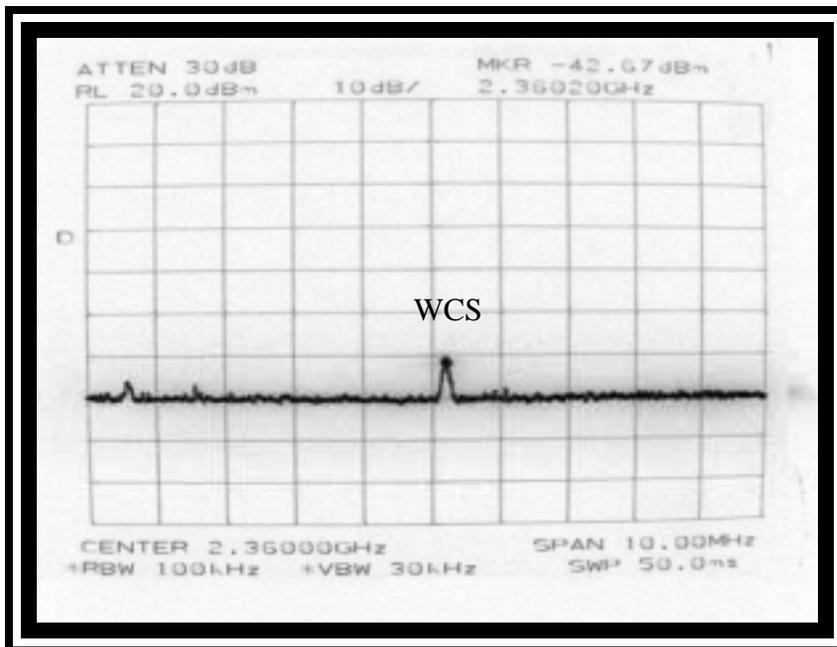
Ant. Polarization: V

Ant. Centerline: 10 Ft.

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002

Time of Day: 1130

Ant. Polarization: H

Ant. Centerline: 10 Ft.

(B)

Figure 3.1-4 RF Spectrum Analysis

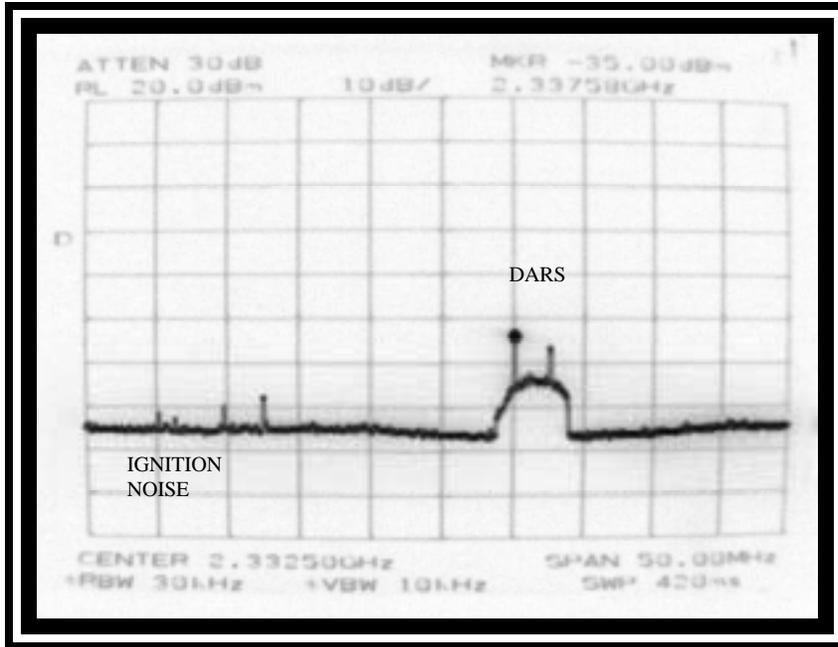
Reagan National Airport

Reference
Level
dBW_I

XM Radio

Azimuth 358°

-87



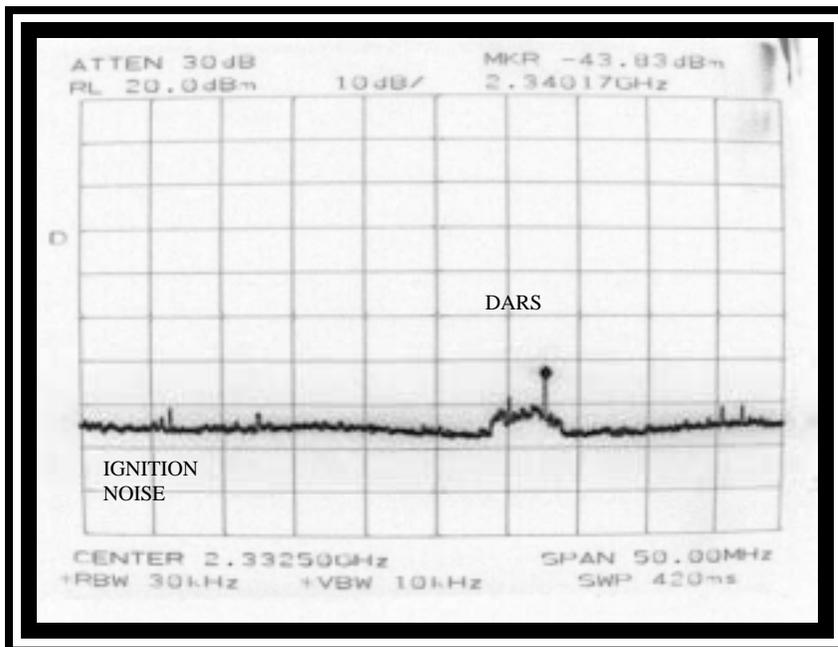
With High-Pass, Tunable and
Notch Filters

Date: January 18, 2002
Time of Day: 1140
Ant. Polarization: V
Ant. Centerline: 10 Ft.

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002
Time of Day: 1145
Ant. Polarization: H
Ant. Centerline: 10 Ft.

(B)

Figure 3.1-5 RF Spectrum Analysis

SECTION 3.2

Dulles Airport

SECTION 3.2

DATA PRESENTATION

The following section contains the tables, site photos, and spectrum photos pertaining to the site location measured.

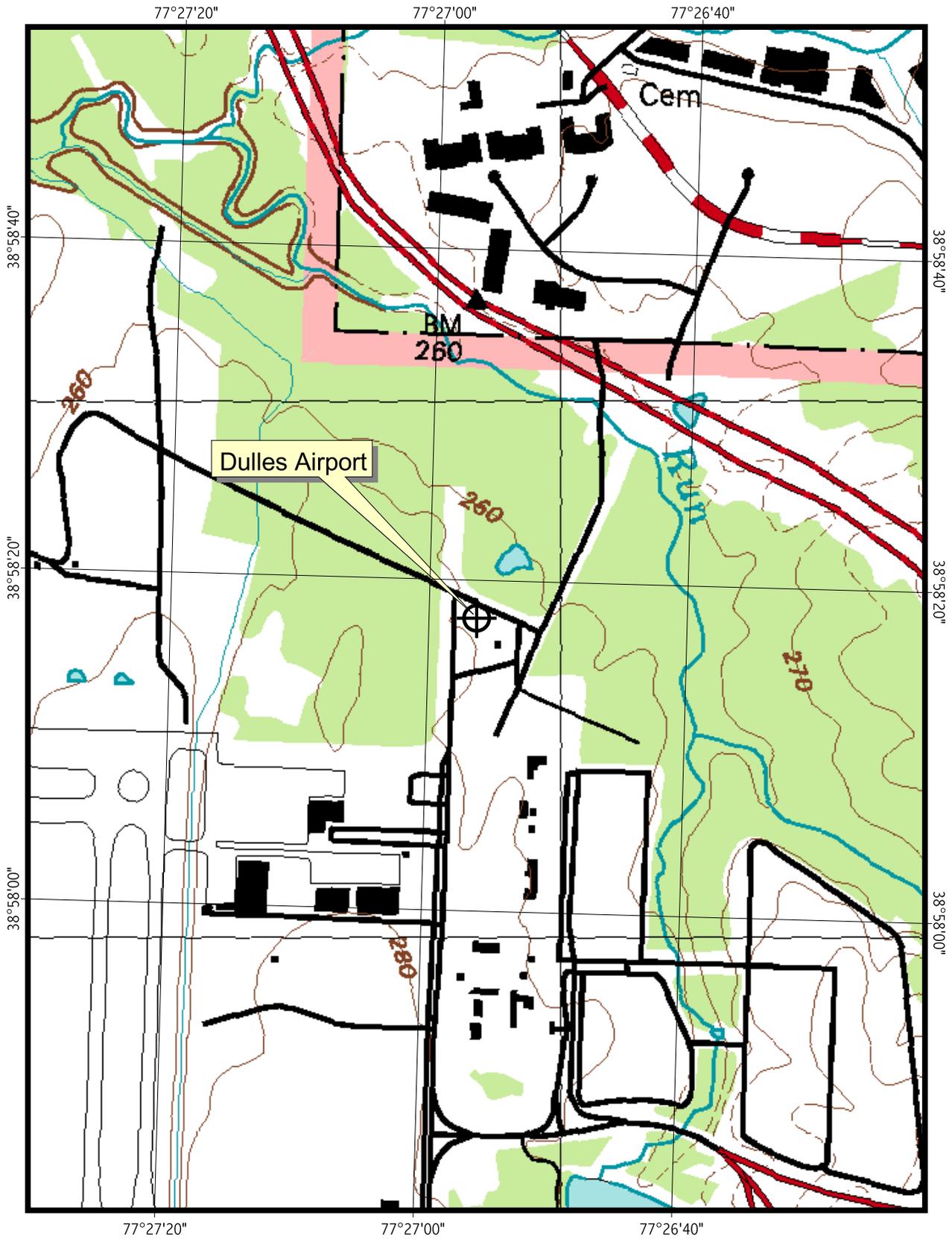
3.2 XM Radio – Dulles Airport

- o Table 3.2-1 presents a site data sheet including all pertinent site information.
- o Figure 3.2-1 contains topographic map denoting the test location throughout the measurements.
- o Figures 3.2-2 are the photographs depicting the test site.
- o Figures 3.2-3 through 3.2-4 are the RF spectrum photographs depicting the interference environment at the test site.

TABLE 3.2-1

MEASUREMENT SITE DATA SHEET

1. SYSTEM NAME:	XM Radio
2. CITY AND STATE:	Dulles, VA
3. SITE IDENTIFICATION:	Dulles Airport
4. COORDINATES: (NAD 1983)	LATITUDE: 38° 58' 21.5" N LONGITUDE: 77° 26' 56.3" W
5. SITE TYPE:	Suburban
6. MEASUREMENT DATES & TIMES:	January 17, 2002 1400-1500 January 21, 2002 1230-1330



XM RADIO
FIGURE 3.2-1



North



East



Figure 3.2-2 Measurement Site Photographs

South



West



Figure 3.2-2 (cont.) Measurement Site Photographs

Az 128°



Az 189°



Figure 3.2-2 (cont.) Measurement Site Photographs

Dulles Airport

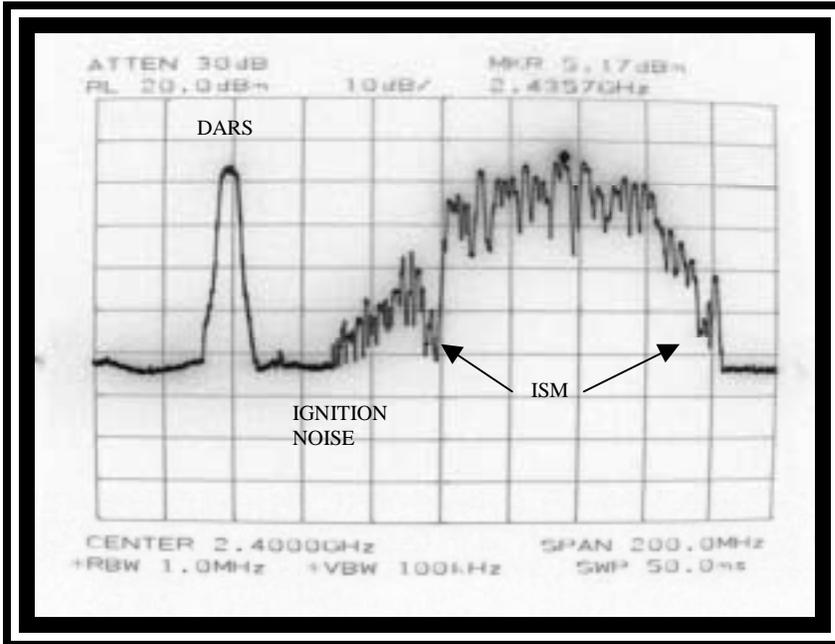
Azimuth 189°

XM Radio

Reference

Level
dBW₁

-89.5



With Tunable and High-Pass
Filters

Date: January 17, 2002

Time of Day: 1440

Ant. Polarization: V

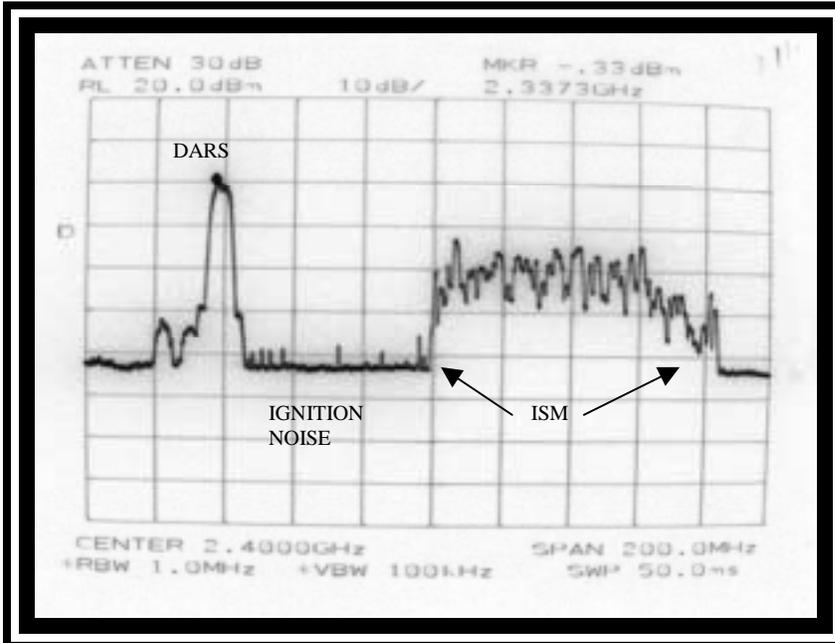
Ant. Centerline: 10 Ft.

(A)

Reference

Level
dBW₁

-89.5



Date: January 17, 2002

Time of Day: 1445

Ant. Polarization: H

Ant. Centerline: 10 Ft.

(B)

Figure 3.2-3 RF Spectrum Analysis

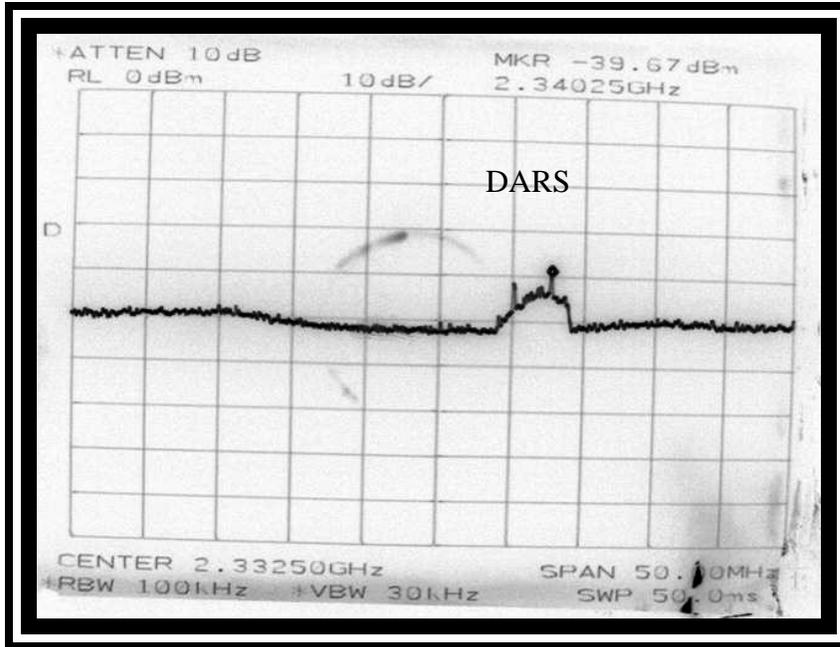
Dulles, Virginia

Azimuth 0-360°

Reference
Level
dBW_I

XM Radio

-107



With High-Pass, Tunable, and
Notch Filters

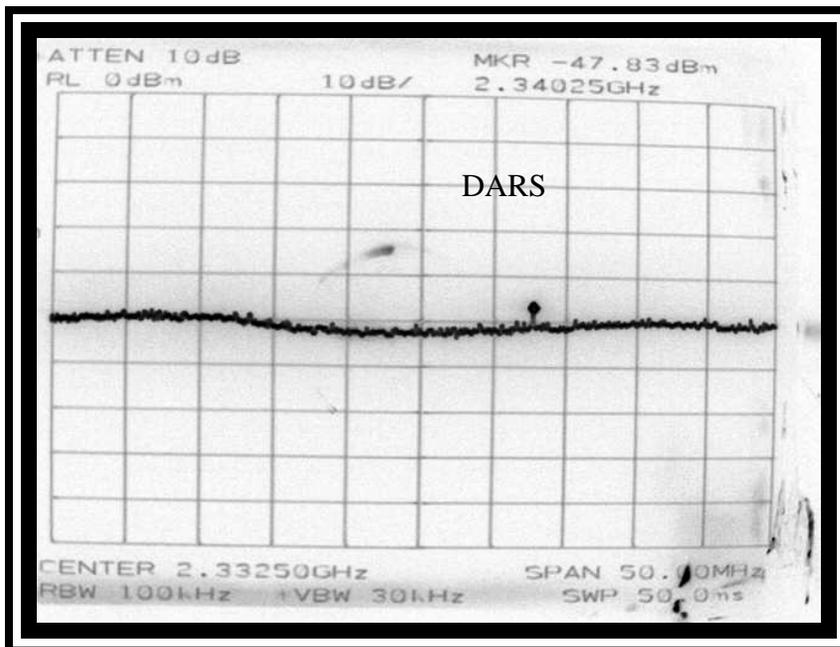
Date: January 21, 2002
Time of Day: 1235
Ant. Polarization: V
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference
Level
dBW_I

-107



Date: January 21, 2002
Time of Day: 1240
Ant. Polarization: H
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.2-4 RF Spectrum Analysis

SECTION 3.3

Reston, VA

SECTION 3.3

DATA PRESENTATION

The following section contains the tables, site photos, and spectrum photos pertaining to the site location measured.

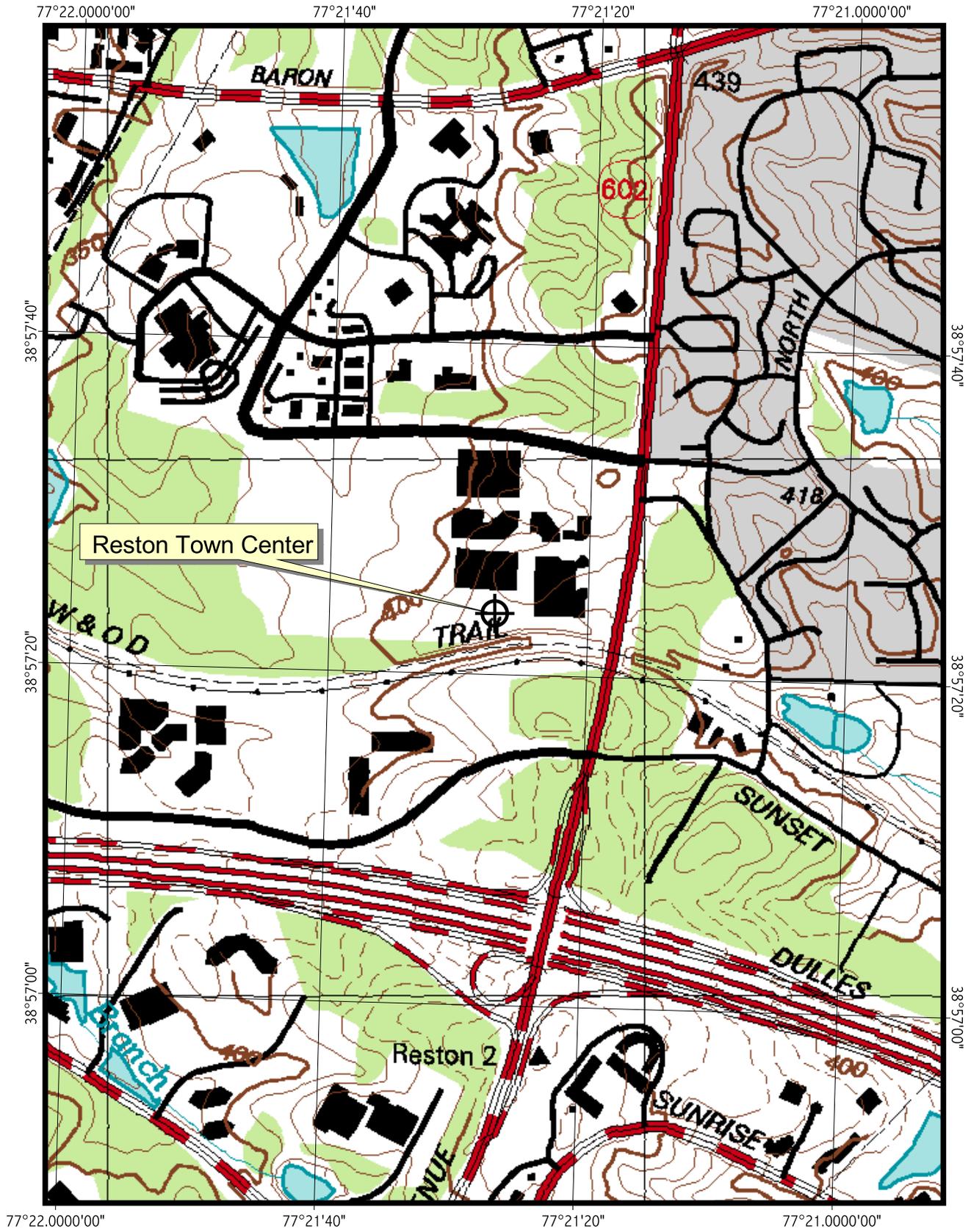
3.3 XM Radio – Reston, VA

- o Table 3.3-1 presents a site data sheet including all pertinent site information.
- o Figure 3.3-1 contains topographic map denoting the test location throughout the measurements.
- o Figures 3.3-2 are the photographs depicting the test site.
- o Figures 3.3-3 through 3.3-4 are the RF spectrum photographs depicting the interference environment at the test site.

TABLE 3.3-1

MEASUREMENT SITE DATA SHEET

1. SYSTEM NAME:	XM Radio
2. CITY AND STATE:	Reston, VA
3. SITE IDENTIFICATION:	Reston Town Center
4. COORDINATES: (NAD 1983)	LATITUDE: 38° 57' 27.2" N LONGITUDE: 77° 21' 27.2" W
5. Site Type:	Urban
6. MEASUREMENT DATES & TIMES:	January 17, 2002 1730-1830 January 18, 2002 1430-1515



XM RADIO
FIGURE 3.3-1



North



East



Figure 3.3-2 Measurement Site Photographs

South



West



Figure 3.3-2 (cont.) Measurement Site Photographs



Az 166°

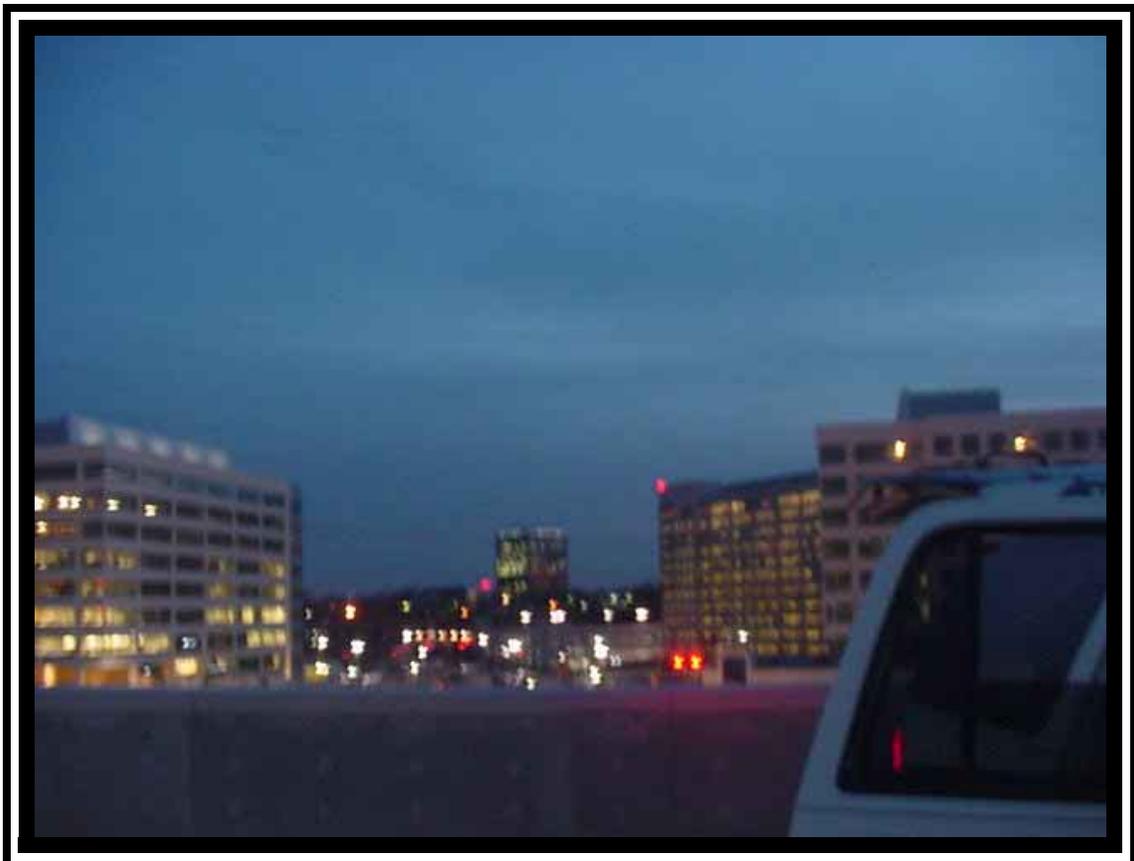


Figure 3.3-2 (cont.) Measurement Site Photographs

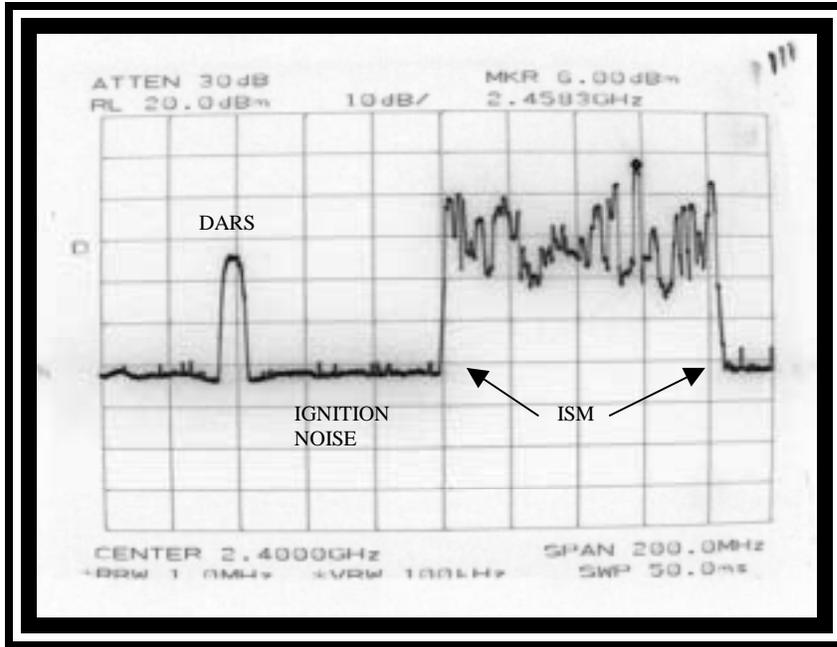
Reston, Virginia

Azimuth 0-360°

Reference
Level
dBW_I

XM Radio

-87



With High-Pass, Tunable and
Notch Filters

Date: January 18, 2002

Time of Day: 1430

Ant. Polarization: V

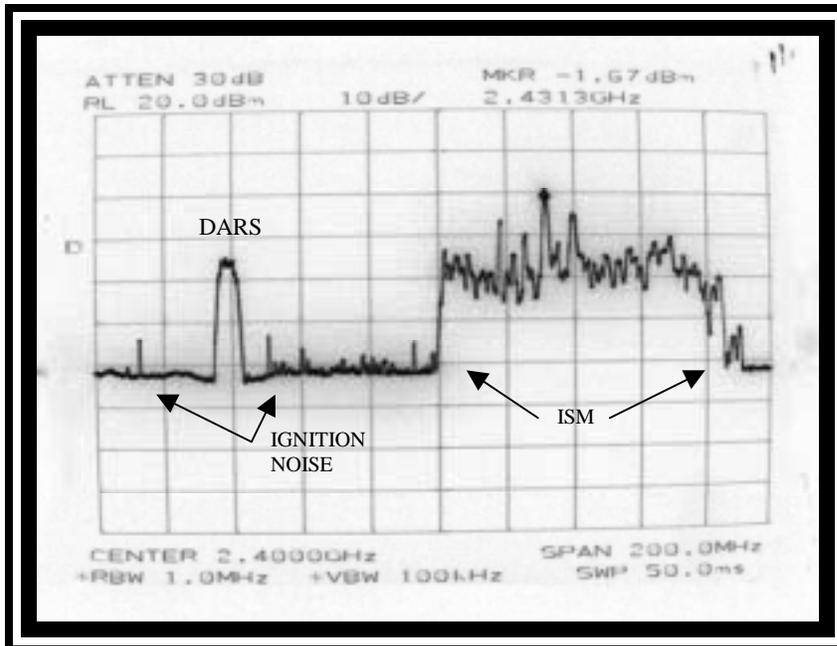
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002

Time of Day: 1435

Ant. Polarization: H

Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.3-3 RF Spectrum Analysis

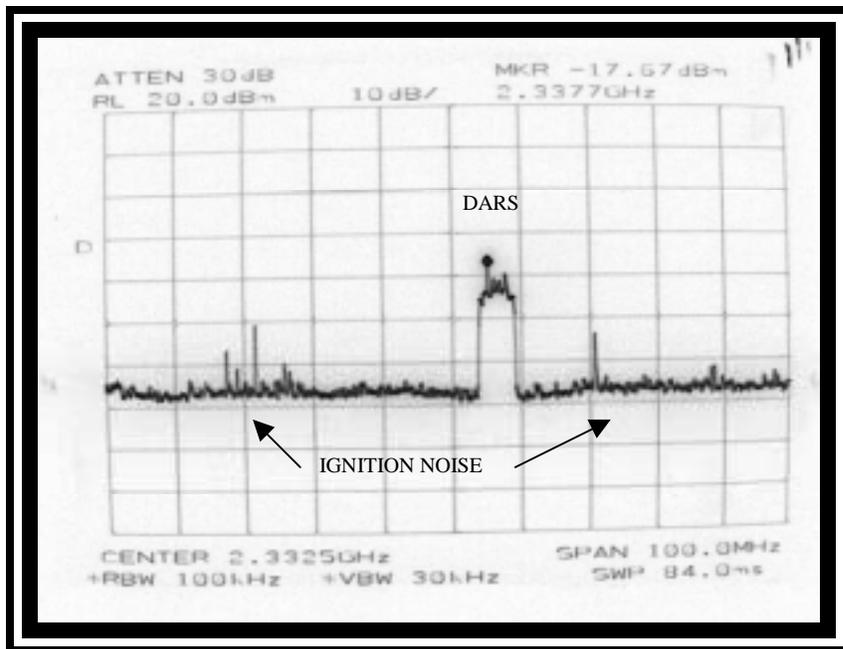
Reston, Virginia

Azimuth 0-360°

Reference
Level
dBW_I

XM Radio

-87



With High-Pass, Tunable, and
Notch Filters

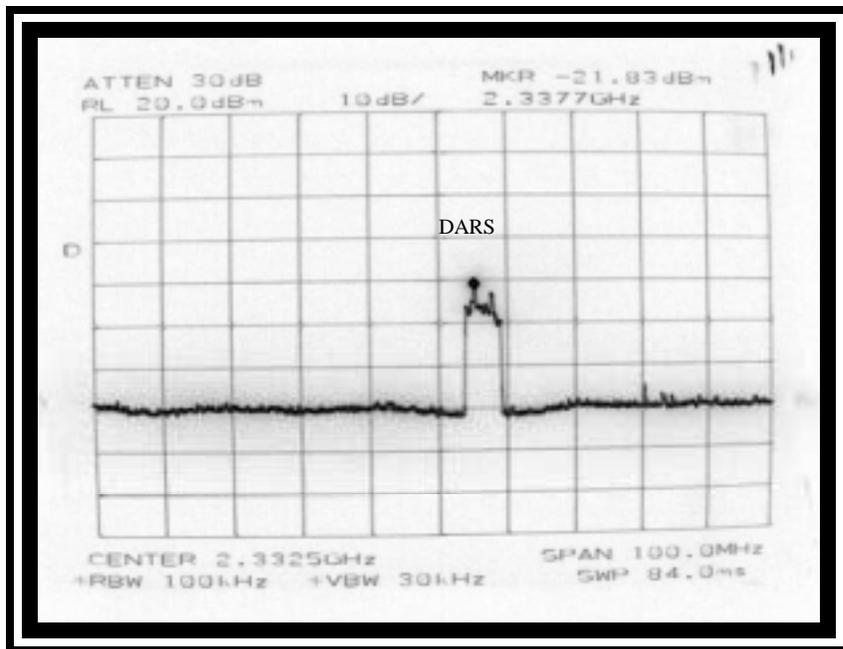
Date: January 18, 2002
Time of Day: 1445
Ant. Polarization: V
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002
Time of Day: 1450
Ant. Polarization: H
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.3-4 RF Spectrum Analysis

SECTION 3.4

Vienna, VA

SECTION 3.4

DATA PRESENTATION

The following section contains the tables, site photos, and spectrum photos pertaining to the site location measured.

3.4 XM Radio – Vienna, VA

- o Table 3.4-1 presents a site data sheet including all pertinent site information.
- o Figure 3.4-1 contains topographic map denoting the test location throughout the measurements.
- o Figures 3.4-2 are the photographs depicting the test site.
- o Figures 3.4-3 through 3.4-4 are the RF spectrum photographs depicting the interference environment at the test site.

TABLE 3.4-1

MEASUREMENT SITE DATA SHEET

1. SYSTEM NAME:	XM Radio
2. CITY AND STATE:	Vienna, VA
3. SITE IDENTIFICATION:	Tyson's Corner
4. COORDINATES: (NAD 1983)	LATITUDE: 38° 55' 19.5" N LONGITUDE: 77° 13' 25.9" W
5. SITE TYPE:	Urban
6. MEASUREMENT DATES & TIMES:	January 17, 2002 1200-1330 January 18, 2002 1300-1400



XM RADIO
FIGURE 3.4-1



North



East



Figure 3.4-2 Measurement Site Photographs

South

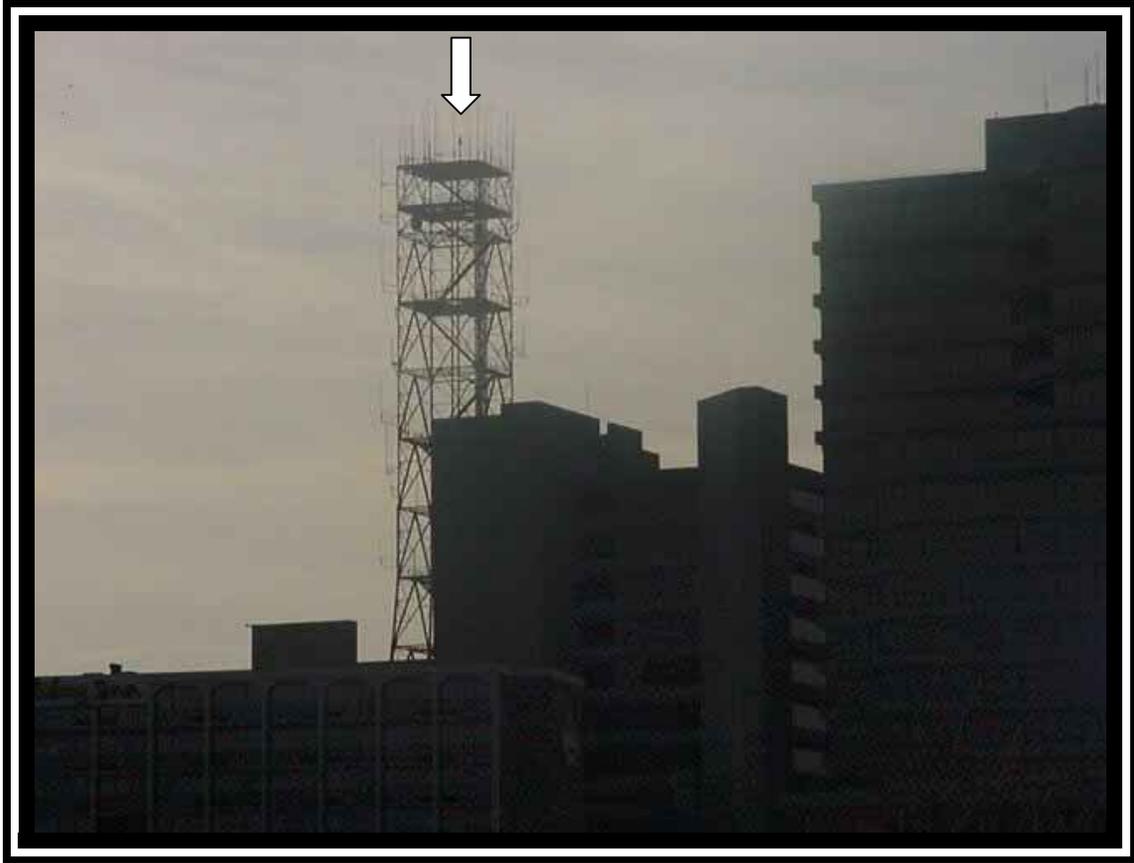


West



Figure 3.4-2 (cont.) Measurement Site Photographs

Az 233°



Az 296°



Figure 3.4-2 (cont.) Measurement Site Photographs

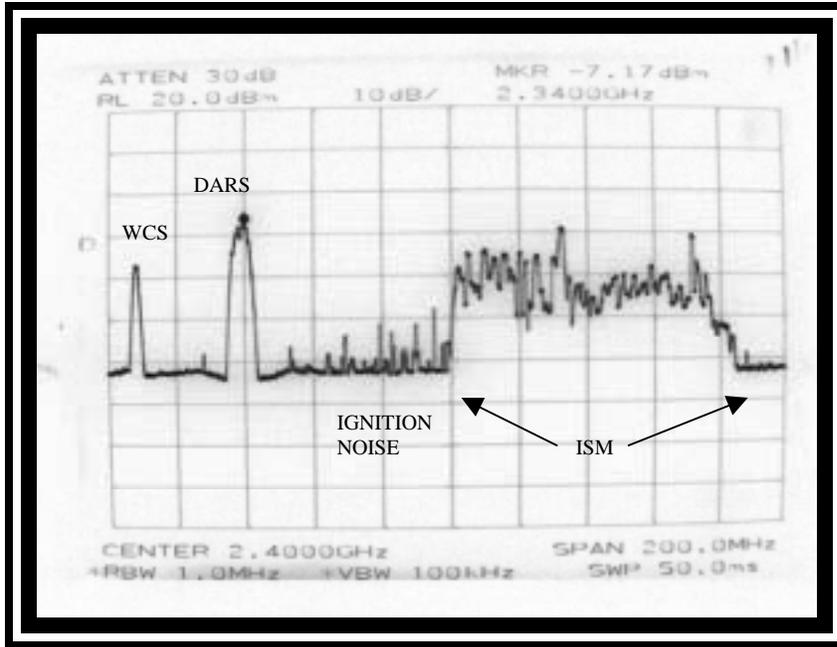
Vienna, Virginia

Azimuth 0-360°

Reference
Level
dBW_I

XM Radio

-87



With High-Pass, Tunable and
Notch Filters

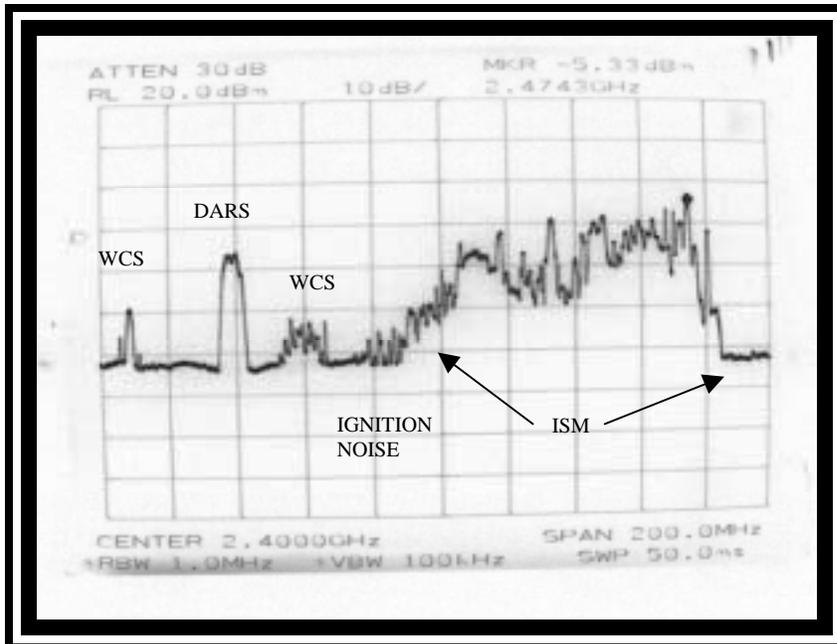
Date: January 18, 2002
Time of Day: 1310
Ant. Polarization: V
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002
Time of Day: 1315
Ant. Polarization: H
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.4-3 RF Spectrum Analysis

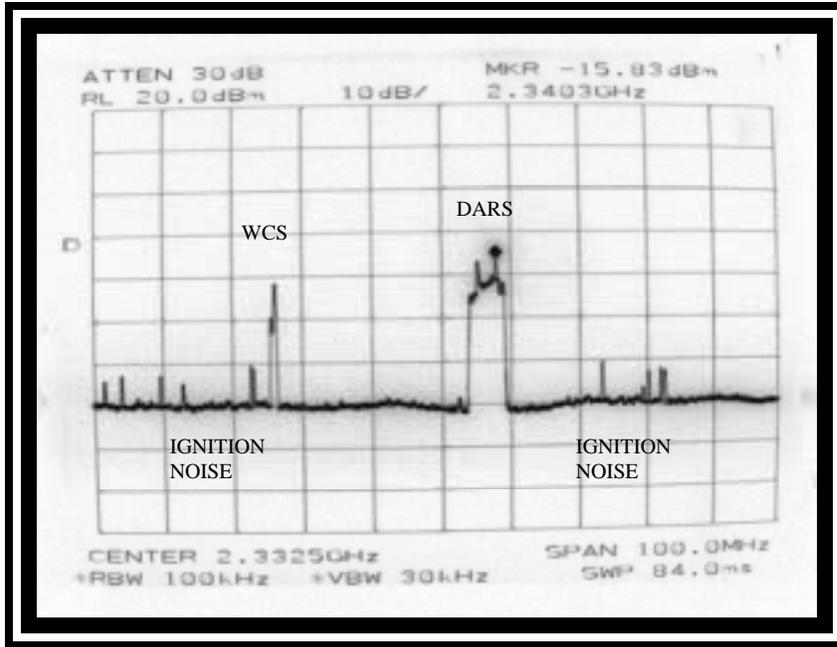
Vienna, Virginia

Azimuth 0-360°

Reference
Level
dBW_I

XM Radio

-87



With High-Pass, Tunable and
Notch Filters

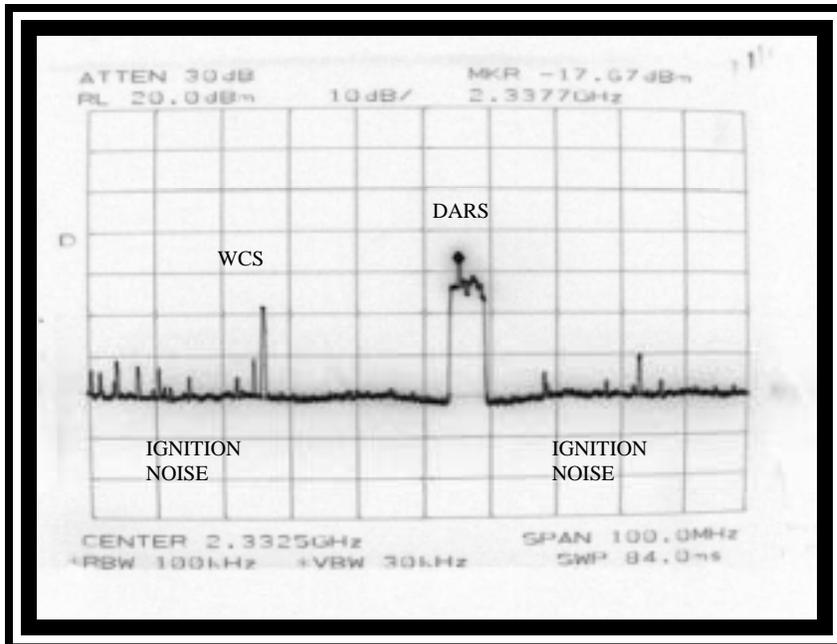
Date: January 18, 2002
Time of Day: 1325
Ant. Polarization: V
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(A)

Reference
Level
dBW_I

-87



Date: January 18, 2002
Time of Day: 1330
Ant. Polarization: H
Ant. Centerline: 10 Ft.

Full Antenna Sweep

(B)

Figure 3.4-4 RF Spectrum Analysis

SECTION 3.5

Leesburg, VA