Progress Report

WA2XMY

Northpoint - DBS Compatibility Tests

Washington, D.C.

October, 1999

Carmen Tawil, P.E., Diversified Communication Engineering, Inc.
Dr. Darrell Word, P.E., D.R. Word Associates
Robert Combs, Broadwave USA

STATE OF TEXAS
CARMEN ARMISTEAD TAWIL
66393
REGISTERED
PROFESSIONAL ENGINEER

STATE OF TEXAS
DARRELL R. WORD
48184
REGISTERED
PROFESSIONAL ENGINEER

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Executive Summary

A series of scientific, controlled and well-defined transmission and field measurements was performed in Washington, D.C. between August 2 and September 30, 1999 documenting the compatibility of Northpoint Technology with the existing direct broadcast satellite (DBS) systems. The engineering and field test team was comprised of personnel from Diversified Communications Engineering, Inc. (DCE), D. R. Word Associates, Broadwave USA and Lucent Technologies operating under an experimental license issued to DCE by the Federal Communications Commission.

Results of Testing

The most significant result of this recent work was that there was not a single case of DBS signal failure attributed to the Northpoint system during the test period. Co-channel reception of the Northpoint system and DBS services was documented through 44 tests at distances ranging from 15 feet from the Northpoint transmitter to a site over eight miles away. This includes operation during widely varying conditions, including Hurricane Floyd on September 16, a rain event sufficiently severe to close Washington area schools and render several hundred thousand local residents without electrical power. At no time during Hurricane Floyd did the Northpoint signal fail nor cause failure of the DBS system.

Types of Tests Conducted

Two basic concepts were tested: the ability of Northpoint to provide quality transmissions with off-the-shelf equipment, and its ability to operate co-channel with DBS without causing harmful interference. The quality of service test included multi-channel and multi-cell transmission of both off-the-air and live video throughout an approximately 100 square miles service area. Simultaneously, the Northpoint co-existence with DBS was demonstrated by conducting repeatable field measurements of DBS operations in the presence of the Northpoint signal. Thousands of measurements were made of the signal strength of multiple DBS systems in the field, and DBS operations were studied with Northpoint both on and off.

Worst Case Conditions Studied

Most measurements were made within one mile of a Northpoint transmitter or repeater where the Northpoint signal is strongest. Northpoint's signal rapidly declines in power as it moves away from the transmitter and attenuates through space. The majority of readings were taken within this worst case region of Northpoint's service area.

Customer Set Top Box Confirms Lack of Interference

One test employed was of the DBS consumer set top box which has an antenna pointing aide used to detect the quality of the consumer's DBS signal. In observing this signal strength indicator, it was determined that the DBS system remained very robust during the Northpoint transmissions. In general, there was no detectable interaction between Northpoint and DBS in sites representing 99% of the Northpoint service area. Furthermore, while some small deflections in the signal strength indicator were observed at certain sites within the 1% worst case region, the data as a whole show no statistical difference, even in the 0.25% of the service area closest to the transmitter. The average change observed with the Northpoint transmitter on was less than one count of the signal strength indicator, a level that is sufficiently low that it can be stated with 95% confidence that there was no statistical difference between the Northpoint "on" and Northpoint "off" conditions. At all times, whether Northpoint was on or off, quasi-error free DBS operation was observed in clear air both before and after decoding. This observation supports the finding that DBS operations are robust, and there is no negative impact on DBS from Northpoint operations.

Readings Taken with Cellular Repeater Did Not Change Conclusions from Single Transmitter Readings

It was found that the operation of multiple Northpoint transmitters operating in a cellular fashion worked well. Importantly, there was no evidence that multi-cell Northpoint architecture caused interference into either DBS systems or to Northpoint itself.

The results of this series of tests confirm previous work done over the last two years in Kingsville and Austin, Texas where successful co-channel operation of Northpoint and DBS was demonstrated in a wide variety of conditions. The Washington, D.C. testing was conducted over a two month period in an area where DBS providers have stated that tens of thousands of DBS customers are located. Neither DBS providers nor any member of the public reported a single instance of harmful interference to any DBS customer attributed to Northpoint during the entire period.

Conclusion

The Washington, D.C. tests are a compelling demonstration that the Northpoint system is a viable spectrum sharing system and is ready for deployment within the United States.

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1. Introduction

An engineering and field team comprised of personnel from Diversified Communications Engineering, Inc., D.R. Word Associates, Lucent Technologies, and Broadwave USA, conducted a compatibility field test in Washington, D.C. between August 2nd and September 30th, 1999. The objective was to conduct a series of scientific, controlled and well-defined transmission and field measurements to document the compatibility of Northpoint Technology[1] with the existing Direct Broadcast Satellite (DBS) systems. These tests were conducted under Experimental License WA2XMY, as granted by the Federal Communications Commission (FCC).

a. Test Objectives

This test examined the coexistence of Northpoint Technology with Direct Broadcast Satellite (DBS) systems. Field measurements were performed to see if Northpoint caused a change in the signal strength pointer[2] (SSP) or caused a change in bit error rate (BER), and to confirm the presence of a good DBS picture. Measurements were performed to determine the presence of multipath signals due to reflections from buildings or bodies of water that might occur. In addition, measurements were made to determine the operational environment with multiple Northpoint transmitters. Beyond the question of mutual coexistence of the Northpoint and DBS systems, the ability of the Northpoint Technology to provide quality service using existing off-the-shelf equipment was investigated.

The operation consisted of three separate phases, each phase with specific objectives. The Phase I objectives were to demonstrate the compatibility between Northpoint and DBS, while operating in a single cell environment and transmitting a single video channel within a 24 MHz carrier. This objective was met by documenting the operation of the DBS system both with and without Northpoint. Phase II demonstrated the Northpoint system ability to carry multiple local television stations multiplexed on a 24 MHz carrier. The purpose of the Phase III test was to examine and determine the impact, if any, of multiple Northpoint transmitters, and to document the performance of the systems during different weather events.

b. Test Approach

Based upon theoretical predictions confirmed by previous testing, a variety of test receive sites were selected, the majority being within one mile of the Northpoint transmitter.

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[1] U.S. Patents No. 5,483,663 (9 Jan 1996) and No. 5,761,605 (2 Jun. 1998) – by Saleem Tawil and Carmen Tawil of DCE, Austin, TX.

[2] The Signal Strength Pointer (SSP) is an indication of DBS signal quality, it is intended to aid the consumer in properly pointing their antenna.

These close-in sites are particularly important because they represent the area where Northpoint's signal is highest. Measurement sites were chosen in many different directions from the transmitter, including behind the transmitter and to the side of the transmitter. Sites that represent the worst case scenario for potential Northpoint interference into DBS receivers were actively sought out.

Each test consisted of a series of measurements with the Northpoint transmitter both on and off. During each trial, the DBS SSP and the power density on the spectrum analyzer were documented. A professional demodulator test set was also used to monitor Eb/No, received signal level, BER and other pertinent variables of the open architecture DVB system used by Echostar. A VLSI chip-set evaluation board capable of demodulating DVB and DSS formats was used to verify results with the Newtec demodulator. Again, these data were taken with the Northpoint transmitter on and off.

The test approach was a departure from the Austin test, where the impact of Northpoint was measured with reference to the adjacent DBS transponders. In contrast, the Washington, D.C. measurements were all taken on the same transponder with Northpoint alternately on and off.

c. Test Team

Dr. Darrell Word, P.E., of D.R. Word and Associates, was the team leader of the field-testing. Several technical school graduates and engineering students assisted him including Floyd Nelson, Stacy Hatcher, Jonathan Vorhis, Akin Falodun, and Aduragba Adekunjo. Dr. Habib Riazi, P.E., led Lucent's participation. Saleem Tawil P.E., Carmen Tawil, P.E., Sophia Collier, Katherine (Chula) Reynolds, Linda Rickman, Robert Combs and Roger Thurston also participated in the test.

2. Compatibility Test Conditions: Environment and Methodology

This section describes the test conditions, the measurement locations and the test methodology. The dates of testing were August 2nd through September 30th, 1999. During the majority of this period, the weather in Washington, D.C. was predominantly hot, clear and dry, with the exception being the occurrence of Hurricane Floyd on September 16th and a few brief periods of light rain. The Northpoint transmitter was located on the top of the USA Today building at 1000 Wilson Boulevard in Rosslyn, Virginia. This is one of the tallest buildings in the D.C. area. For the Phase III multi-cell test, a repeater was installed on top of a 10 story building at Ft. Lincoln, 6.2 miles away from the main transmitter.

For all three phases, test measurement sites that were concentrated in the 1% of the Northpoint service area near a Northpoint transmitter were selected in order to test where the Northpoint signal is the highest. The test methodology and procedures were developed to identify using scientific methods what impact Northpoint might have on DBS operations.

a. DBS Operations in the Washington, D.C. Area

In the band 12.2 - 12.7 GHz, on August 2, 1999, there were three DBS satellite locations operating and providing service to the Washington, D.C. metro area.

Table 1. DBS Operations in Washington, D.C. Area

Satellite	Longitude (deg. W)	Azimuth (deg)	Elevation (deg)
DirecTV	101	225	38
Echostar	61.5	165	42
Echostar	119	244	28

Both Echostar and DirecTV intend to provide service from 110 west longitude. However, no satellite signal was found at that location on August 2, 1999. Later, it was determined that transmission from the 110 west longitude location began at some time during the test period. However, the compatibility tests for the satellites operating 9 degrees on either side of 110 (101 and 119 west longitude) would encompass, and are comparable to, the 110 west longitude location.

b. Measurement Sites Concentrated Near Transmitters

Measurement sites were specifically selected to examine the premise that Northpoint would cause harmful interference into DBS receivers. Twenty-nine measurement sites were identified and the appropriate permits from local and national authorities were obtained . The testing comprised 44 separate tests at these 29 different sites. Seventythree percent (73%) of these measurements were within one mile of a transmitter or repeater, in the area where the Northpoint signal is the strongest (see Appendix I). Other test locations were selected to measure the performance of DBS with multi-cell Northpoint transmissions during Phase III, and to verify performance of Northpoint at various distances. A repeater was installed at the Ft. Lincoln transmit site for Phase III of the test.

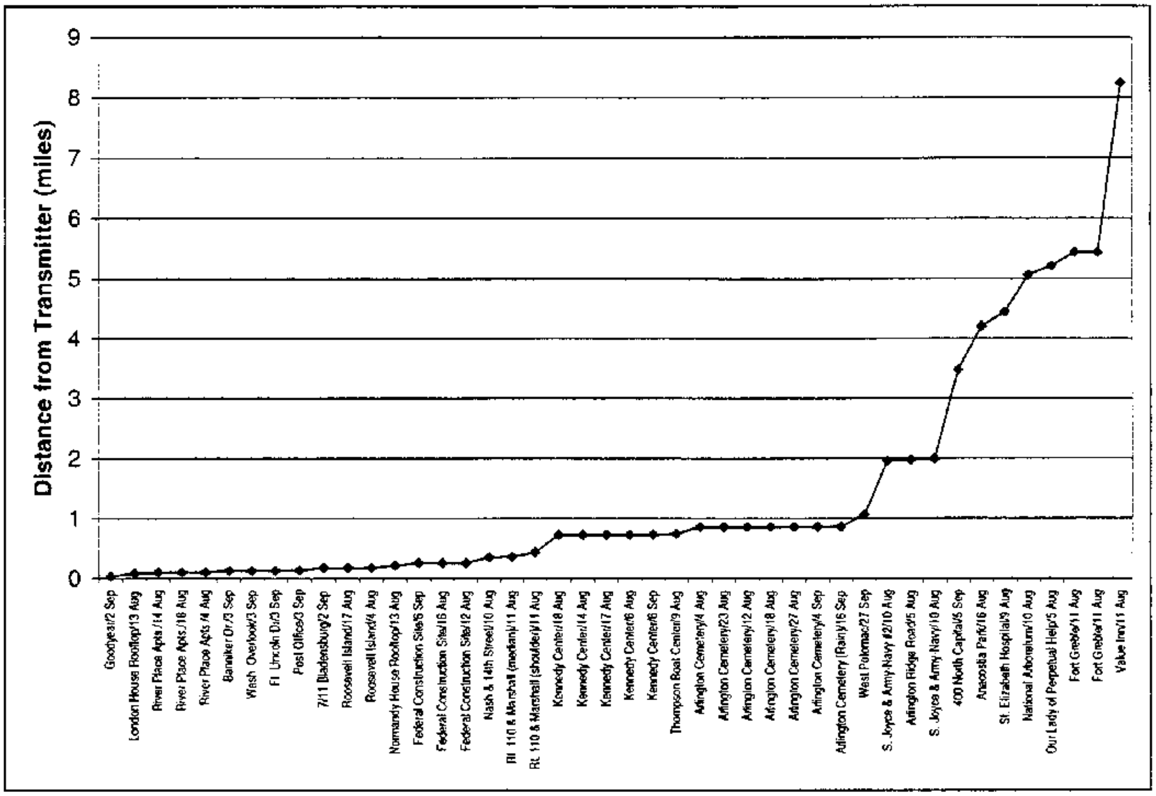

Figure 1. Measurements and Distance from Transmitter

Relation of Test Sites to Predicted C/I Levels

Since one primary test goal was to document the ability of Northpoint to operate co-channel with DBS, an initial step in the test planning was to plot the contours of any areas within the Northpoint service area where the Carrier to Interference ratio (C/I) between DBS and Northpoint was below 6 dB, 10 dB, 15 dB and 20 dB. In previous Northpoint technology experimental work in Kingsville, it was documented that 4.8 dB was the critical C/I ratio in which Northpoint's signal could cause harmful interference to DBS.

In establishing the orientation and location of the Northpoint transmitter, care was taken to minimize the area within these contours. As shown in Appendix I, there is no area around Northpoint's primary transmitter that is within the 6 or 10 dB contour. The tiny area within the 15 dB contour is completely located in the Potomac River. This real world installation shows the ability of a Northpoint engineer to use site specific techniques to minimize and eliminate the potential for interference before the transmitter is ever placed in service. A portion of the 20 dB contour, which still provides more than 15 dB of margin, falls over land, however, it is important to note that this area is primarily uninhabited and comprises only a tiny fraction (0.3%) of the service area. This installation is typical of the way in which Northpoint installations will be made in the real world.

Notwithstanding the fact that there was little chance of harmful interference within or in the immediate vicinity of the 20 dB contour, this is the area where the Northpoint signal is strongest and therefore most of the testing was concentrated in this area of interest. In this report the areas within or near the 20 dB contour are referred to as the Near In Region.

c. Test Methodology and Procedures

Data was taken in a rigid, scientific manner, and with the use of repetition to verify the results and ensure repeatability. Each measurement consisted of a set-up with the Northpoint transmitter off, establishment of a DBS baseline without the Northpoint signal present, and a data collection phase with the Northpoint transmitter on.

At the start of each test, each of the receive antennae, DBS and Northpoint, was precisely pointed using in-line satellite pointing devices such that all signals were at their highest power. The 34' boom lift was used as necessary to acquire the Northpoint signal.

After the measurement equipment was set-up, the Northpoint transmitter was turned off to establish the DBS normal operational baseline at each site. Two measurements were made of each DBS system -- the set-top box SSP indication and the power density indicated by the spectrum analyzer. Both the spectrum analyzer power level and SSP meter readings were taken over the same period in time.

The Northpoint transmitter was then turned on and maintained at a nominal 12.5 dBm Effective Isotropic Radiated Power (EIRP). With the transmitter on, measurements were repeated of power density and SSP readings. Therefore, data was obtained with the Northpoint transmitter on and off for each DBS satellite visible at each measurement site.

A similar methodology was used for collection of data with the professional (Newtec) demodulator. The Newtec data was collected with Northpoint alternately on and off for 15 - 30 minutes at a time. The Newtec demodulator and data logging provides an accurate record of many important variables for systems using the open DVB standard, such as Echostar. The software records at a specified interval the apparent Eb/No, the received signal level, the bit error rate, the decoder internal temperature, and several other parameters. The Newtec software provides its estimated Eb/No and other values by directly reading these results from the demodulator chipset.

To evaluate the DSS protocol, a CAS2993A DVB and DSS Receiver Variable Rate Front End Receiver Board was acquired from VLSI with software capable of displaying a BER rate[3] and other values for both DSS and DVB protocols, similar to those provided by the Newtec demodulator. The VLSI product allowed reading of values but had limited logging capabilities. A comparison of the VLSI product output with that of the Newtec demodulator was made, and it was determined that the Newtec unit provides a good proxy for DSS formatted data as well as its native DVB format. It was used to verify results with the Newtec demodulator. Since the DSS protocol is considered more robust than DVB this is a conservative approach.

Although the data were taken at fixed points in space, some time obviously elapsed between the "transmitter on" and "transmitter off" times. Thus, a temporal variance may be introduced, due to normal variations in the DBS system and/or the atmosphere that occur regardless of whether the Northpoint signal is present or not. To account for this variance, some tests were repeated at the same site on different days. Clearly, if Northpoint had a significant effect that is greater than the inherent random event, it would have been revealed by the repetitive scientific methodology used in the test.

After making all measurements of the DBS systems, a sweep was performed using the Northpoint antenna and receiver and the spectrum analyzer to determine the existence and extent of any multipath signals.

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[3] BER as low as 10^9. At no time did it vary from this value.

3. Compatibility Test Demonstrates No Significant Impact

No evidence of harmful interference was found at any time throughout the test. The findings described in this section include:

- Very close range tests where no local interference mitigation was required, even within 15 feet of the transmitter. This was achieved through transmit site design criteria.
- Signal Strength Pointer (SSP) and power density results that demonstrate the robust nature of DBS in the presence of Northpoint. The temporal and spatial changes in DBS operation, both with and without Northpoint, were documented. The Northpoint induced changes are smaller than the normal variance of DBS.
- Bit Error Rate and Eb/No investigation where DBS/Northpoint interaction is verified with a professional demodulator.
- Compatibility of Northpoint and DBS during extreme rain events, which demonstrate coexistence during Hurricane Floyd without a failure.
- Tests of multiple Northpoint cells in simultaneous operation, where it is shown that no DBS interaction difference is detectable between single and multi-cell operations.
- Document that neither multipath nor reflections impact DBS or Northpoint.
- Demonstrate the superb performance of Northpoint Technology.

a. Very Close Range Tests

Close attention was paid to the area near the Northpoint transmitter. Of the 44 measurements that were taken, 32 were within one mile of the transmitter and 36 were within 2 miles of the transmitter.[4] Apart from concentrating the measurements in the Near In Region where the Northpoint signal is the highest, tests were conducted very near the transmitter to ensure no harmful interference would occur to nearby DBS installations.

No Interference Mitigation Was Necessary

No local shielding or other interference mitigation was required to protect any DBS user. This can be attributed in part to the site-specific engineering techniques available to terrestrial transmit installations. DBS dishes were observed on the condominiums and

[4] Several sites were revisited, such as Arlington Cemetery and the Kennedy Center, to collect data on different days.

apartments directly adjacent to the USA today building, within several hundred feet of the transmitter. No interference was reported at any time during the test. In each case these dishes were naturally shielded from the Northpoint transmitter by the buildings to which these dishes were attached. This was consistent with the national survey of DBS dish owners conducted by the survey firm of Bennett, Pettis and Blumenthal during July 1999. In this survey, which is attached as Appendix IV, it was found that 86% of all dish owners have natural shielding, meaning that their dishes have something behind them such as a house, chimney or trees.

DBS Operations within 100 Feet of Transmitter Not Effected

There are, for example, two DirecTV antennae permanently installed on the USA Today building within approximately 100 feet of, and on the same roof as, the Northpoint transmitter. In order to avoid interference with these dishes, the Northpoint transmit antenna was installed four feet down the face of the building, completely protecting these installations. To confirm the operation of DBS on the rooftop, Echostar and DirecTV systems were both installed during the test within 15 feet of the transmit antenna. No impairment to these system's video reception or significant signal depression was observed.

b. SSP and Power Density Tests

The set-top-box manufacturer provides the signal strength pointer (SSP), one measure of performance in the test, for the consumers as an aid in pointing their antennas. It is one way to measure signal quality. DirecTV has stated the SSP is the best way to assess the potential impact to consumers.[5] In this section, the performance of DBS is compared with and without the Northpoint signal present, according to the SSP and the power density in the band.

Signal Strength Pointer Implementation Varies between DirecTV and Echostar

A number of tests were performed to examine the normal function of the SSP without the Northpoint signal present. The response was measured over both short and long periods of time, and throughout the Washington, D.C. area. It was found that the set-top box remains very robust displaying a clear picture over a range of normal variations, both temporal and spatial.

The spatial variance is defined as the normal variance in average SSP readings measured throughout the D.C. metro area. For example, the minimum DirecTV SSP reading was 75 (site 1A) and the maximum was 87.4 (site 1), less than a quarter-mile away. Similarly for Echostar 61.5 the minimum was 74.8 (site 1A), and the maximum reading was 98 (site 1). The Echostar 119 SSP varied between 78.2 (site 7) and 98 (site 3). These readings show the spatial, as well as day to day, variation found throughout the test area.

[5] Presentation to the FCC, July 21 1999.

The short-term temporal variance was measured by taking 200 consecutive measurements over 200 consecutive observations. The DirecTV temporal variance was found to be similar to Echostar, although somewhat higher -- over two counts vs. less than one. The analysis is presented in the appendices, and the results are presented in Table 2.

Table 2. Normal Indication of Signal Strength Pointer - Northpoint Off

	DTV 101	ES61.5	ES119
Maximum	87.4	98.6	98.0
Average	80.8	92.0	88.7
Minimum	74.7	74.8	78.1
Range	13	24	20
Std. Deviation (Spatial) (Northpoint Off)	2.7	4.3	4.3
Std. Deviation (Temporal) (Northpoint Off)	2.1	0.6	0.4

As can be seen from Table 2, a range of values from 74.7 to 98.6 was found. With the professional demodulator it was determined that at these values DBS is operating on a quasi-error free basis. This is consistent with information that DirecTV submitted to the FCC wherein they assert that this "quasi-error free" operation exists at SSP readings above 28.[6]

DBS Operated Quasi-Error Free in the Presence of the Northpoint Signal

DBS was equally robust in the presence of the Northpoint signal, achieving quasi-error free operations with signal strength readings between 72.2 and 98. The average change between the Northpoint "on" and Northpoint "off" conditions was less than one count, an amount that is within the margin of error.

No Significant Change Seen with Northpoint Transmitter Present

If Northpoint significantly decreases the overall link margin, a significant change in the pointer reading would be expected. In fact, Northpoint caused no significant change in the SSP. Note the standard deviation of the expected SSP value -- in the absence of Northpoint -- is in all cases greater than the average change observed with Northpoint on.

Table 3. Signal Strength Pointer Shows No Significant Change

	DTV101	ES61.5	ES119
Average SSP Meter (Northpoint Off)	80.8	92.0	88.7
Average SSP Meter (Northpoint On)	80.1	91.7	88.5
Average Change	-0.7	-0.3	-0.2
SSP Spatial Deviation (Northpoint Off)	2.7	4.3	4.3
SSP Temporal Deviation (Northpoint Off)	2.1	0.6	0.4

[6] Presentation by DirecTV to the FCC July 21, 1999.

The power density (in a 1 MHz reference band at the center of a DBS transponder, typically transponder 18) was also measured and recorded at all locations, with the Northpoint transmitter both on and off. All of the clear-air test data are plotted in the scatter plots Figures 2-4, which show that there is no obvious difference between the Northpoint "on" and "off" conditions.

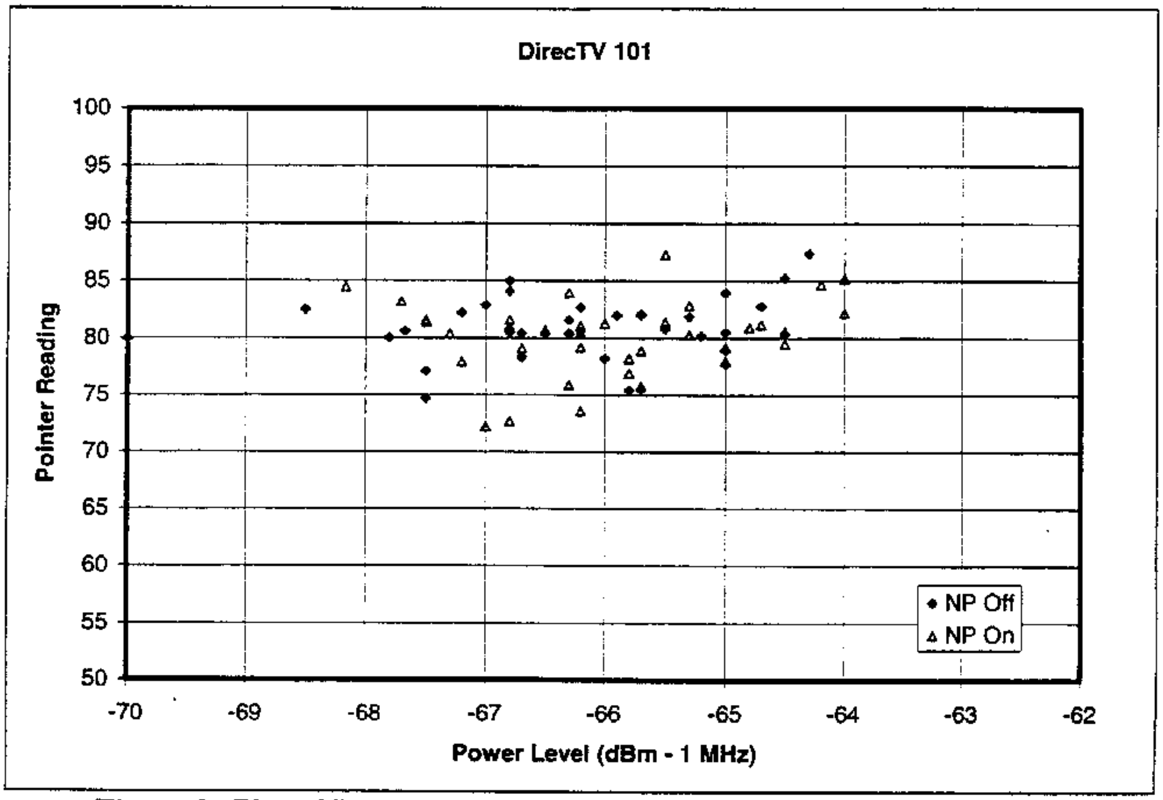

Figure 2. Plot of Pointer Reading vs. Power Density Level for DirecTV

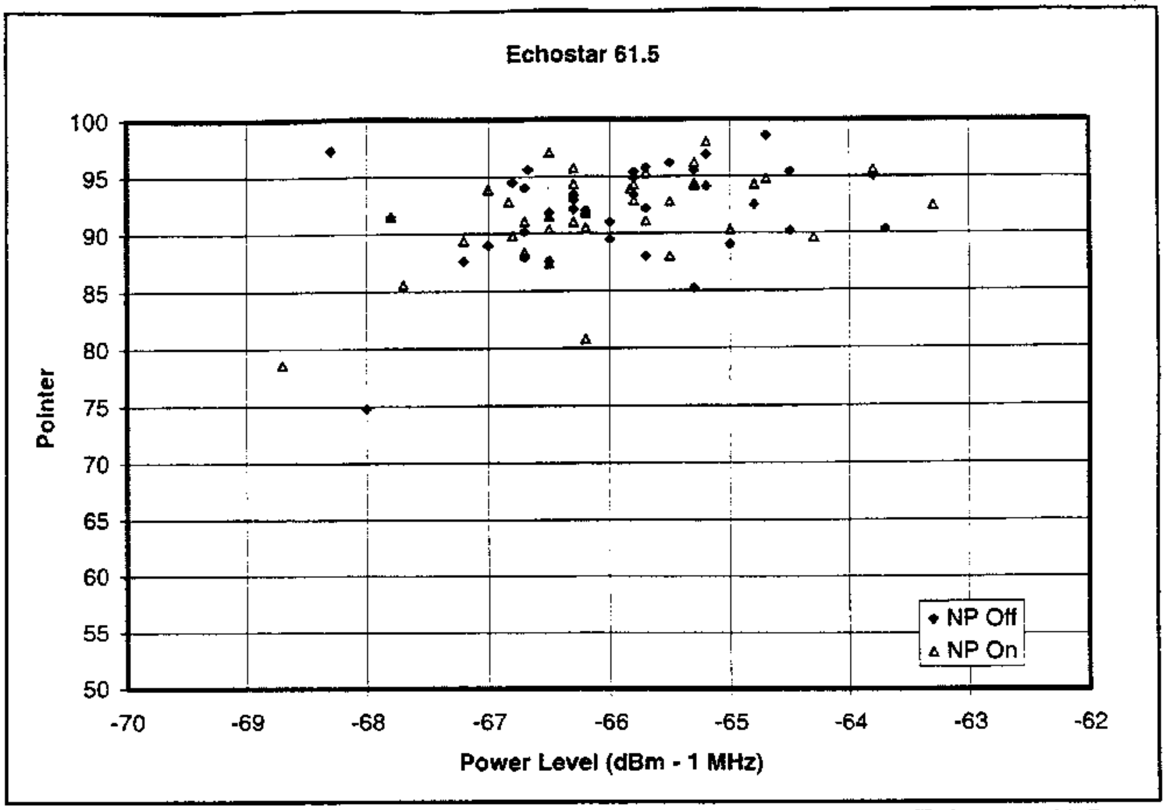

Figure 3. Plot of Pointer Reading vs. Power Density Level for Echostar 61.5

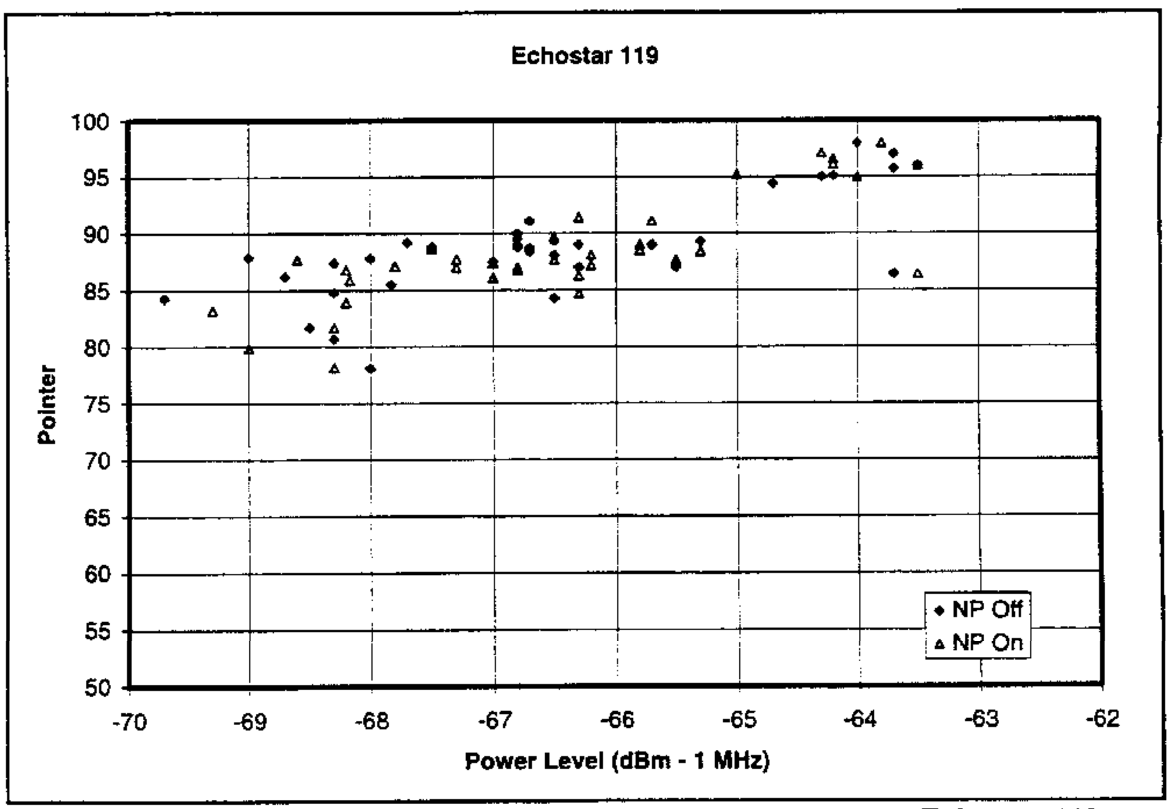

Figure 4. Plot of Pointer Reading vs. Power Density Level for Echostar 119

No Statistical Difference Between Northpoint "On" and "Off" Conditions

As previously described, the inherent spatial/temporal variation in the pointer indicator is approximately 3-5 counts. This is normal and reflects a robust DBS system. The average change, when the Northpoint transmitter was turned on, was found to be less than one count. Therefore, the expected normal variation in DBS operation is greater than the change observed when the Northpoint transmitter was turned on. In fact, when a standard test for statistical difference was applied, it was found that the "on" condition is not statistically different than the "off" condition. Using Student's *t* test for statistical significance reveals that a statistician would find no difference between the Northpoint "off" and Northpoint "on" conditions at a 95% confidence level.

Statistical Methods Explained

The *t*-test was used to assess whether variations noted between Northpoint "off" and Northpoint "on" are statistically significant. That is, could the difference in sample means be attributed to Northpoint with a high degree of confidence given the inherent variances within the DBS system? In general, it was found that the difference could not be attributed to Northpoint.

A *t*-test is a tool used to identify the probability of there being a difference between two samples of a population. A sample of a population can only represent that population within a certain margin of error depending upon the sample size and the variance of the sample. The *t*-test is based on central limit theorem and gives the probability that the average of a sample lies within a specific interval around the average for an entire population.

In the two sample *t*-test, two sets of samples are compared, and assumed to be from the same population, which is assumed to have a normal distribution, with mean η and variance σ^2. The two sets of samples have means y_a and y_b, n_a and n_b number of samples, and sample variances s_a and s_b, where

$$s_a^2 = \frac{\sum (y_i - y_a)^2}{n_a - 1},$$

and similarly for s_b. The quantity $t = (y-\eta)/s$ has a known distribution, referred to as the *t* distribution. The *t* distribution approaches the normal distribution as the sample size increases. The probability that $y_a = y_b$ can then be estimated by comparing the value for *t* with the known *t* distribution for that sample size. This common test is implemented in commercial software statistical systems.[7]

As an example of how the normal DBS operational variation can affect the SSP readings, at some of the near-in sites, a deflection in the SSP was observed on some days with Northpoint on, and not on others. At Site 7 (Arlington Cemetery) there was a deflection

[7] Minitab was used to generate the statistics in this report.

on DirecTV on one day of 5 counts, and on another day of 2.2 counts, and on the third measurement day, no deflection was seen. Similar results were noted at another close-in site, the Federal Construction site, where on one day there was a positive change of 2.4 counts and another day, no change was observed. In about 40% of measurements, the SSP showed an increase when Northpoint was turned on.

While, at certain sites, insignificant SSP deflections of 1-5 counts were observed, overall the data show no statistical difference, even in the part of the service area closest to the transmitter. At a 95% confidence interval, there is no statistical difference between Northpoint "on" and Northpoint "off" conditions. This analysis reflects the data as a whole and represents the average condition found.

Table 4. Results of *t*-test for Statistical Difference of SSP Readings

System	Distance of Data	Average Delta	Statistical Significance of Delta	95% Confidence Interval (Single-Sided)	*t*	P	DF
DTV101	Half-Mile	-1.62	Insignificant	2.77	1.21	0.24	25
DTV101	First Mile	-1.46	Insignificant	1.76	1.68	0.1	45
DTV101	Beyond First Mile	+0.91	Insignificant	2.38	-0.79	0.44	21
DTV101	All Data	-0.70	Insignificant	1.40	0.99	0.33	69
ES 61.5	Half-Mile	-0.85	Insignificant	3.05	0.57	0.57	27
ES 61.5	First Mile	-0.52	Insignificant	1.84	0.57	0.57	49
ES 61.5	Beyond First Mile	+0.05	Insignificant	4.85	-0.02	0.98	19
ES 61.5	All Data	-0.35	Insignificant	1.93	0.36	0.72	71
ES 119	Half-Mile	-0.32	Insignificant	2.33	0.28	0.78	27
ES 119	First Mile	-0.46	Insignificant	2.23	0.42	0.68	49
ES 119	Beyond First Mile	+0.30	Insignificant	4.60	-0.14	0.89	21
ES 119	All Data	-0.23	Insignificant	2.04	0.22	0.83	73

The following figures show the results of the SSP *t*-test for statistical significance. The data for each DBS system are presented for four cases:

1. The data taken within the first half-mile of a transmitter - representing 0.25% of the Northpoint service area.
2. Data taken within the first mile of a transmitter - representing 1.0% of the Northpoint service area.
3. Data taken beyond the first mile of a transmitter - representing 99% of the Northpoint service area.
4. All data taken.

Two values for each case are shown; the average of the observations within that zone for each of the Northpoint "on" and "off" conditions. The vertical bars represent the confidence intervals given by the *t*-test, or the range of averages that can be expected to be found 95% of the time. The scale to the right shows the number of samples used in that test. In all cases, the measured average with the Northpoint transmitter "on" falls within the range of expected variation, with a 95% confidence level. These observations support the finding that Northpoint has less impact on DBS than the normal variation of DBS's own performance.

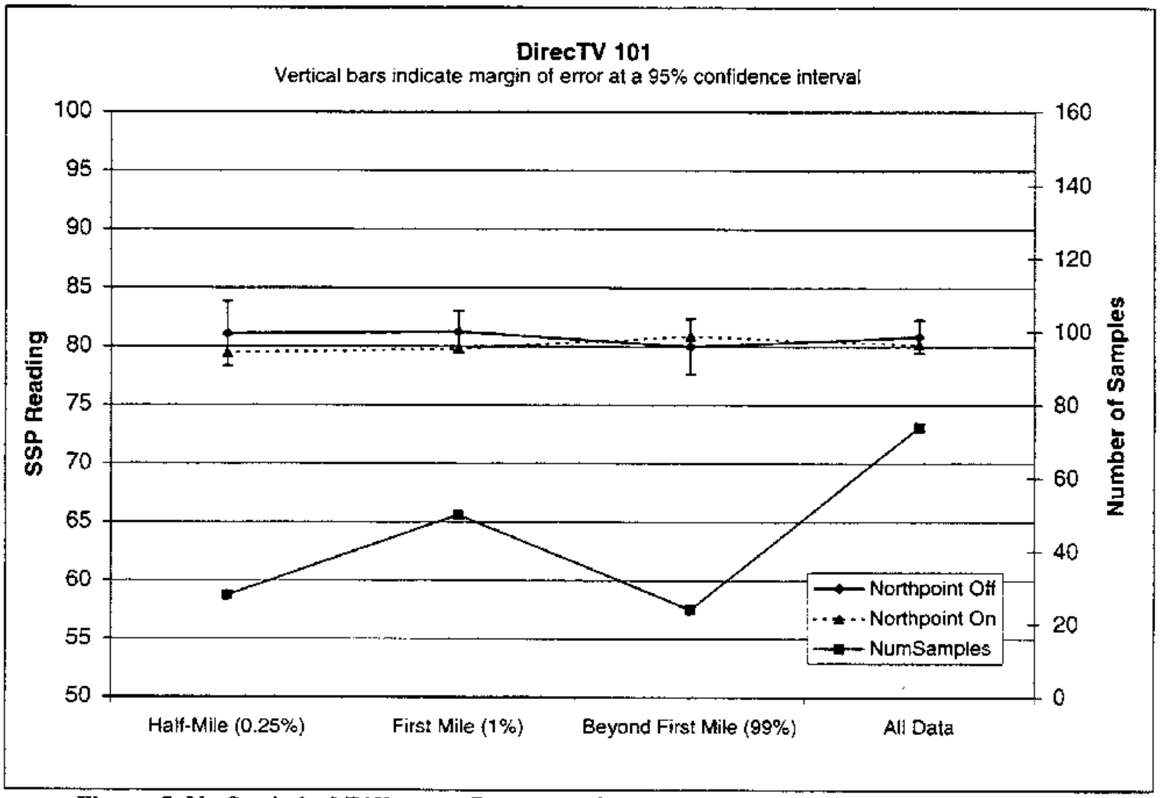

Figure 5. No Statistical Difference Between "On" and "Off" Conditions for DirecTV 101

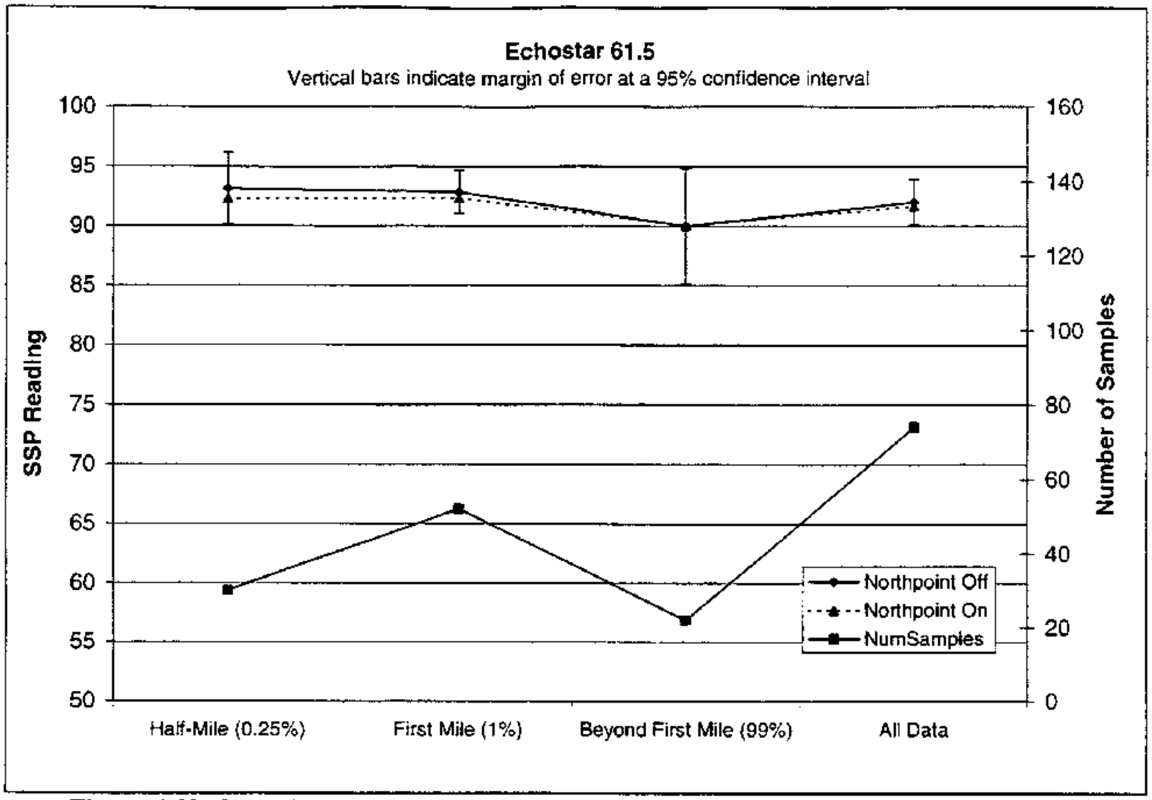

Figure 6. No Statistical Difference Between "On" and "Off" Conditions for Echostar 61.5.

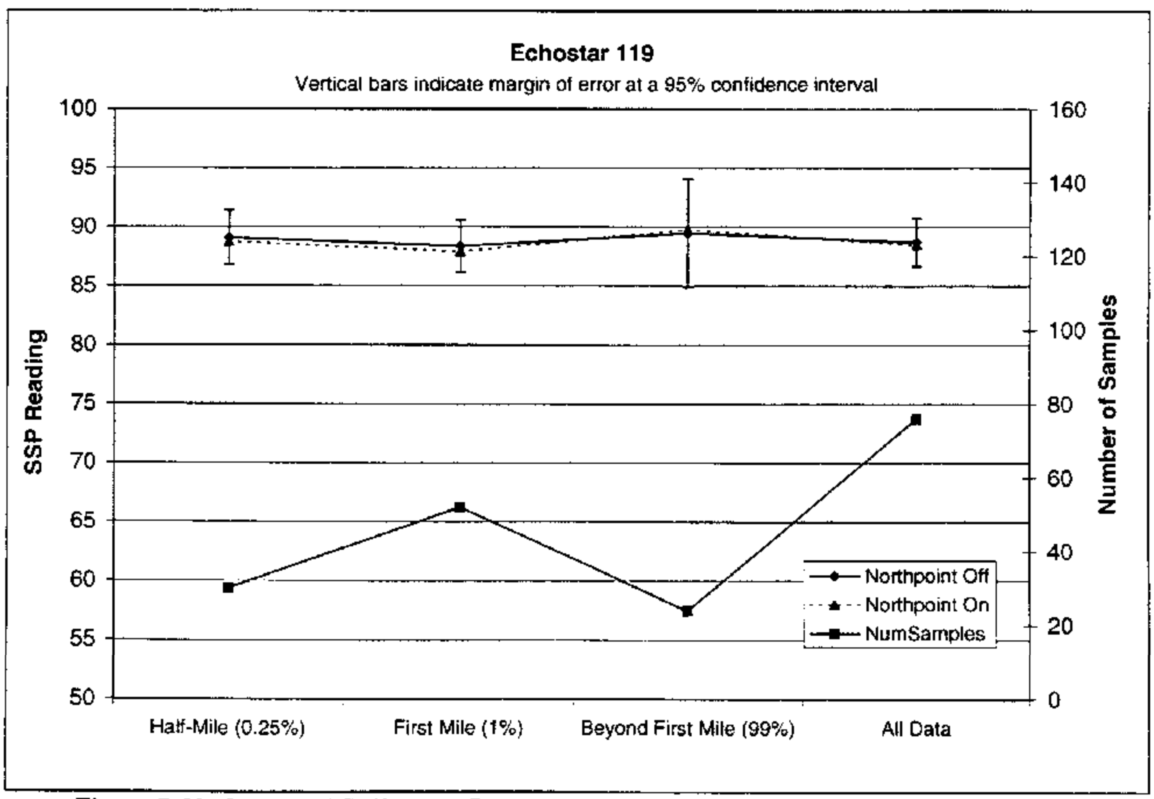

Figure 7. No Statistical Difference Between "On" and "Off" Conditions for Echostar 119

c. <u>No Significant Link Degradation or Increase in BER Observed</u>

Data were taken of DVB Echostar satellite transmissions with the aid of a Newtec demodulator and accompanying software. Testing was concentrated within the Northpoint service area where the Northpoint signal is highest, at one mile or less from a Northpoint transmitter.

The Echostar DBS system uses the DVB open standard packet format for encoding data. DirecTV uses the proprietary DSS standard. Both encoding schemes packetize MPEG2 data for encoding, and both use Viterbi and Reed-Solomon encoding, the primary encoding difference being the payload length. DSS is more robust, due to the use of a146 byte packet, with 130 bytes of payload, whereas DVB uses a 188/204 payload/packet ratio.

Quasi-Error Free Operation Observed at All Times

With the Newtec demodulator the uncorrected byte error rate, and the corrected bit error rate, each at an average of a 10 second interval were recorded. Quasi-error free operation in clear air both before and after decoding was observed at all times, whether Northpoint was on or off. This observation supports the finding that DBS operations are robust with or without the presence of Northpoint, and there is no impact from Northpoint operations.

No Significant Eb/No Degradation

The demodulator data readings were concentrated in the Near In Region. No detectable Eb/No variation was expected outside of this area, and this was confirmed at the Anacostia site. The data for the areas where readings were taken show the average link degradation attributed to Northpoint was about a tenth of a decibel. The maximum degradation was 0.4 dB at 0.13 miles from the transmitter, while outside of about a mile, no degradation was found, see Table 5 and plots of the link Eb/No data in Appendix III. Data taken at the Kennedy Center represents the average condition found and reproduced below. An environmental data log was taken with these readings, so that it could later be identified if any environmental factors such as airplanes might have had an impact on the Eb/No. No significant changes were found; these logs are in the appendix.

Table 5. DVB Eb/No Performance in Clear Air (with and without Northpoint)

Date	Site No.	Site Name	Dist. from Xmitter (miles)	Eb/No (NP Off) (dB)	Eb/No (NP On) (dB)	Apparent Link Deg. (dB)	Equivalent Reduction of Rain Margin (dB)
9/2/99	R2	Goodyear	0.04	10.71	10.72	-0.01	-
8/18/99	1	River Place Apartments	0.11	11.59	11.38	0.21	0.10
9/3/99	R4	Banniker Drive	0.13	11.42	11.37	0.05	0.02
9/3/99	R6	Ft. Lincoln Drive	0.13	11.68	11.30	0.39	0.20
8/17/99	1A	Theo. Roosevelt Island	0.18	11.40	11.23	0.17	0.08
9/2/99	R1	Bladensburg	0.18	11.33	11.24	0.09	0.05
8/16/99	10A	Construction Site	0.26	11.74	11.71	0.04	0.02
8/18/99	3	Kennedy Center	0.73	10.20	10.09	0.12	0.06
8/18/99	7	Arlington	0.86	10.90	10.80	0.10	0.05
8/23/99	7	Arlington	0.86	11.75	11.67	0.08	0.04
8/16/99	19	Anacostia	4.20	10.21	10.24	-0.02	-
		Average change in Eb/No observed				0.11	0.06

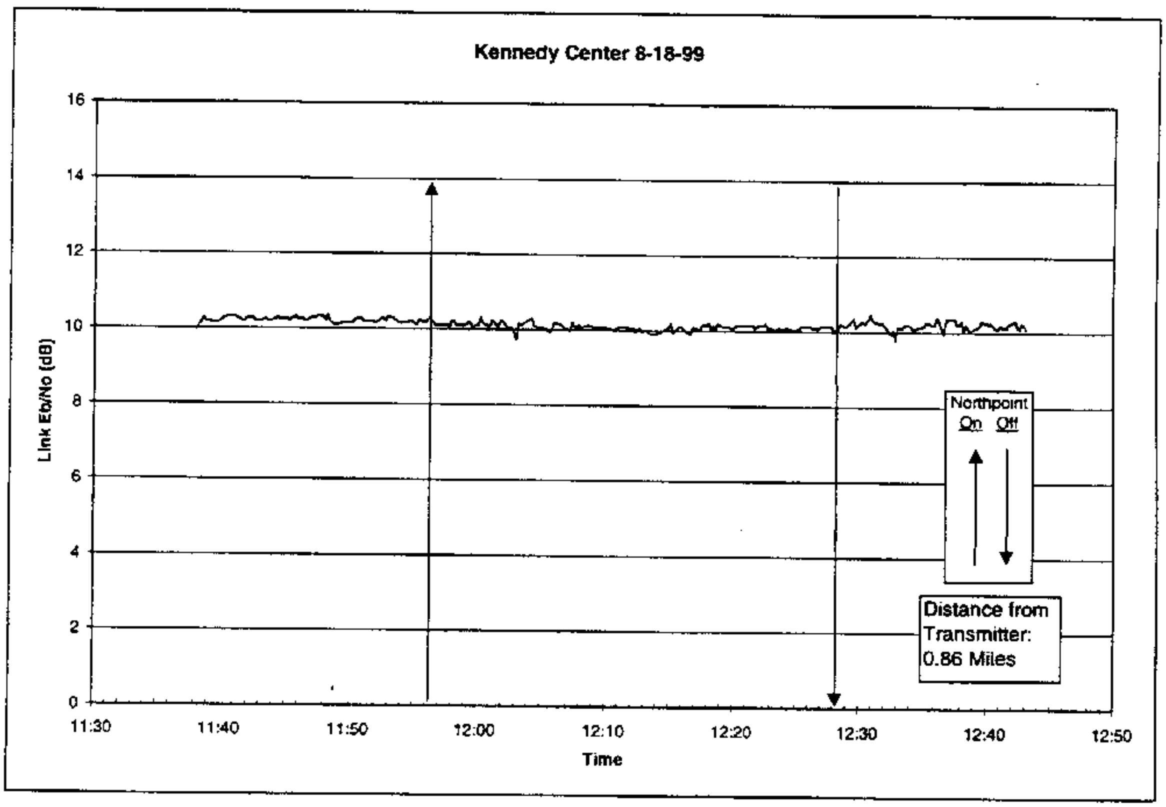

Figure 8. Link Degradation for Echostar 119, Kennedy Center

Interpretation of Clear Air Link Degradation

Except for the rain tests, the Eb/No data was recorded in clear air conditions. However, link margin is only employed during conditions of impairment, and there is a significant difference between link degradation in clear air, and link degradation during a rain event. During a rain event, there is a natural increase in thermal noise, and this increase in thermal noise must be taken into account when computing the loss of link margin. This concept is well understood by satellite companies, and is a factor that is included in the ongoing EPFD proceedings in the development of sharing criteria between the NGSO and the BSS and FSS in the ITU.

In the example in the following table, the clear sky C/I ratio is 20 dB, and the I/N ratio is -8 dB. The clear sky C/I ratio of 20 dB equates to a 17 dB C/I ratio during a 3 dB rain fade. However, the DBS system noise would increase by 3.3 dB during this same event, which reduces the effect of interference noise now at a level 11.3 dB below the noise floor of DBS. While in this example there is an apparent 0.6 dB link degradation in clear air, the actual reduction of link *margin* is only 0.3 dB during rainy conditions.

Table 6. Comparison of Link Degradation During Clear Sky and Rain Event

	Units	Clear Sky Conditions	Significant Rain Event
Carrier Power	dBW	-121.8	-121.8
Rain Attenuation	dB	0.0	-3.0
C	dBW	-121.8	-124.8
I	dBW	-141.8	-141.8
No	dBW	-133.8	-133.8
Rain Temp Increase	dB	0.0	-3.3
N	dBW	-133.8	-130.5
C/I	dB	20.0	17.0
I/N	dB	-8.0	-11.3
C/N	dB	12.0	5.7
C/(N+I)	dB	11.4	5.4
Link Degradation	dB	0.6	0.3

There is no clear-air link degradation in over 99% of the Northpoint service area. In less than 1% of the service area, the average link degradation is about 0.11 dB. As discussed in the previous paragraph, during a significant rain event, this would equate to about 0.06 dB of link margin loss. The effect of any given level of link degradation can be seen in the following figure, which shows the required link margin for a specified availability in the Washington, D.C. area. As shown in the next section, DBS maintains a 99.9% availability in the Washington, D.C. area. This is significantly higher than the 99.7% availability sought by DBS. As can be seen in Figure 8, even a 0.5 dB link degradation would not significantly change the DBS availability, and according to the test data, Northpoint is far below the level to cause 0.5 dB of link degradation.

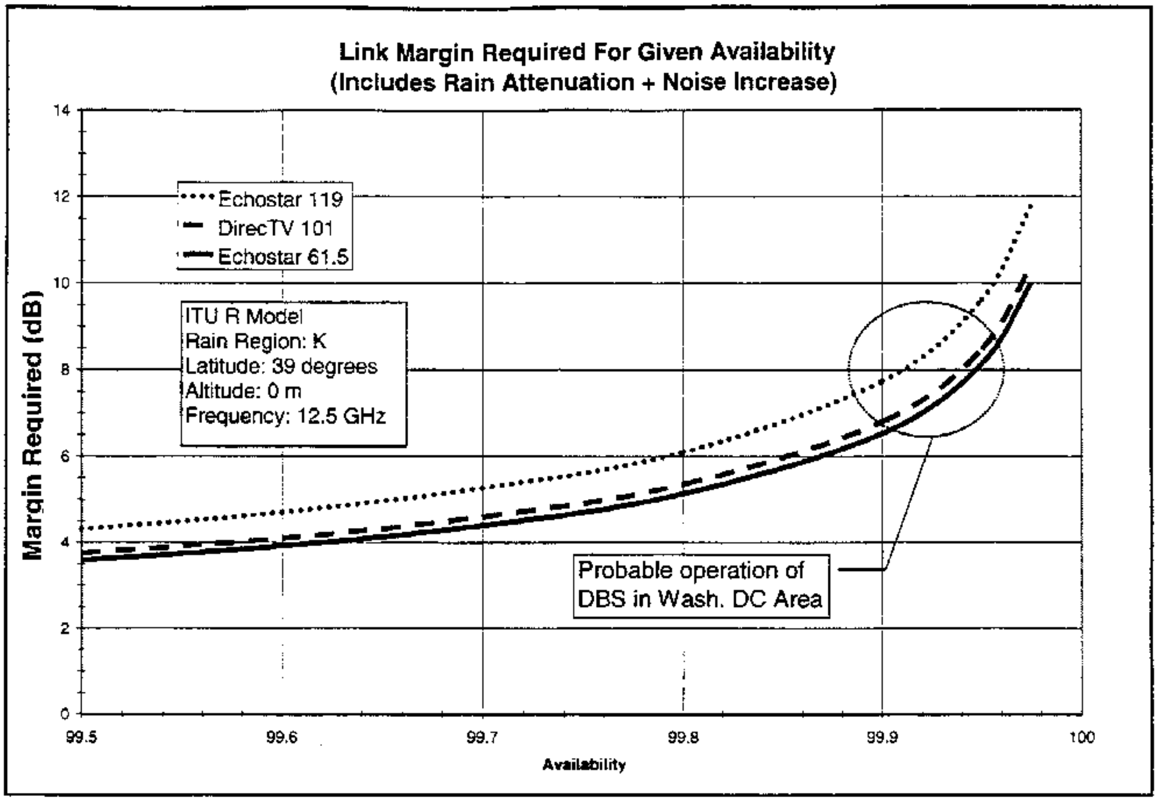

Figure 9 . Link Margin Required for Given Availability (rain attenuation + thermal noise increase).

d. <u>Rain Tests - No DBS Outages during Hurricane Floyd</u>

Data collection during Hurricane Floyd commenced at 10:25 a.m. on September 16, 1999. The transmitter was turned on and off at approximately one hour intervals, per Table 7. The test equipment was situated at the Arlington Cemetery site, where weather data was collected, in addition to the DBS performance data.

Table 7. Data Collection Times During Hurricane Floyd

	Transmitter Off	Transmitter On
Start Data Collection	10:25	10:45
	11:38	12:44
	14:05	15:33
	16:38	
End Data Collection	17:17	

Hurricane Floyd was a significant weather event. It was downgraded from a hurricane to a tropical storm at 5:00 p.m. local time, after it had passed the Washington, D.C. area. The significance of this rain event to the DBS operations, and to the coexistence test can be seen in Figure 10 and Figure 11, the rain rates measured by Northpoint and NOAA during the event. NOAA reports the rain data at hourly intervals. Arlington Cemetery rain measurements recorded at smaller intervals than the hourly reports provided by NOAA, and more accurately identify the rain rate. This means that very high periods of rain are shown more accurately, rather than hidden in an average. The total rain recorded at Arlington corresponds to the total rain reported by NOAA, confirming the Arlington data.

Attenuation Higher than Critical 0.1% Levels Predicted by ITU Rain Model

The recorded rain rates at the test site, as well as NOAA weather stations in the area exceeded a critical 0.1% level during the test.[8] The critical 0.1% rain rate for ITU-R rain region K (which includes Washington, D.C.) is 12 mm/hr, and the 0.3% rain rate is 4.5 mm/hr.[9] From inspection of Figure 10 and Figure 11, the rain rates exceeded the 0.3% level of 4.5 mm/hr for several hours, and exceeded the 0.1% level for at least part of the event. The rain rate along the exact satellite RF path is unknown, and cannot be known. However, reductions of 5 dB in RSL were recorded for Echostar 119 (see Figure 14). This reduction of 5 dB also exceeds the predicted 0.1% level for this satellite, confirming that the availability for Echostar 119 is greater than 99.9%.[10] Echostar 119 represents the worst-case, because it is the satellite at the lowest elevation angle serving the Washington, D.C. area, and would therefore require more link margin to maintain the same availability as the other satellites as shown in Figure 9.

---

[8] The 0.1% level (12 mm/hr) is the rain rate that is exceeded only 0.1% of the time in any given year. This level of rain is sufficient to cause outages to systems that are designed to provide less than 99.9% availability.

[9] ITU-R Recommendation PN.837-1

[10] The required rain margin is 3.9 dB at 99.9% availability for ITU rain region K, elevation angle 28°, Latitude 39°.

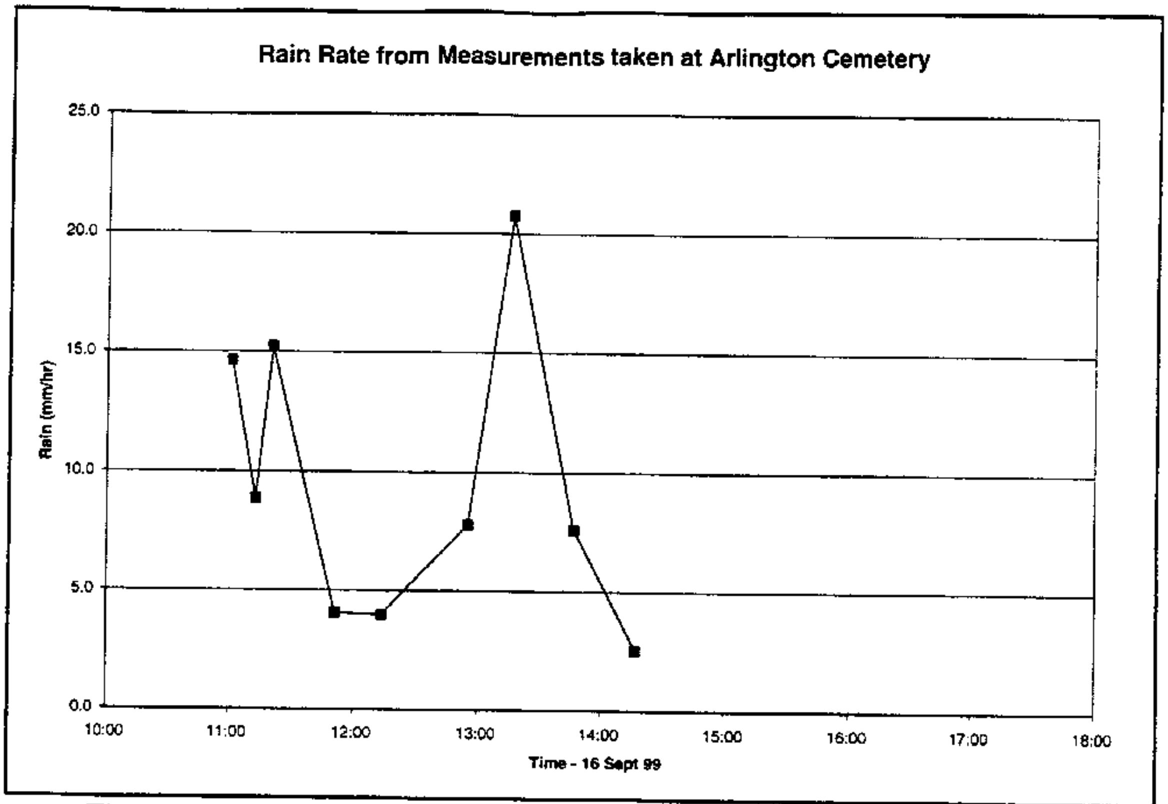

Figure 10. Rain Rates from Measurements taken at Arlington Cemetery

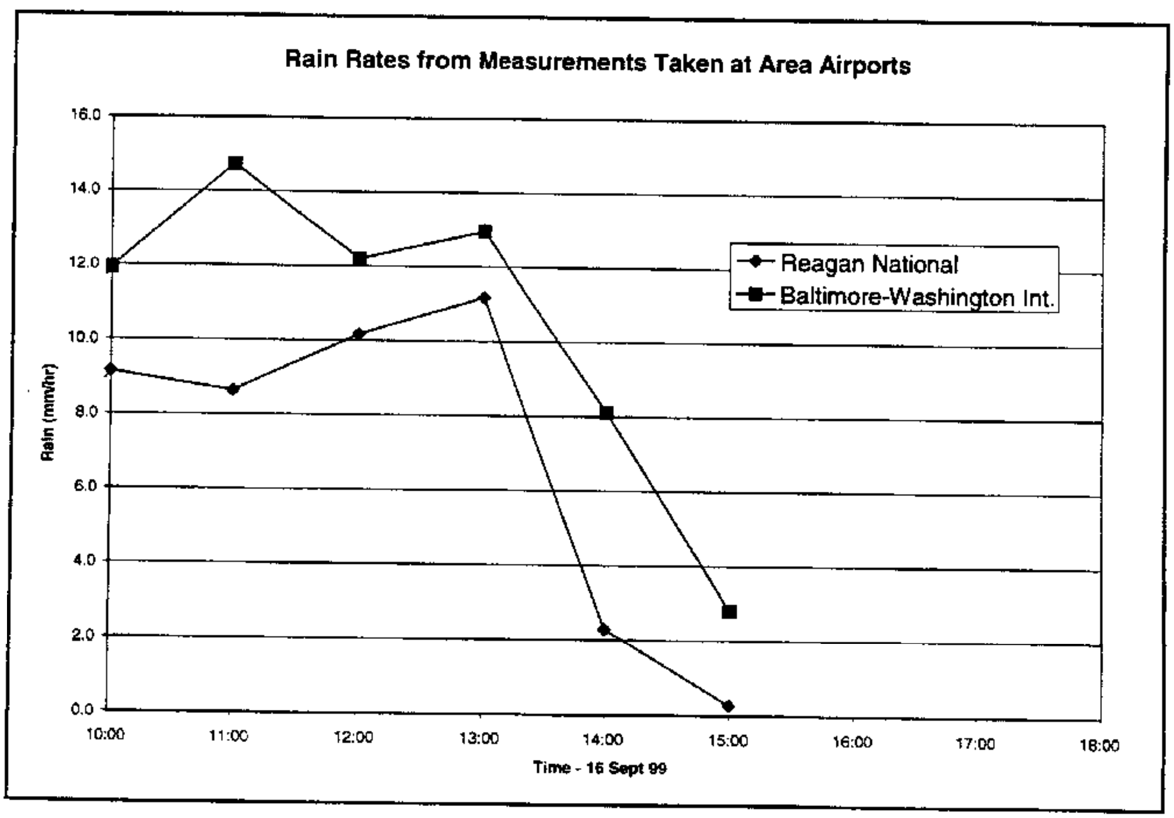

Figure 11. Rain Rates from NOAA Measurements at Area Airports

No Loss of Signal during Hurricane Floyd

No outages were observed by the test team during the entire test period. Not only were no outages observed during the test, no reports of harmful interference were received by Broadwave for investigation, despite Northpoint's broadcasting for much of the heaviest rain. This demonstrates the robust operation of DBS in the presence of Northpoint and that Northpoint has no significant impact during heavy rain events.

During the rain test, the lowest SSP noted was about 50 for the DirecTV system, well above the required level, as presented in Figure 12. Data taken with the Newtec demodulator showed that Echostar at 119 West also always maintained its Eb/No above the critical value for loss of lock (believed to be 3-5 dB) as shown in Figure 13. Further, the received signal level varied over 4 dB, a change in RSL that also exceeds the 99.9% level for rain attenuation, see Figure 14.

Quasi-error Free DBS Operation During Hurricane Floyd

The Newtec demodulator records the byte error rate before decoding, as well as the bit error rate after decoding. The data show an increase in errors before decoding (with a decrease in Eb/No), however, the decoder continued to correct these errors to a bit error rate better than 10-20 for the entire test, indicating quasi-error free operation the entire time.

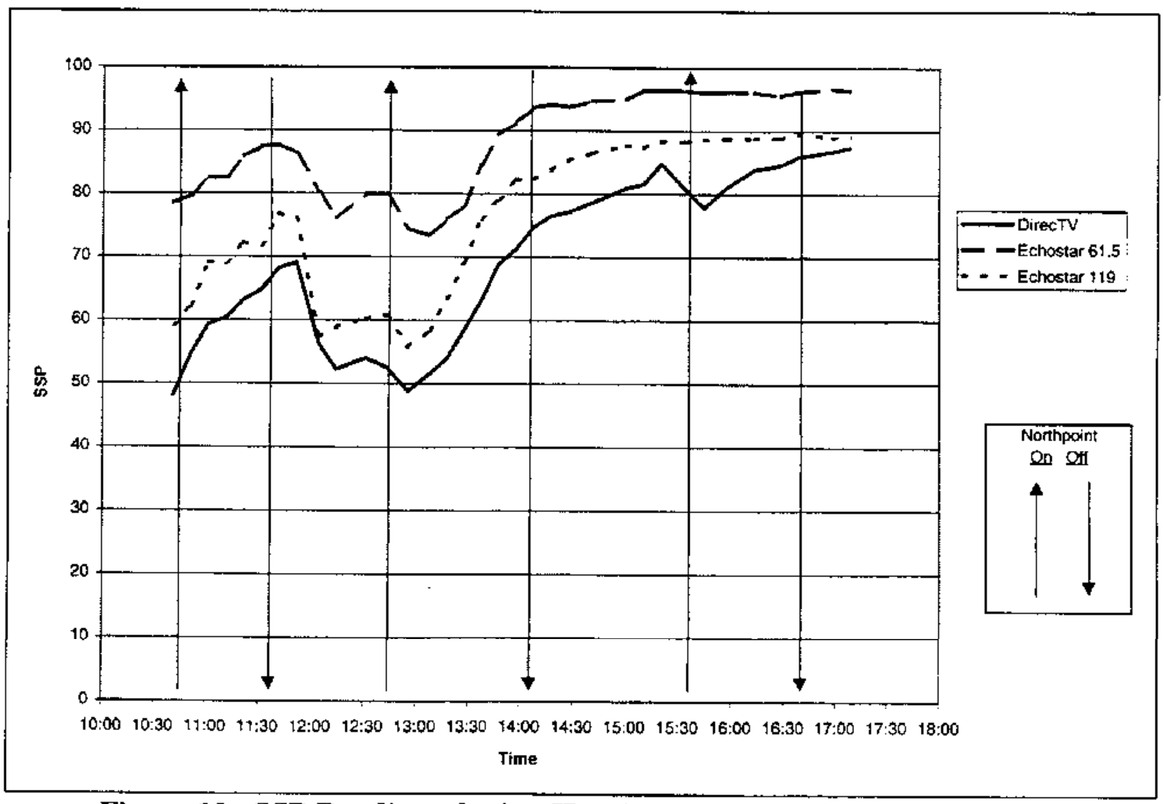

Figure 12. SSP Readings during Hurricane Floyd, September 16, 1999

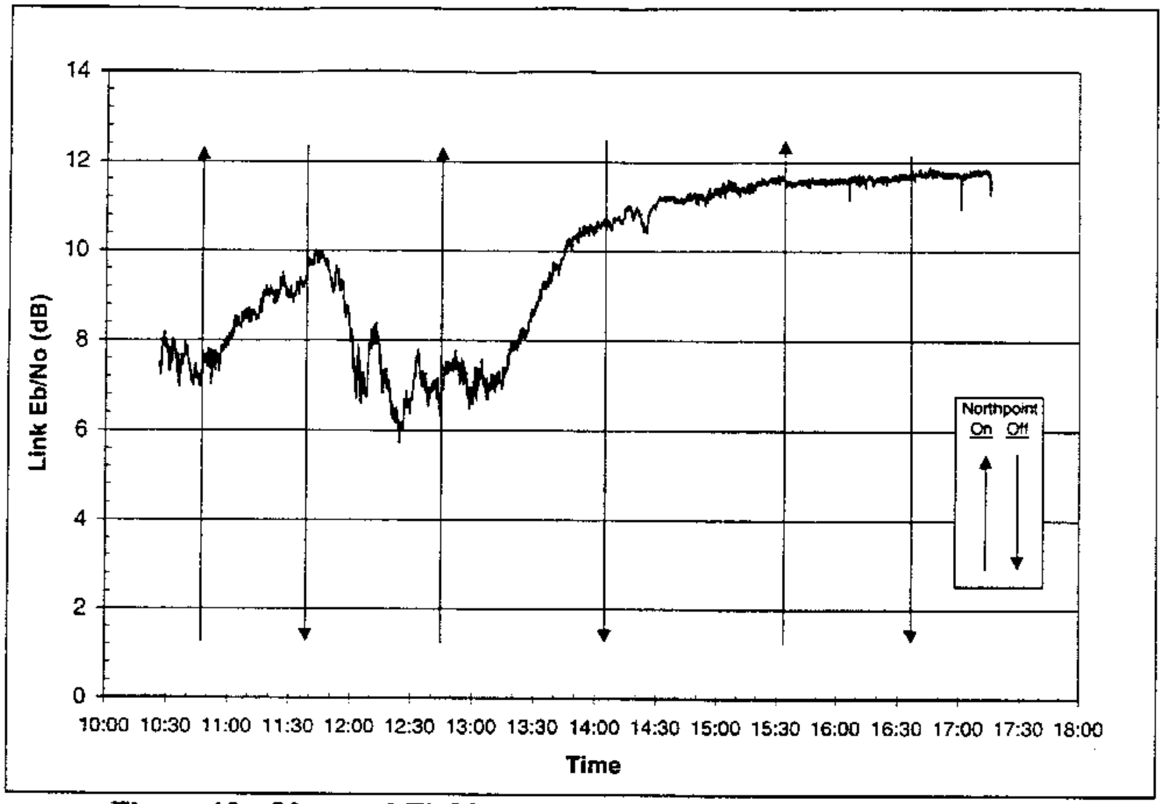

Figure 13. Observed Eb/No for Echostar @ 119 W, Hurricane Floyd

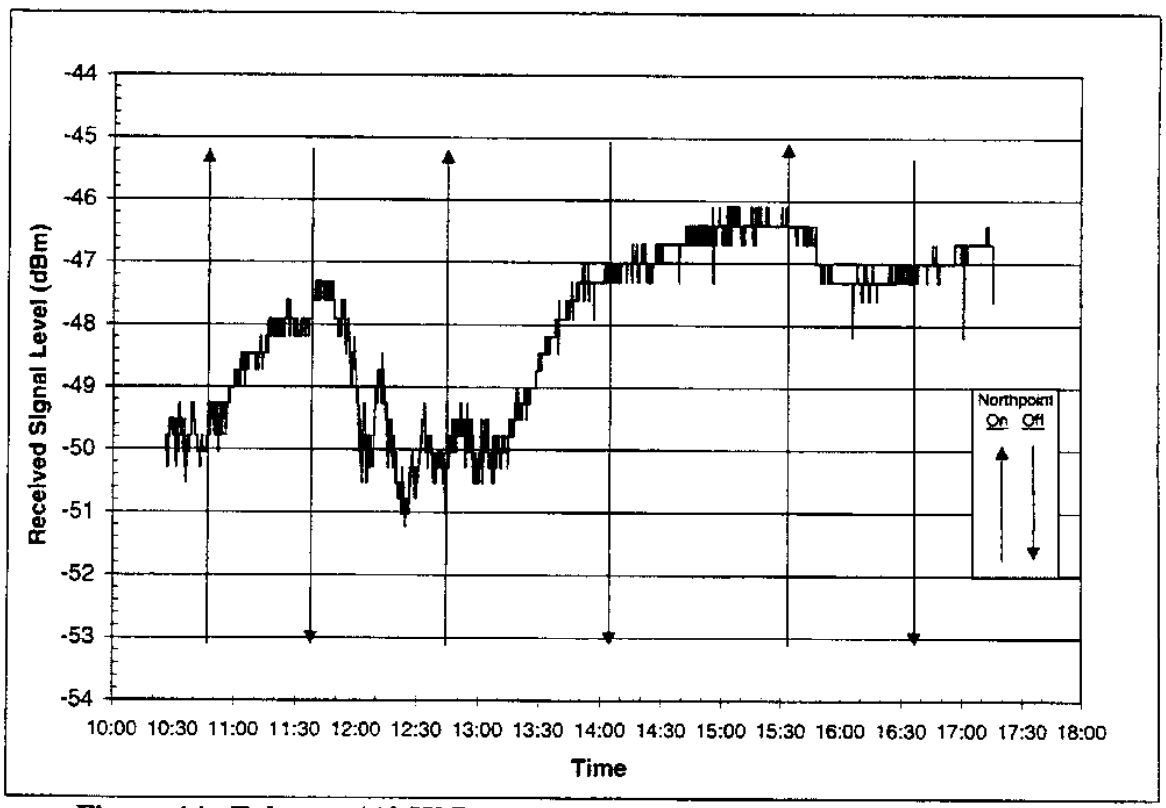

Figure 14. Echostar119 W Received Signal Level during Hurricane Floyd

e. <u>No Measurable Change with Multiple Northpoint Cells in Operation</u>

Phase III of the test examined the possible interaction of multiple Northpoint transmitters. The repeater site was 6.2 miles away from the main transmitter, such that the two Northpoint signals overlapped. Measurements were made at eight sites, four near the repeater, three near the main transmitter, and one at a mid-point between the two signals where the overlap is the strongest. The overlap and the sites are shown in Appendix I.

Near the repeater site, no significant SSP deflections were found. Near the main transmitter, three close-in sites were re-measured and no change was found between the multi-cell data and the single-cell data from Phase I. At the point of highest signal overlap, where the measurement site was about three miles from both the transmitter and the repeater, there was no significant change in DBS operation found.

f. <u>Multipath and Reflection Tests Favorable</u>

For each site, where appropriate, measurements were made to determine whether significant multipath or reflection signals were present. The Northpoint DBS antenna was used to scan the most likely regions, while observing the signal on the spectrum analyzer. At most location, any reflections found were very small compared to the main signal path (typically 20 dB or more down).

However, two sites had large reflections present: Site 3 (Kennedy Center) and Site 13A (Potomac Park). These sites are located across the river from the NP transmitter site, and the water surface provides a substantial reflector. In the case of Site 3, the reflection path was found to be approximately 10 degrees below the main path in elevation angle, and the reflected signal was 8 to 10 dB below the main signal level. For Site 13A, the reflection path was more diffuse (probably due to the bridge in and near the pathway) with two distinct reflection peaks observed. One occurred at approximately 5 to 7 degrees below the main path, and the other peak occurred a few degrees lower. These reflections were 12 to 15 dB below the main signal.

No multi-path interference or any other ill effects were observed for any of the cases where reflections were found to exist. This is due to the high degree of DBS antenna pointing selectivity, which significantly decreases the likelihood that a distinct reflection path at a given site can be found at the same time that the antenna is pointed to the main signal source. In general, where reflections are seen due to a diffusive scattering from rough or complex reflectors, the reflected signals are normally both small and, once again, along paths that are unlikely to enter the receiving antenna main beam.

During the testing history for both Austin and Washington, DC, no multi-path situation has yet been observed to cause a problem for either Northpoint or the DBS service.

g. Superb Performance of Northpoint Technology

Measured Northpoint Signal Levels Close to Free-Space Propagation

The measurement of the Northpoint signal power generally conforms to free-space propagation predictions, when making allowances for terrain clutter, as seen in Figure 15. The notable exception was within 200 meters of the USA Today building, where a higher than predicted power level was measured. It is believed that that close in to the USA Today building, the signal is effected by the building structure itself (which is composed of 31 stories of leaded glass and aluminum) and the fact that the transmit antenna is mounted on the face of the building rather than on the top.

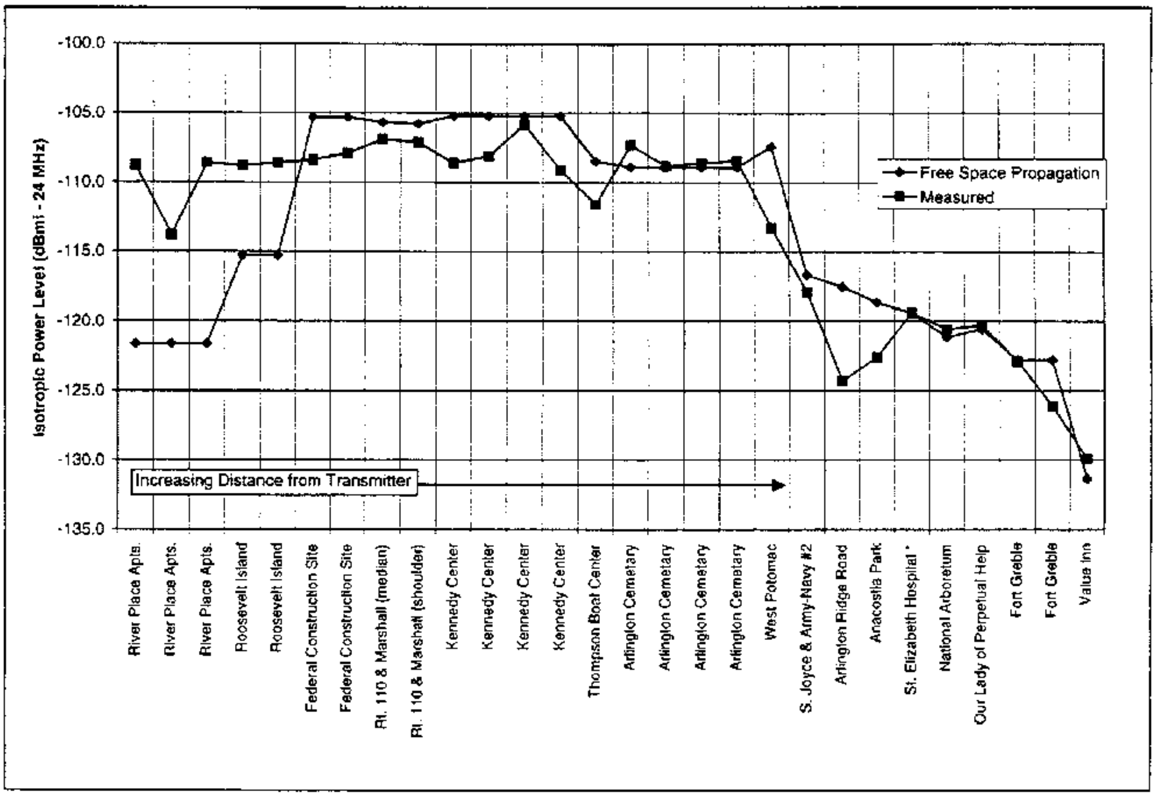

Figure 15. Northpoint Signal Strength

Excellent Results for Multi-Channel Video

Phase II was a demonstration of the ability of the Northpoint system to carry multi-channel video. While there is no intrinsic difference in a data link for the 24 MHz single channel used in Phase I and a 24 MHz multi-channel link, the Phase II demonstration highlights Northpoint's ability to use off-the-shelf equipment to offer an attractive, low cost, high quality service re-transmitting local television programming.

The "head-end" for Phase II consisted of a high quality over-the-air antenna system suitable for receiving off-air television stations, and included demodulation and baseband processing equipment. There were six demodulation systems utilized for this test. The six baseband signals were then fed into the Lucent Videostar encoding system. These signals were encoded into an MPEG-2 transport stream and were then converted to an ASI data stream that was fed to the Northpoint transmitter. The Northpoint transmitter further formatted the ASI data stream into the DVB format that was then modulated and transmitted on the Northpoint channel. Thus, the 24 MHz radiated signal that was broadcast throughout the service area carried six video channels.

Site 7, at Arlington Cemetery, was used as a reception test site. Reception was achieved with an unmodified DBS dish and both a Global brand satellite receiver and a SatCruiser brand receiver. This was significant because it demonstrated that off-the-shelf equipment could be used successfully to receive the Northpoint signal. No conditional access system was used. The video output was excellent. No differences were noted in the reception of the multi-channel programming, versus the single 24 MHz channel used previously at the same site in Phase I testing.

Experimental Repeater Equipment Demonstrated

One of the best aspects of the FCC experimental program is the opportunity to take experimental equipment out of the lab and test it in the field. Northpoint's repeater technology is central to Northpoint's deployment plans. The Northpoint repeater consists of a dish antenna to receive Northpoint signals from an adjacent cell, an amplifier to boost the signal power to an acceptable level and a transmit antenna to propagate the signal in the repeaters service area. The goal of the Northpoint repeater is to retransmit the entire 500 MHz band at a high quality and low cost. After installing the repeater, some very low power out-of-band emissions were found, so the repeater's series of filters were modified and thus the problem was eliminated. A plot of the repeater's proper function is presented in Appendix V.

4. Conclusion

The measurement data conclusively show that Northpoint has no significant adverse impact on DBS operations. In sites representing over 99% of the service area, there was no detectable interaction between Northpoint and DBS. In the Near In Region, while some insignificant SSP depression was observed at certain sites within about a mile of a transmitter, overall the data show no statistical difference, even in the 0.25% of the service area closest to the transmitter. At no time did DBS fail due to Northpoint operations or operate out of the quasi-error-free zone. The average change observed with Northpoint on was sufficiently low to be within the 95% confidence level for margin of error indicating that there is no statistical difference between the Northpoint "on" and Northpoint "off" conditions.

The BER tests demonstrated that DBS operated in the quasi-error free zone at all times, providing robust quality with and without Northpoint. The Eb/No tests showed no significant link degradation. The compatibility of Northpoint and DBS during extreme rain events was demonstrated during Hurricane Floyd without a failure or report of interference. It was demonstrated that the DBS systems operated in the quasi-error free zone during the entire test.

The multiple Northpoint cellular architecture was also successfully tested, and found to have no impact to DBS. Further, and significantly, during the entire test, there were absolutely no complaints of DBS outages attributed to Northpoint. No localized interference mitigation was required, even with DBS operating on the same roof, and within 15 feet of the Northpoint transmitter. Finally, the Northpoint signal levels were in general agreement with predictions and there was no impact from multipath reflections. Northpoint is a viable technology and ready for deployment through the United States.

List of Appendices

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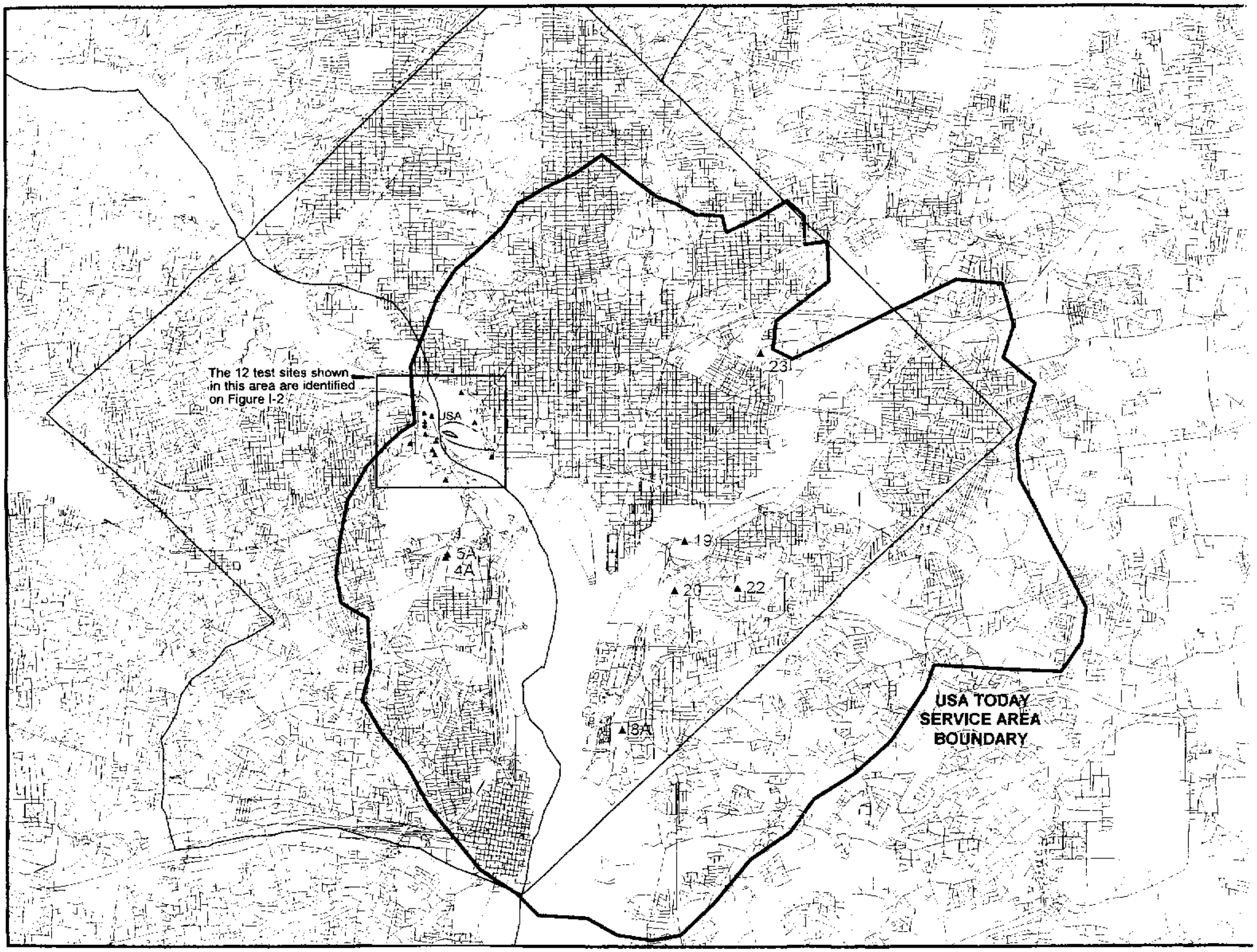
Appendix I

I. Maps of Test Sites and Service Areas



MSITE™: Wash I1.map

Prop. model: Free Space + RMD
Time: 50.0% Loc.: 50.0%
Prediction Confidence Margin: 0.0dB
Climate: Continental Temperate
Groundcover: none
Atmospheric Abs.: none
K Factor: 1.333
RX Antenna - Type: DA
Height: 9.1 m AGL Gain: 31.85 dBd

Site	Ant. Elev. AMSL (m)	ERPd (dBW)/Orient.	Ant. Type	Coordinates
USA	118.9	-19.65	DA-H	N38°53'36.00"
group: 1	12500.0000 MHz	113.0		W77°04'07.00"

Notes

CONTOURS:
YELLOW: 6 DB C/I MITIGATION ZONE (NONE)
RED: 10 DB C/I MITIGATION ZONE (NONE)
BLUE: 15 DB C/I MITIGATION ZONE
GREEN: 20 DB C/I MITIGATION ZONE

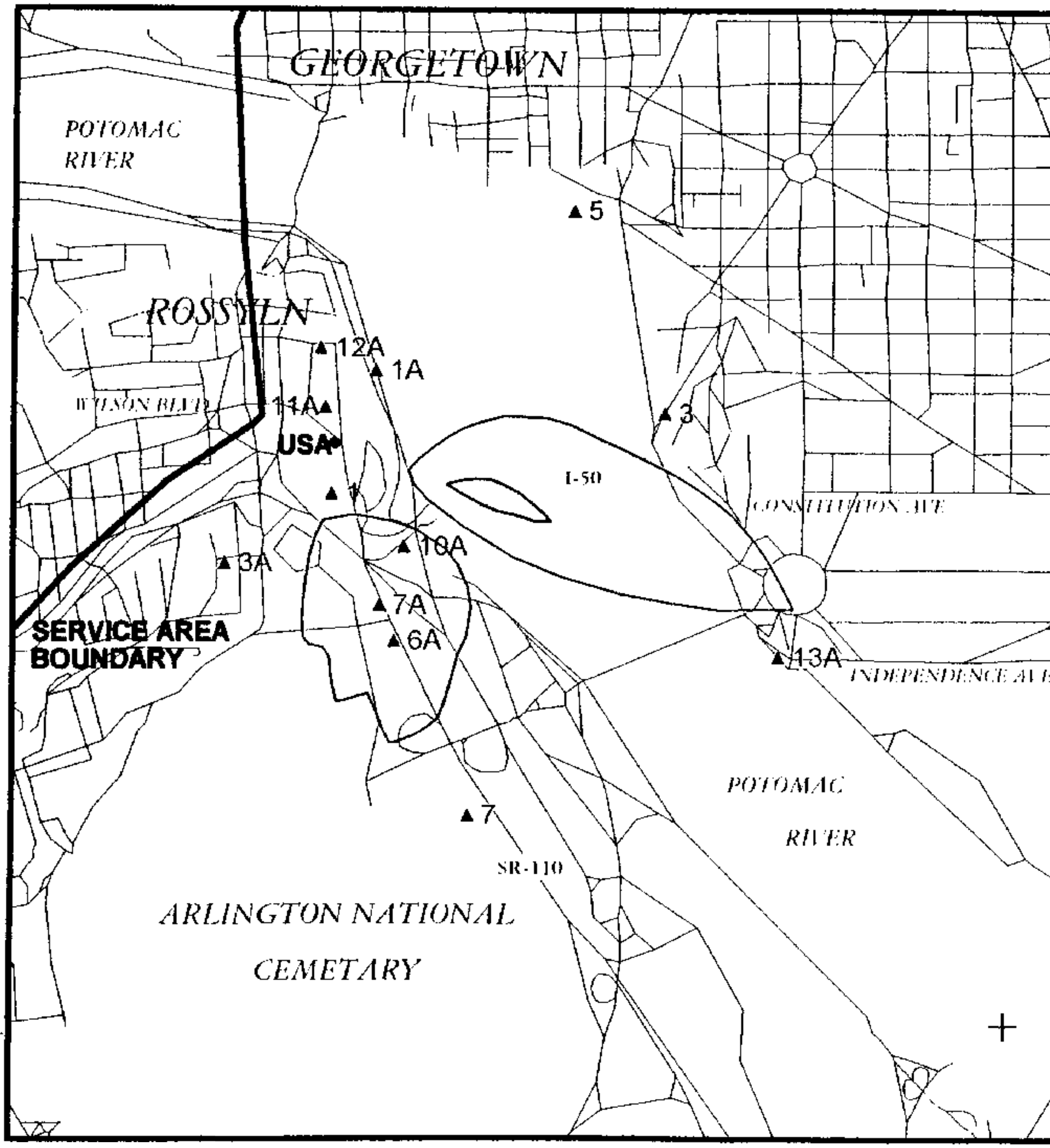
Site: N38-53-36; W77-04-07; EIRP:-17.5 dBW
Antenna Rad. Center: 100m AGL (119m AMSL)

KILOMETERS
-1 0 4

FIGURE I-1

SERVICE AREA, USA TODAY

SATs:61.5,101,110,119 991007



MSITE™: Wash I2.map

Prop. model: Free Space + RMD
Time: 50.0% Loc.: 50.0%
Prediction Confidence Margin: 0.0dB
Climate: Continental Temperate
Groundcover: none
Atmospheric Abs.: none
K Factor: 1.333
RX Antenna - Type: DA
Height: 9.1 m AGL Gain: 31.85 dBd

Site	Ant. Elev. AMSL (m)	ERPd (dBW)	Ant. Type /Orient.	Coordinates
USA	118.9	-19.65	DA-H	N38°53'36.00"
group: 1	12500.0000 MHz		113.0	W77°04'07.00"

Notes

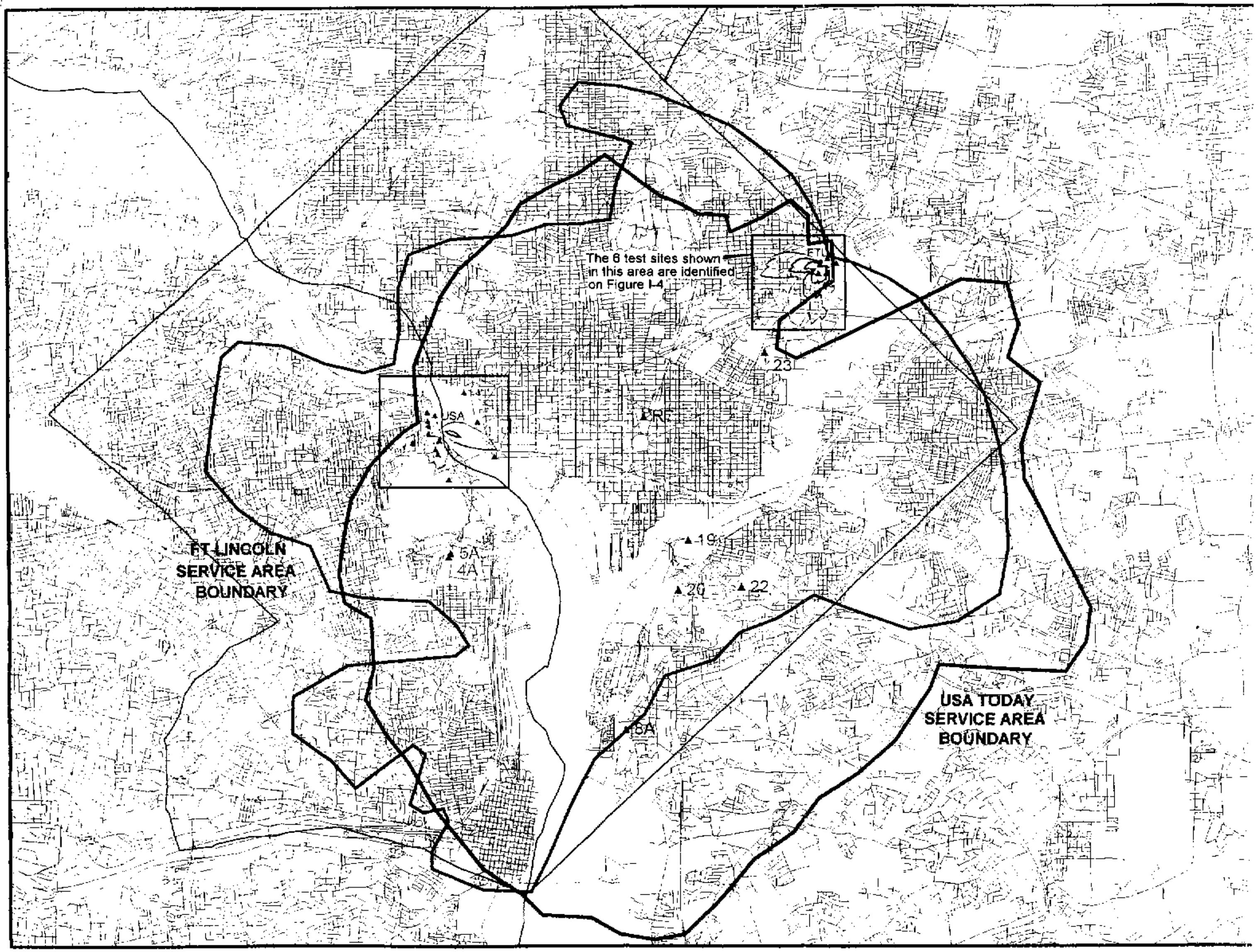
CONTOURS:
YELLOW: 6 DB C/I MITIGATION ZONE (NONE)
RED: 10 DB C/I MITIGATION ZONE (NONE)
BLUE: 15 DB C/I MITIGATION ZONE
GREEN: 20 DB C/I MITIGATION ZONE
*
Site: N38-53-36; W77-04-07; EIRP:-17.5 dBW
Antenna Rad. Center: 100m AGL (119m AMSL)

METERS
-500 0 500

FIGURE I-2

NEAR IN REGION, USA TODAY

SATs:61.5,101,110,119 991007



MSITE™: Wash i3.map

Prop. model: Free Space + RMD
Time: 50.0% Loc.: 50.0%
Prediction Confidence Margin: 0.0dB
Climate: Continental Temperate
Groundcover: none
Atmospheric Abs.: none
K Factor: 1.333
RX Antenna - Type: DA
Height: 9.1 m AGL Gain: 31.85 dBd

Site	Ant. Elev. AMSL (m)	ERPd (dBW)/Orient.	Ant. Type	Coordinates
USA	118.9	-19.65	DA-H	N38°53'36.00"
group: 1	12500.0000 MHz	113.0		W77°04'07.00"
FTL	70.0	-19.65	DA-H	N38°55'42.00"
group: 1	12500.0000 MHz	225.0		W76°57'39.00"

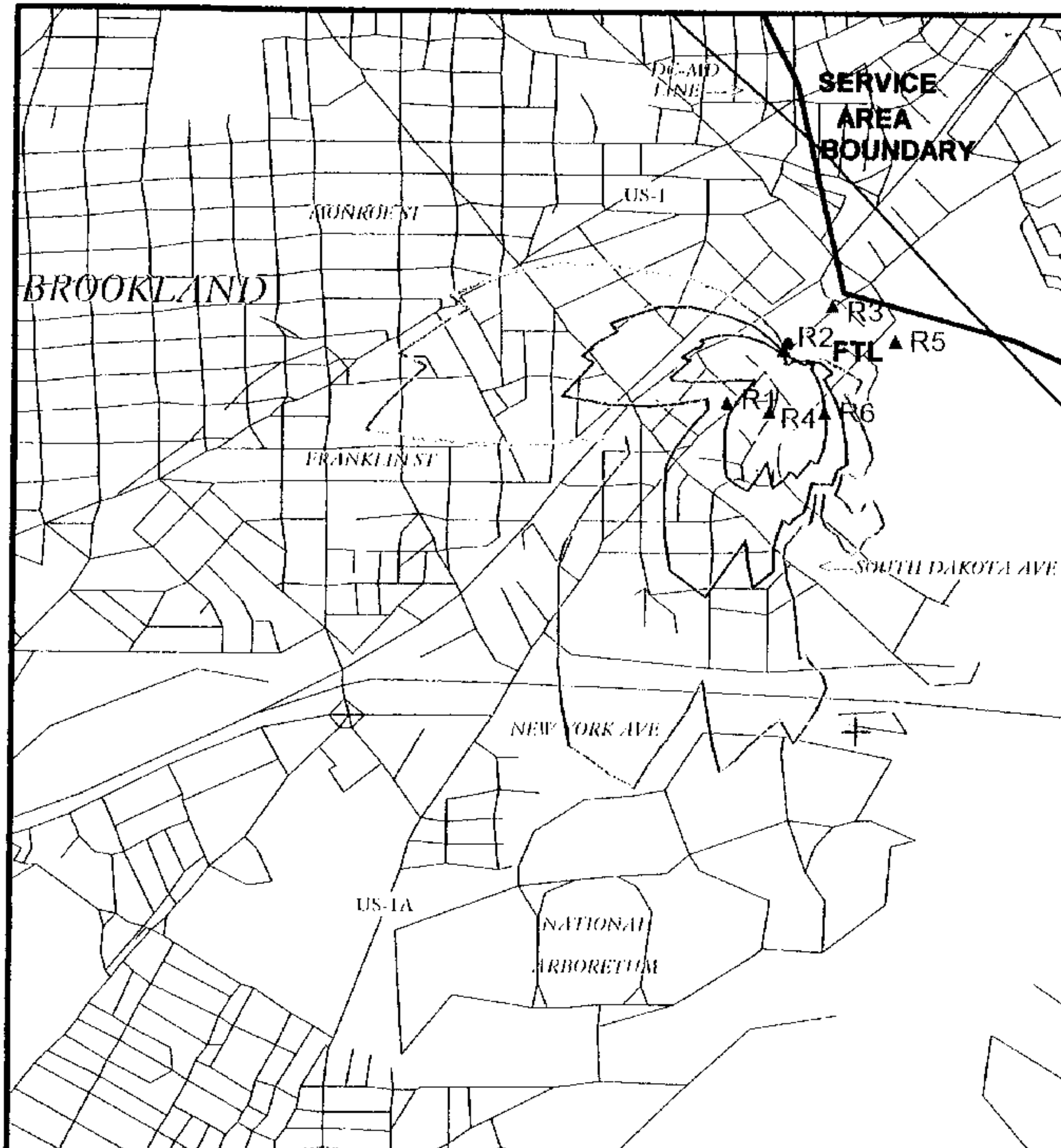
Notes

CONTOURS:
YELLOW: 6 DB C/I MITIGATION ZONE
RED: 10 DB C/I MITIGATION ZONE
BLUE: 15 DB C/I MITIGATION ZONE
GREEN: 20 DB C/I MITIGATION ZONE

KILOMETERS
-1 0 4

FIGURE I-3

SERVICE AREA, USA TODAY/FT LINCOLN
SATS:61.5,101,110,119 991007



MSITE™: Wash I4.map

Prop. model: Free Space + RMD
Time: 50.0% Loc.: 50.0%
Prediction Confidence Margin: 0.0dB
Climate: Continental Temperate
Groundcover: none
Atmospheric Abs.: none
K Factor: 1.333
RX Antenna - Type: DA
Height: 9.1 m AGL Gain: 31.85 dBd

Site	Ant. Elev. AMSL (m)	ERPd (dBW)	Ant. Type /Orient.	Coordinates
FTL	70.0	-19.65	DA-H	N38°55'42.00"
group: 1	12500.0000 MHz		225.0	W76°57'39.00"

Notes

CONTOURS:
YELLOW: 6 DB C/I MITIGATION ZONE
RED: 10 DB C/I MITIGATION ZONE
BLUE: 15 DB C/I MITIGATION ZONE
GREEN: 20 DB C/I MITIGATION ZONE
*
Site: N38-55-42; W76-57-39; EIRP:-17.5 dBW
Antenna Rad. Center: 38m AGL (70m AMSL)

METERS
-500 0 500

FIGURE I-4

NEAR IN REGION, FT. LINCOLN

SATs"61.5,101,110,119 991007

Appendix II

II. Equipment Setup and Calibration

General

Figures II-1, II-2, and II-3 show block diagrams of the main instrument systems for this test project. This appendix section will describe the essentials of the equipment and the implementations used. The equipment shown in the figures includes, respectively, the Northpoint transmitter, the repeater, and the field measurement equipment or receiver system. The transmitter and repeater systems were installed at fixed locations for the test, and the receiver system was implemented as a mobile field station for use in monitoring and assessing the DBS satellite and Northpoint signals at numerous geographical locations in the test area.

1. Transmitter System

The Northpoint Transmitter (NPTx) of Figure II-1 is comprised of the following main components:

a. Transmitter unit -- LNR Communications, Inc. model DVE-Ku-1 s/n 164, 1 watt power amplifier w/ digital encoder, QPSK modulation and power level control -- Items (30), (31), (32), (33).

b. Seavy Engineering custom horn antenna w/ 10 dB gain, horizontal polarization, 110 degree horizontal beam width and 17 degree vertical beam width -- Item (35).

c. Andrew EW127 14' wave guide sections with four WR75 flanges -- Item (34).

d. Video sources -- Item (40). Video signal sources during the test consist of local signal sources (camera or color bar generator) and of live signal feeds from certain local TV stations, depending on the project phase, as described in the report text.

e. Directional Coupler -- Item (35). Used to monitor the transmitter power output during transmitter operation.

The HPE4418B / HPE4412A power meter/sensor unit was used to calibrate the NPTx and then to monitor the power during transmitter operation during the tests. A notebook PC computer was employed to log the power meter readings every few seconds via a GPIB interface with the HP power meter.

Setup and Operation

The transmitter was installed on the roof of the USA Today building, with the transmit antenna overhanging the parapet and suspended four feet below the roofline of the building. This installation scheme provided some natural shielding of the Northpoint signal toward the region behind the antenna and on the rooftop so as not to interfere with roof mounted DBS receiver antennas that were in close proximity to the transmitter. The antenna was pointed in a southerly direction along an azimuth of 113 degrees, with zero degrees of beam tilt. The antenna height was approximately 400 feet AGL.

The transmitter was operated at a nominal power level of 12.5 dBm EIRP and with a typical carrier frequency of 12.47 GHz. The effective operating band corresponds to transponder 18 for all pertinent DBS satellites. The transmit data rate was 27647128 bps for a baud rate of 20000050 symbols per second and a transmit bandwidth of 24 MHz. A manual log was kept of the transmitter operation, including ON/OFF times and output power. In addition, a digital computer file of output power vs. time was produced and archived.

Calibration

On initial setup, the transmitter was calibrated by connecting the HP power meter directly to the output port at the antenna input and in place of the antenna. The power was adjusted so that the Effective Isotropic Radiated Power (EIRP) would be 12.5 dBm when using an antenna with a gain of 10 dBi. The antenna was replaced and the directional coupler output sample was measured with the power meter to determine the value corresponding to the 12.5 dBm output level. The corresponding monitor output level was determined to be -1.5 dBm. This sample was then monitored during the test work and the power was adjusted as required to maintain the intended output level.

2. Repeater System

The Northpoint Repeater (NPRp) of Figure II-2 consists of the following main items:

a. LNR custom repeater unit with in-line attenuator, upconverter, and power amplifier (maximum 2 watts power output), with F (75 ohm) input for L-Band signal, and with WR75 flange output -- Items (22), (23).

b. Band Pass filter in L-Band signal path for band limiting signals and noise produced by the receiving antenna -- Item (24).

c. Seavy Engineering custom horn antenna w/ 10 dB nominal gain, horizontal polarization, 110 degree horizontal beam width and 17 degree vertical beam width -- Item (35).

d. Channel Master 0.9 meter receiving antenna and LNB, with L-Band output -- Item (20).

The HPE4418B / HPE4412A Power Meter / Sensor Unit was used to calibrate the NPRp.

Setup and Operation

The repeater system was installed atop a 10 story apartment building in the Ft. Lincoln area. The repeater unit assembly with transmit antenna was placed on the building parapet, and the receiving antenna was located below the parapet in a position to provide adequate input to output isolation. The receiving antenna was pointed toward the NPTx system. The transmit antenna was pointed at an azimuth of approximately 225 degrees, with zero beam tilt. The antenna height was approximately 125 feet AGL. The pointing direction was such as to direct the repeater output back into the primary service area cell, in order to facilitate worst-case performance tests in regard to overlap of the repeater and the main transmitter signal. During the appropriate test phase, as described in the report text, the repeater was operated continuously when in use, producing an output signal when the NPTx signal was present.

Calibration

The repeater was calibrated by connecting the HP power meter to the WR75 output port (via a flange to N adapter). With the NPTx transmitter ON, the repeater attenuator was adjusted to produce an output power of 2.5 dBm. The transmit antenna was then replaced for operation of the repeater. The L-Band signal was initially monitored with a spectrum analyzer to assess the stability and input/output isolation with the repeater in the operating mode.

3. Receiver System

The Receiver/Test System is described as shown in Figure II-3. Four each DBS antennas were used in order to simultaneously monitor the NPTx signal and each of the three satellites: Direct TV -101 (DTV), Echostar - 61.5 (ES1), and Echostar - 119 (ES2). Signal from the DBS antennas were transmitted by four each RG-6 coax cables (75 ft. length) to the receiver and monitoring systems. Each signal is connected to an appropriate IRD (DBS Receiver) via a power splitter. The alternate output of the splitter for each signal channel is used for sampling and monitoring the signal with the HP8563E spectrum analyzer or the Newtec demodulator box. A video/audio monitor is connected to the IRD for each signal channel used. In the diagram, 5 signal channels are shown, with splitters and IRD's 0 through 5. The channel to signal assignments as shown in the block diagram were consistently used, except as specifically stated otherwise in the logs. Antenna connections were assigned and logged for each measurement according to the cable number. The system component list is as follows:

a. Four each DBS antennas RCA/ DSA100RW with 18 inch dish, specially calibrated to determine the gain over isotropic. The tags identify the antennas used: DBS1, NP2, NP3, NP4.

b. Five each L-Band Power Splitters.

c. Two each RCA IRD's (DSS format) for DirecTV reception.

d. Two each Dish IRD's (DVB format) for Echostar reception.

e. One each Tiernan IRD for NPTx reception.

f. Four each Video/Audio monitors.

g. HP8563E Spectrum Analyzer with 75/50 ohm impedance matching pad.

h. HP2225A Ink Jet printer/plotter.

i. Newtec demodulator unit (provided by Lucent Technologies) for assessment of DVB signal, including Eb/No (signal to noise), link margin, and bit error rate (BER).

j. PC Notebook Computer with software interface for the Newtec demodulator (in-house special package provided by Newtec).

k. Related cables as described in the figure.

l. Motor-Generator unit -- Honda EZ2500 -- 2500 watt, for AC electrical power.

Setup and Operation

The mobile Receiver System was implemented in a 15 passenger Ford van. A towable hydraulic boom lift was used to implement the antenna platform. The four DBS antenna mounts were installed on specially constructed platforms on the boom lift carriage, with one antenna at each of the four corners of the carriage basket. Signal cables were routed along the boom to allow for elevated operation of the boom when needed for NP signal acquisition. A specially modified DBS antenna mount was used for the NP antenna to allow for the lower elevation angles normally required for the terrestrial signal. A motor-generator was mounted on the boom lift frame and used for electrical power for the system.

This mobile unit was used to acquire the test data for most measurement sites in the test, except for sites not accessible by the van (e.g. building rooftops). In cases of such inaccessible sites, the appropriate equipment was removed from the instrument van and hand carried to the site and assembled and used.

Calibration

The four antennas and the related signal channels were calibrated in terms of the equivalent gain over isotropic, in order to allow for quantitative assessment of the signal and the signal spectrum as viewed by the spectrum analyzer. D. R. Word Associates specially calibrated the four DBS antennas used.

Appendix II

The four DBS antennas were found to agree in gain to within 1 dB, and the average gain at the LNB outputs is 90.4 dB over isotropic. For the system conditions in use, the signal transmission elements of concern to the calibration are as follows:

a. Cables	--	(-6 dB).
b. Splitters	--	(-4 dB).
c. Cables (*) to SA	--	(-0.6 dB).

Thus, the gain calibration at the end of the cable to the Spectrum analyzer (*) in the figure is 79.8 dB over isotropic.

For the HP8563E spectrum analyzer (SA), the input impedance is 50 ohms, and a matching pad was used to monitor the DBS signals with 75 ohm output impedance. The matching pad insertion loss is 5.7 dB, requiring a gain correction of -5.7 dB for the SA readings.

The overall system gain as applied to the SA readings is 74.1 dB over isotropic.

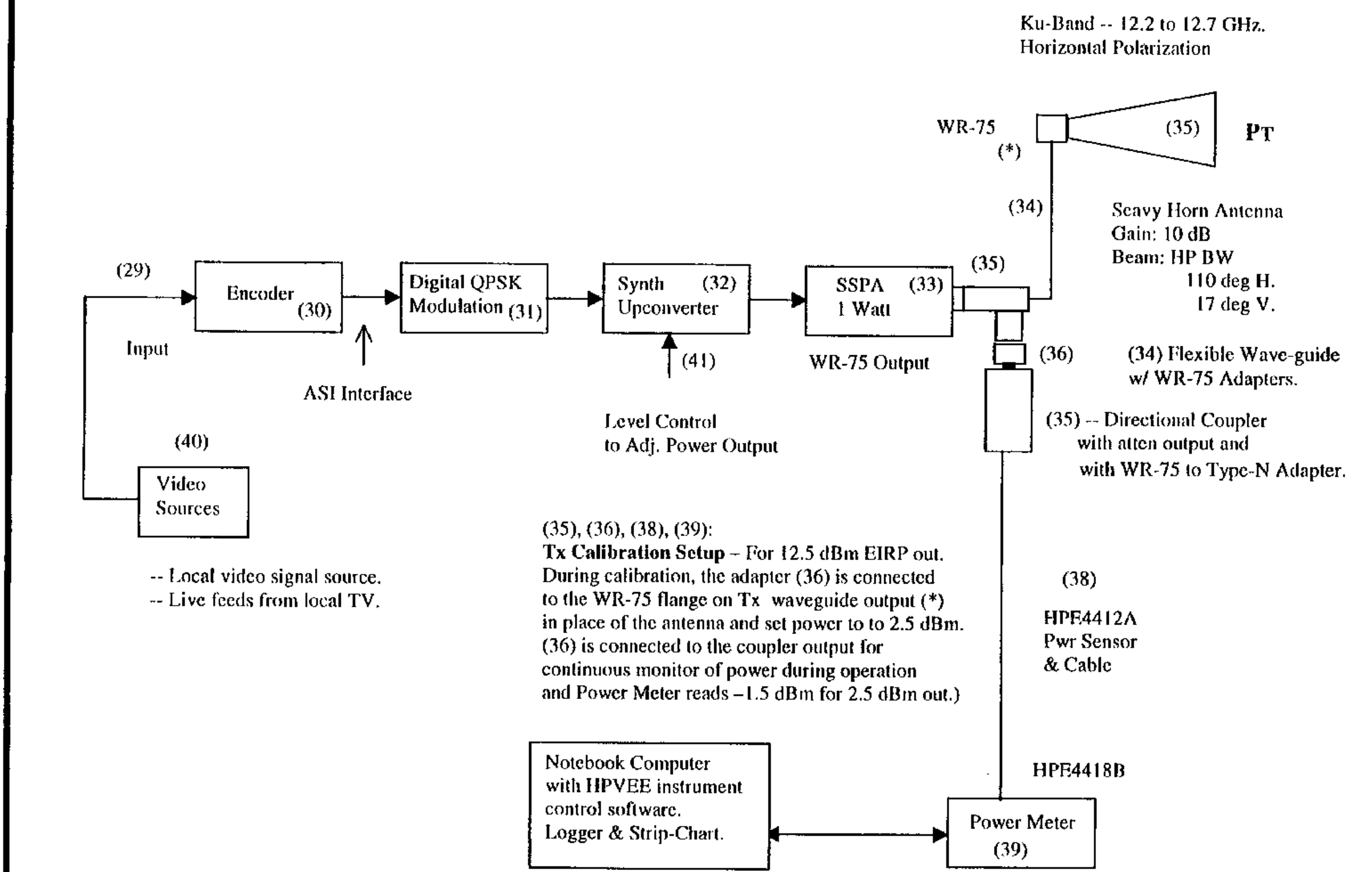


Fig. II-1: Northpoint Terrestrial Transmitter Block Diagram.

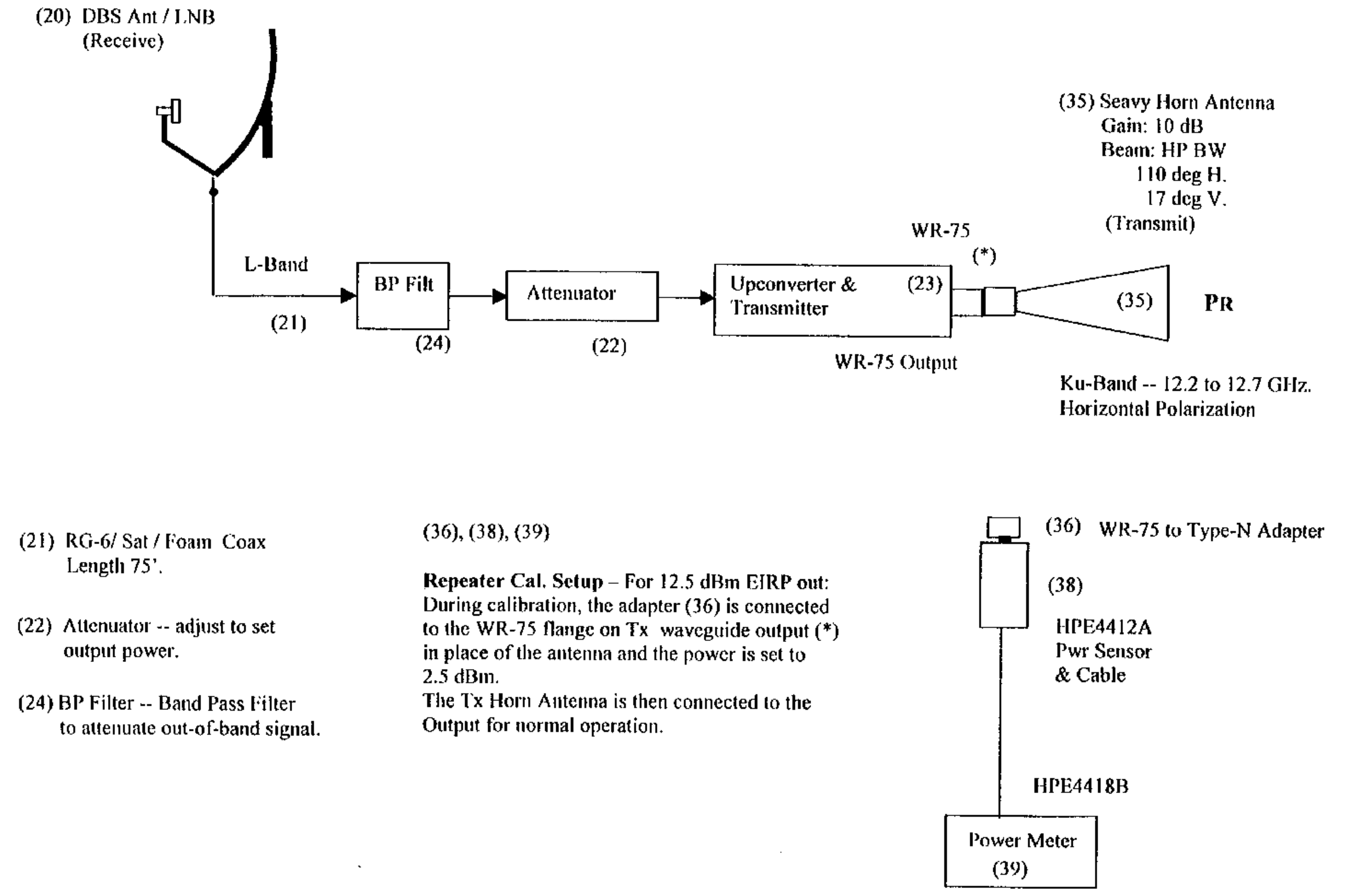


Fig. II-2: Northpoint Terrestrial Repeater Block Diagram.

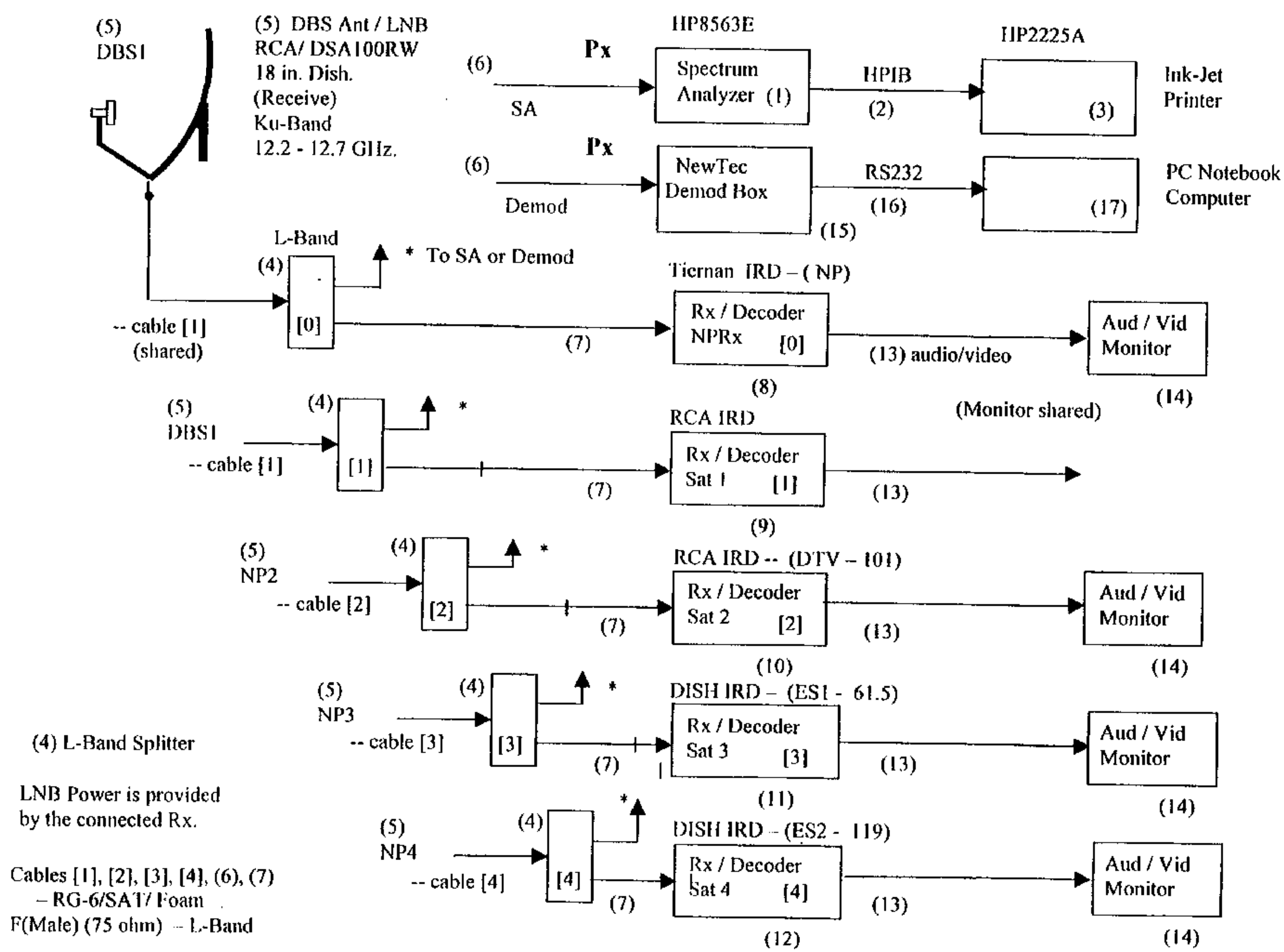


Fig. II-3: Mobile Receiver System Block Diagram

Appendix III

III. Field Data and Analysis

Table III-1. Transmitter Test Coordinates (with polar position from transmitter)

Site No.	Site Name	Range (miles)	Range (km)	Azimuth (deg)	Elevation AMSL (m)	Latitude Deg	Longitude Deg
-	Transmitter	0.00	0.00	0.0	134.4	38.89333	77.06861
11A	London House Rooftop	0.09	0.14	339.0	55.5	38.89453	77.06917
1	River Place Apts.	0.11	0.17	189.6	19.8	38.89181	77.06889
1A	Roosevelt Island	0.18	0.29	26.0	12.2	38.89569	77.06714
12A	Normandy House Rooftop	0.22	0.35	349.1	54.9	38.89642	77.06936
10A	Federal Construction Site	0.26	0.42	147.2	9.1	38.89014	77.06597
3A	Nash & 14th Street	0.35	0.57	223.8	18.3	38.88961	77.07319
7A	Rt. 110 & Marshall (median)	0.36	0.58	165.5	12.2	38.88828	77.06694
6A	Rt. 110 & Marshall (shoulder)	0.44	0.71	163.9	11.3	38.88717	77.06633
3	Kennedy Center	0.73	1.17	83.5	6.1	38.89453	77.05525
5	Thompson Boat Center	0.74	1.19	47.4	6.1	38.90056	77.05853
7	Arlington Cemetery	0.86	1.38	160.5	11.0	38.88164	77.06331
13A	West Potomac	1.06	1.71	115.7	4.6	38.88639	77.04997
5A	S. Joyce & Army-Navy #2	1.96	3.15	170.9	15.5	38.86539	77.06289
2A	Arlington Ridge Road	1.98	3.18	176.4	39.6	38.86478	77.06631
4A	S. Joyce & Army-Navy	2.00	3.21	172.0	17.7	38.86469	77.06344
19	Anacostia Park	4.20	6.76	114.4	4.6	38.86822	76.99750
20	St. Elizabeth Hospital	4.44	7.15	124.1	48.8	38.85731	77.00022
23	National Arboretum	5.06	8.14	77.4	51.8	38.90925	76.97669
22	Our Lady of Perpetual Help	5.21	8.39	117.9	81.7	38.85794	76.98292
8A	Fort Greble	5.44	8.75	147.6	51.8	38.82686	77.01442
9A	Value Inn	8.25	13.27	184.6	73.1	38.77436	77.08089

Table III-2. Repeater Test Coordinates (with polar position from repeater)

Site No.	Site Name	Range (miles)	Range (km)	Azimuth (deg)	Elevation AMSL (m)	Latitude (Deg)	Longitude (Deg)
-	Repeater	0.00	0.00	0.0	69.8	38.928333	76.96083
R1	7/11 Bladensburg	0.18	0.29	237.3	29.9	38.926944	76.96361
R2	Goodyear	0.04	0.06	301.3	29.6	38.928611	76.96139
R3	Post Office	0.14	0.22	33.1	28.3	38.930000	76.95944
R4	Banniker Dr.	0.13	0.21	207.7	33.5	38.926667	76.96194
R5	Wash. Overlook	0.13	0.21	79.6	33.5	38.928889	76.95694
R6	Ft. Lincoln Dr	0.13	0.21	152.4	50.3	38.926667	76.95972
R7	400 North Capital	3.48	5.60	229.0	12.2	38.895278	77.00972

Table III-3. Spectrum Analyzer Power Levels (dBm - 1 MHz)

				Northpoint		DBS (Northpoint Off)			DBS (Northpoint On)		
Date	Ph.	Site	Site Name	Trans.	Rep.	DTV	E61.5	E119	DTV	E61.5	E119
13-Aug	I	11A	London House Rooftop	-74.0			-63.7	-63.7		-63.3	-63.5
4-Aug	I	1	River Place Apts.	-56.2		-64.3	-64.7	-65.7	-64.2	-65.2	-65.5
14-Aug	I	1	River Place Apts.	-51.2		-65.7	-65.7	-66.3	-65.8	-65.7	-67.0
18-Aug	I	1	River Place Apts.	-51.0				-66.8			-66.5
4-Aug	I	1A	Roosevelt Island	-51.0		-64.7	-65.3	-63.7	-64.8	-66.2	-64.2
17-Aug	I	1A	Roosevelt Island	-51.2		-67.5		-67.0	-67.0		-66.8
13-Aug	I	12A	Normandy House Rooftop	*		-66.8	-65.7	-66.7	-65.3	-65.3	-66.3
12-Aug	I	10A	Federal Construction Site	-50.3		-66.3	-66.5	-66.5	-66.3	-66.5	-65.3
16-Aug	I	10A	Federal Construction Site	-50.8		-67.5	-65.2	-66.5	-67.2	-65.8	-66.5
10-Aug	I	3A	Nash & 14th Street	*			-63.8			-63.8	
11-Aug	I	7A	Rt. 110 & Marshall (median)	-49.3		-65.5	-65.7	-64.7	-65.7	-65.5	-65.0
11-Aug	I	6A	Rt. 110 & Marshall (shoulder)	-49.5		-66.0	-64.5		-66.2	-64.8	
6-Aug	I	3	Kennedy Center	-51.5		-65.9	-66.0	-64.0	-65.5	-66.2	-64.3
14-Aug	I	3	Kennedy Center	-50.5		-66.2	-66.5	-66.7	-66.2	-66.7	-66.2
17-Aug	I	3	Kennedy Center	-48.2		-66.2	-66.3	-67.5	-65.7	-66.2	-66.8
18-Aug	I	3	Kennedy Center	-51.0		-66.3	-66.3	-68.5	-66.2	-66.3	-68.3
9-Aug	I	5	Thompson Boat Center	-54.0		-64.5	-66.0		-64.0	-66.8	
4-Aug	I	7	Arlington Cemetery	-49.7		-66.7	-64.5	-65.5	-66.8	-65.0	-65.8
12-Aug	I	7	Arlington Cemetery	-51.0		-65.2	-65.3	-68.0	-65.0	-64.7	-68.3
18-Aug	I	7	Arlington Cemetery	-50.8				-67.5			-67.3
23-Aug	I	7	Arlington Cemetery	-51.2		-66.2	-65.8	-67.7	-66.5	-66.3	-67.5
10-Aug	I	5A	S. Joyce & Army-Navy #2	-60.3		-64.5	-68.0	-65.3	-64.7	-68.7	-65.7
5-Aug	I	2A	Arlington Ridge Road	-66.7		-65.0		-65.5	-64.5		-66.3
10-Aug	I	4A	S. Joyce & Army-Navy	*		-65.8	-64.8	-65.7	-66.3	-65.5	-65.8
16-Aug	I	19	Anacostia Park	-65.0		-66.8	-65.2	-68.3	-66.8	-65.3	-69.0
9-Aug	I	20	St. Elizabeth Hospital	-61.8		-65.0	-66.2	-63.5	-64.5	-66.5	-63.5
10-Aug	I	23	National Arboretum	-63.0		-65.7	-65.0	-66.5	-65.8	-64.3	-66.3
5-Aug	I	22	Our Lady of Perpetual Help	-62.7		-65.3	-66.7	-64.2	-64.0	-66.5	-63.8
11-Aug	I	8A	Fort Greble	-68.5		-65.0	-67.0	-64.3	-65.0	-67.2	-64.0
11-Aug	I	8A-A	Fort Greble	-65.3		-65.7	-67.2	-63.7	-65.3	-67.7	-64.2
11-Aug	I	9A	Value Inn	-72.3		-65.0	-66.7	-66.3	-65.5	-66.7	-66.2
27-Aug	II	7	Arlington Cemetery	-51.7		-66.8	-66.3	-66.8	-66.0	-65.8	-67.3
2-Sep	III	R2	Goodyear		-62.0	-67.7	-65.8	-68.3	-67.3	-65.7	-68.2
3-Sep	III	R4	Banniker Dr.		-47.5	-66.8	-65.8	-68.7	-67.7	-66.2	-67.0
3-Sep	III	R5	Wash. Overlook		*						
3-Sep	III	R6	Ft. Lincoln Dr		-43.2	-66.7	-66.3	-66.8	-66.2	-66.3	-66.8
3-Sep	III	R3	Post Office		*						
2-Sep	III	R1	7/11 Bladensburg		-41.2	-66.5	-65.5	-66.7	-66.7	-65.3	-65.5
6-Sep	III	10A	Federal Construction Site	-49.6		-67.8	-66.8	-68.3	-67.5	-65.8	-67.8
6-Sep	III	3	Kennedy Center	-47.8		-67.0	-67.8	-69.7	-67.5	-67.8	-69.3
4-Sep	III	7	Arlington Cemetery	-51.2		-67.2	-66.7	-68.0	-66.8	-67.0	-68.2
16-Sep	III	7	Arlington Cemetery (Rain)	-52.2							
27-Sep	III	13A	West Potomac	-55.7		-68.5	-66.7	-67.8	-68.2	-66.8	-68.2
5-Sep	III	R7	400 North Capital	-66.7	-69.5	-70.5	-68.3	-69.0	-70.0	-66.5	-68.6
	All Data		Average			-66.24	-65.95	-66.49	-66.07	-66.00	-66.39
			Standard Deviation			1.25	1.05	1.66	1.27	1.08	1.58

* Not found

Appendix III

Table III-4. Isotropic Power Levels (dBmi - 24 MHz)

				Northpoint		DBS (Northpoint Off)			DBS (Northpoint On)		
Date	Ph.	Site	Site Name	Trans.	Rep.	DTV	E61.5	E119	DTV	E61.5	E119
13-Aug	I	11A	London House Rooftop	-134.0			-124.3	-124.3		-123.9	-124.1
4-Aug	I	1	River Place Apts.	-116.2		-124.9	-125.3	-126.3	-124.8	-125.8	-126.1
14-Aug	I	1	River Place Apts.	-111.2		-126.3	-126.3	-126.9	-126.4	-126.3	-127.6
18-Aug	I	1	River Place Apts.	-111.0				-127.4			-127.1
4-Aug	I	1A	Roosevelt Island	-111.0		-125.3	-125.9	-124.3	-125.4	-126.8	-124.8
17-Aug	I	1A	Roosevelt Island	-111.2		-128.1		-127.6	-127.6		-127.4
13-Aug	I	12A	Normandy House Rooftop	*		-127.4	-126.3	-127.3	-125.9	-125.9	-126.9
12-Aug	I	10A	Federal Construction Site	-110.3		-126.9	-127.1	-127.1	-126.9	-127.1	-125.9
16-Aug	I	10A	Federal Construction Site	-110.8		-128.1	-125.8	-127.1	-127.8	-126.4	-127.1
10-Aug	I	3A	Nash & 14th Street	*			-124.4			-124.4	
11-Aug	I	7A	Rt. 110 & Marshall (median)	-109.3		-126.1	-126.3	-125.3	-126.3	-126.1	-125.6
11-Aug	I	6A	Rt. 110 & Marshall (shoulder)	-109.5		-126.6	-125.1		-126.8	-125.4	
6-Aug	I	3	Kennedy Center	-111.5		-126.5	-126.6	-124.6	-126.1	-126.8	-124.9
14-Aug	I	3	Kennedy Center	-110.5		-126.8	-127.1	-127.3	-126.8	-127.3	-126.8
17-Aug	I	3	Kennedy Center	-108.2		-126.8	-126.9	-128.1	-126.3	-126.8	-127.4
18-Aug	I	3	Kennedy Center	-111.0		-126.9	-126.9	-129.1	-126.8	-126.9	-128.9
9-Aug	I	5	Thompson Boat Center	-114.0		-125.1	-126.6		-124.6	-127.4	
4-Aug	I	7	Arlington Cemetery	-109.7		-127.3	-125.1	-126.1	-127.4	-125.6	-126.4
12-Aug	I	7	Arlington Cemetery	-111.0		-125.8	-125.9	-128.6	-125.6	-125.3	-128.9
18-Aug	I	7	Arlington Cemetery	-110.8				-128.1			-127.9
23-Aug	I	7	Arlington Cemetery	-111.2		-126.8	-126.4	-128.3	-127.1	-126.9	-128.1
10-Aug	I	5A	S. Joyce & Army-Navy #2	-120.3		-125.1	-128.6	-125.9	-125.3	-129.3	-126.3
5-Aug	I	2A	Arlington Ridge Road	-126.7		-125.6		-126.1	-125.1		-126.9
10-Aug	I	4A	S. Joyce & Army-Navy	*		-126.4	-125.4	-126.3	-126.9	-126.1	-126.4
16-Aug	I	19	Anacostia Park	-125.0		-127.4	-125.8	-128.9	-127.4	-125.9	-129.6
9-Aug	I	20	St. Elizabeth Hospital	-121.8		-125.6	-126.8	-124.1	-125.1	-127.1	-124.1
10-Aug	I	23	National Arboretum	-123.0		-126.3	-125.6	-127.1	-126.4	-124.9	-126.9
5-Aug	I	22	Our Lady of Perpetual Help	-122.7		-125.9	-127.3	-124.8	-124.6	-127.1	-124.4
11-Aug	I	8A	Fort Greble	-128.5		-125.6	-127.6	-124.9	-125.6	-127.8	-124.6
11-Aug	I	8A-A	Fort Greble	-125.3		-126.3	-127.8	-124.3	-125.9	-128.3	-124.8
11-Aug	I	9A	Value Inn	-132.3		-125.6	-127.3	-126.9	-126.1	-127.3	-126.8
27-Aug	II	7	Arlington Cemetery	-111.7		-127.4	-126.9	-127.4	-126.6	-126.4	-127.9
2-Sep	III	R2	Goodyear		-122.0	-128.3	-126.4	-128.9	-127.9	-126.3	-128.8
3-Sep	III	R4	Banniker Dr.		-107.5	-127.4	-126.4	-129.3	-128.3	-126.8	-127.6
3-Sep	III	R5	Wash. Overlook		*						
3-Sep	III	R6	Ft. Lincoln Dr		-103.2	-127.3	-126.9	-127.4	-126.8	-126.9	-127.4
3-Sep	III	R3	Post Office		*						
2-Sep	III	R1	7/11 Bladensburg		-101.2	-127.1	-126.1	-127.3	-127.3	-125.9	-126.1
6-Sep	III	10A	Federal Construction Site	-109.6		-128.4	-127.4	-128.9	-128.1	-126.4	-128.4
6-Sep	III	3	Kennedy Center	-107.8		-127.6	-128.4	-130.3	-128.1	-128.4	-129.9
4-Sep	III	7	Arlington Cemetery	-111.2		-127.8	-127.3	-128.6	-127.4	-127.6	-128.8
16-Sep	III	7	Arlington Cemetery (Rain)	-112.2							
27-Sep	III	13A	West Potomac	-115.7		-129.1	-127.3	-128.4	-128.8	-127.4	-128.8
5-Sep	III	R7	400 North Capital	-126.7	-129.5	-131.1	-128.9	-129.6	-130.6	-127.1	-129.2

* Not found

Table III-5. SSP Indications

Date	Phase	Site	Site Name	DBS (Northpoint Off)			DBS (Northpoint On)		
				DTV	E61.5	E119	DTV	E61.5	E119
13-Aug	Phase I	11A	London House Rooftop		90.3	86.4		92.4	86.4
4-Aug	Phase I	1	River Place Apts.	87.4	98.6	88.9	84.7	98.0	87.6
14-Aug	Phase I	1	River Place Apts.	82.0	92.2	89.0	76.9	91.1	87.4
18-Aug	Phase I	1	River Place Apts.			88.8			87.7
4-Aug	Phase I	1A	Roosevelt Island	82.8	85.2	95.7	80.9	80.8	96.1
17-Aug	Phase I	1A	Roosevelt Island	74.7		87.5	72.2		86.8
13-Aug	Phase I	12A	Normandy House Rooftop	84.1	95.8	91.1	82.9	96.2	91.4
12-Aug	Phase I	10A	Federal Construction Site	81.6	87.6	88.1	84.0	87.4	88.4
16-Aug	Phase I	10A	Federal Construction Site	77.1	96.9	89.3	77.9	94.3	89.7
10-Aug	Phase I	3A	Nash & 14th Street		95.0			95.6	
11-Aug	Phase I	7A	Rt. 110 & Marshall (median)	80.8	88.0	94.4	75.8	88.0	95.2
11-Aug	Phase I	6A	Rt. 110 & Marshall (shoulder)	78.2	95.4		73.6	94.3	
6-Aug	Phase I	3	Kennedy Center	82.0	91.0	98.0	81.4	90.5	97.1
14-Aug	Phase I	3	Kennedy Center	82.7	91.8	88.7	81.1	91.1	88.1
17-Aug	Phase I	3	Kennedy Center	80.6	92.1	88.7	78.9	91.8	87.0
18-Aug	Phase I	3	Kennedy Center	80.4	93.4	81.7	80.5	94.3	81.7
9-Aug	Phase I	5	Thompson Boat Center	85.3	89.5		85.2	89.8	
4-Aug	Phase I	7	Arlington Cemetery	78.3	90.2	87.1	72.7	90.3	88.5
12-Aug	Phase I	7	Arlington Cemetery	80.2	95.5	78.1	78.0	94.8	78.2
18-Aug	Phase I	7	Arlington Cemetery			88.8			87.7
23-Aug	Phase I	7	Arlington Cemetery	80.6	95.4	89.2	80.7	95.7	88.7
10-Aug	Phase I	5A	S. Joyce & Army-Navy #2	80.4	74.8	89.3	81.2	78.6	91.1
5-Aug	Phase I	2A	Arlington Ridge Road	77.7		87.0	79.5		86.3
10-Aug	Phase I	4A	S. Joyce & Army-Navy	75.4	92.5	89.0	75.9	92.8	89.0
16-Aug	Phase I	19	Anacostia Park	80.5	94.1	80.7	81.6	94.4	79.9
9-Aug	Phase I	20	St. Elizabeth Hospital	80.5	92.0	96.0	80.6	91.5	96.0
10-Aug	Phase I	23	National Arboretum	75.5	89.0	84.3	78.2	89.6	84.7
5-Aug	Phase I	22	Our Lady of Perpetual Help	81.9	90.2	95.1	82.2	90.4	98.0
11-Aug	Phase I	8A	Fort Greble	78.9	89.0	95.0	79.2	89.4	95.0
11-Aug	Phase I	8A-A	Fort Greble	82.1	87.6	97.0	80.3	85.6	96.6
11-Aug	Phase I	9A	Value Inn	84.0	87.9	87.0	87.3	88.4	87.2
27-Aug	Phase II	7	Arlington Cemetery	80.8	92.9	89.0	81.3	92.9	87.0
2-Sep	Phase III	R2	Goodyear	80.6	94.9	84.8	80.4	95.3	83.9
3-Sep	Phase III	R4	Banniker Dr.	85.0	93.4	86.2	83.2	92.0	86.1
3-Sep	Phase III	R5	Wash. Overlook						
3-Sep	Phase III	R6	Ft. Lincoln Dr	80.4	93.3	90.0	79.2	91.0	89.8
3-Sep	Phase III	R3	Post Office						
2-Sep	Phase III	R1	7/11 Bladensburg	80.4	96.2	88.4	79.1	94.2	87.7
6-Sep	Phase III	10A	Federal Construction Site	80.0	94.5	87.4	81.6	93.9	87.1
6-Sep	Phase III	3	Kennedy Center	82.9	91.5	84.3	81.4	91.5	83.2
4-Sep	Phase III	7	Arlington Cemetery	82.2	94.0	87.8	80.9	93.9	86.8
16-Sep	Phase III	7	Arlington Cemetery (Rain)						
27-Sep	Phase III	13A	West Potomac	82.5	95.6	85.5	84.5	92.8	85.9
5-Sep	Phase III	R7	400 North Capital	80.4	97.3	87.9	80.2	97.1	87.7
	All Data		Average	80.84	92.02	88.72	80.14	91.67	88.49
			Standard Deviation	2.7	4.4	4.4	3.3	4.1	4.6
			Max	87.4	98.6	98.0	87.3	98.0	98.0
			Min	74.7	74.8	78.1	72.2	78.6	78.2
			Range	12.7	23.8	19.9	15.1	19.4	19.8

Table III-6. Analysis of Delta Change with Northpoint Transmitter On

				Power Delta			Pointer Delta		
Date	Phase	Test No.	Site Name	DTV	ES61.5	ES119	DTV	ES61.5	ES119
13-Aug	Phase I	11A	London House Rooftop		0.4	0.2		2.1	0.0
4-Aug	Phase I	1	River Place Apts.	0.1	-0.5	0.2	-2.7	-0.6	-1.3
14-Aug	Phase I	1	River Place Apts.	-0.1	0.0	-0.7	-5.1	-1.1	-1.6
18-Aug	Phase I	1	River Place Apts.			0.3			-1.1
4-Aug	Phase I	1A	Roosevelt Island	-0.1	-0.9	-0.5	-1.9	-4.4	0.4
17-Aug	Phase I	1A	Roosevelt Island	0.5		0.2	-2.5		-0.7
13-Aug	Phase I	12A	Normandy House Rooftop	1.5	0.4	0.4	-1.2	0.4	0.3
12-Aug	Phase I	10A	Federal Construction Site	0.0	0.0	1.2	2.4	-0.2	0.3
16-Aug	Phase I	10A	Federal Construction Site	0.3	-0.6	0.0	0.8	-2.6	0.4
10-Aug	Phase I	3A	Nash & 14th Street		0.0			0.6	
11-Aug	Phase I	7A	Rt. 110 & Marshall (median)	-0.2	0.2	-0.3	-5.0	0.0	0.8
11-Aug	Phase I	6A	Rt. 110 & Marshall (shoulder)	-0.2	-0.3		-4.6	-1.1	
6-Aug	Phase I	3	Kennedy Center	0.4	-0.2	-0.3	-0.6	-0.5	-0.9
14-Aug	Phase I	3	Kennedy Center	0.0	-0.2	0.5	-1.6	-0.7	-0.6
17-Aug	Phase I	3	Kennedy Center	0.5	0.1	0.7	-1.7	-0.3	-1.7
18-Aug	Phase I	3	Kennedy Center	0.1	0.0	0.2	0.1	0.9	0.0
9-Aug	Phase I	5	Thompson Boat Center	0.5	-0.8		-0.1	0.3	
4-Aug	Phase I	7	Arlington Cemetery	-0.1	-0.5	-0.3	-5.6	0.1	1.4
12-Aug	Phase I	7	Arlington Cemetery	0.2	0.6	-0.3	-2.2	-0.7	0.1
18-Aug	Phase I	7	Arlington Cemetery			0.2			-1.1
23-Aug	Phase I	7	Arlington Cemetery	-0.3	-0.5	0.2	0.1	0.3	-0.5
10-Aug	Phase I	5A	S. Joyce & Army-Navy #2	-0.2	-0.7	-0.4	0.8	3.8	1.8
5-Aug	Phase I	2A	Arlington Ridge Road	0.5		-0.8	1.8		-0.7
10-Aug	Phase I	4A	S. Joyce & Army-Navy	-0.5	-0.7	-0.1	0.5	0.3	0.0
16-Aug	Phase I	19	Anacostia Park	0.0	-0.1	-0.7	1.1	0.3	-0.8
9-Aug	Phase I	20	St. Elizabeth Hospital	0.5	-0.3	0.0	0.1	-0.5	0.0
10-Aug	Phase I	23	National Arboretum	-0.1	0.7	0.2	2.7	0.6	0.4
5-Aug	Phase I	22	Our Lady of Perpetual Help	1.3	0.2	0.4	0.3	0.2	2.9
11-Aug	Phase I	8A	Fort Greble	0.0	-0.2	0.3	0.3	0.4	0.0
11-Aug	Phase I	8A-A	Fort Greble	0.4	-0.5	-0.5	-1.8	-2.0	-0.4
11-Aug	Phase I	9A	Value Inn	-0.5	0.0	0.1	3.3	0.5	0.2
27-Aug	Phase II	7	Arlington Cemetery	0.8	0.5	-0.5	0.5	0.0	-2.0
2-Sep	Phase III	R2	Goodyear	0.37	0.1	0.1	-0.2	0.4	-0.9
3-Sep	Phase III	R4	Banniker Dr.	-0.9	-0.4	1.7	-1.8	-1.4	-0.1
3-Sep	Phase III	R5	Wash. Overlook						
3-Sep	Phase III	R6	Ft. Lincoln Dr	0.5	0.0	0.0	-1.2	-2.3	-0.2
3-Sep	Phase III	R3	Post Office						
2-Sep	Phase III	R1	7/11 Bladensburg	-0.2	0.2	1.2	-1.3	-2.0	-0.7
6-Sep	Phase III	10A	Federal Construction Site	0.3	1.0	0.5	1.6	-0.6	-0.3
6-Sep	Phase III	3	Kennedy Center	-0.5	0.0	0.4	-1.5	0.0	-1.1
4-Sep	Phase III	7	Arlington Cemetery	0.4	-0.3	-0.2	-1.3	-0.1	-1.0
16-Sep	Phase III	7	Arlington Cemetery (Rain)						
27-Sep	Phase III	13A	West Potomac	0.33	-0.16	-0.34	2.0	-2.8	0.4
5-Sep	Phase III	R7	400 North Capital	0.5	1.8	0.4	-0.2	-0.2	-0.2
	All Data		Average	0.16	-0.05	0.10	-0.69	-0.35	-0.22

Table III-7. Average SSP Values within Various Distances from Transmitter, DIRECTV

Northpoint Transmitter	Distance of Data	Number Samples	Sample Mean	Sample St. Dev.	Standard Error
OFF	Half-Mile	14	81.08	3.23	0.86
ON	Half-Mile	14	79.46	3.83	1.00
OFF	First Mile	25	81.24	2.66	0.53
ON	First Mile	25	79.78	3.46	0.69
OFF	Beyond First Mile	12	79.98	2.68	0.77
ON	Beyond First Mile	12	80.89	2.93	0.85
OFF	All Data	37	80.84	2.7	0.44
ON	All Data	37	80.14	3.3	0.54

Table III-8. Average SSP Values within Various Distances from Transmitter, Echostar 61.5

Northpoint Transmitter	Distance of Data	Number Samples	Sample Mean	Sample St. Dev.	Standard Error
OFF	Half-Mile	15	93.15	3.81	0.98
ON	Half-Mile	15	92.3	4.31	1.10
OFF	First Mile	26	92.87	3.13	0.61
ON	First Mile	26	92.35	3.47	0.68
OFF	Beyond First Mile	11	90	5.96	1.80
ON	Beyond First Mile	11	90.05	4.9	1.50
OFF	All Data	37	92.02	4.29	0.71
ON	All Data	37	91.67	4.02	0.66

Table III-9. Average SSP Values within Various Distances from Transmitter, Echostar 61.5

Northpoint Transmitter	Distance of Data	Number Samples	Sample Mean	Sample St. Dev.	Standard Error
OFF	Half-Mile	15	89.07	2.9	0.75
ON	Half-Mile	15	88.75	3.3	0.85
OFF	First Mile	26	88.36	3.94	0.77
ON	First Mile	26	87.9	4.03	0.79
OFF	Beyond First Mile	12	89.48	5.19	1.50
ON	Beyond First Mile	12	89.78	5.59	1.60
OFF	All Data	38	88.72	4.33	0.70
ON	All Data	38	88.49	4.59	0.74

Table III-10. Short-Term Standard Deviation Data

DIRECTV (Northpoint Off)
81, 82, 79, 82, 81, 81, 83, 76, 82, 84, 81, 81, 80, 83, 78, 81, 78, 81, 79, 85, 79, 84, 77, 81, 76, 82, 80, 80, 81, 84, 80, 79, 80, 80, 82, 81, 79, 81, 77, 81, 82, 84, 80, 80, 83, 82, 83, 83, 80, 80, 80, 79, 78, 79, 84, 82, 80, 83, 83, 80, 80, 81, 80, 80, 81, 79, 81, 82, 80, 82, 81, 76, 78, 78, 83, 82, 85, 78, 82, 82, 79, 78, 81, 80, 78, 78, 82, 78, 82, 81, 82, 84, 85, 78, 83, 82, 84, 85, 78, 79, 84, 83, 80, 80, 84, 83, 81, 79, 80, 81, 82, 78, 80, 80, 84, 80, 77, 83, 82, 83, 79, 82, 82, 78, 81, 82, 80, 82, 79, 81, 79, 74, 81, 85, 78, 79, 80, 79, 79, 82, 81, 79, 83, 81, 81, 84, 79, 83, 82, 80, 82, 81, 81, 80, 82, 81, 81, 80, 80, 79, 79, 81, 81, 82, 87, 80, 81, 79, 80, 79, 81, 81, 79, 82, 82, 81, 80, 84, 81, 83, 79, 79, 79, 84, 78, 81, 84, 76, 80, 82, 81, 81, 79, 85, 81, 80, 80, 82, 80, 81.
Average 80.78
Std. Deviation 2.05

Echostar 61.5 (Northpoint Off)
95, 96, 96, 95, 96, 96, 97, 96, 96, 97, 95, 95, 96, 96, 95, 96, 96, 97, 96, 95, 95, 96, 97, 96, 96, 96, 96, 95, 95, 95, 96, 96, 95, 96, 95, 96, 97, 96, 96, 96, 96, 96, 96, 96, 97, 95, 95, 96, 96, 96, 95, 95, 95, 95, 95, 95, 96, 97, 96, 97, 96, 95, 96, 96, 95, 96, 95, 96, 95, 96, 95, 95, 95, 96, 96, 96, 95, 95, 96, 96, 95, 95, 95, 95, 95, 95, 96, 95, 96, 96, 95, 95, 96, 97, 96, 96, 96, 96, 95, 95, 95, 95, 95, 95, 95, 95, 96, 95, 96, 95, 95, 96, 95, 96, 95, 96, 95, 95, 96, 96, 95, 96, 96, 95, 95, 95, 95, 96, 95, 96, 95, 95, 95, 95, 95, 96, 95, 96, 96, 95, 96, 96, 95, 95, 95, 95, 95, 95, 95, 97, 95, 95, 95, 95, 96, 96, 95, 95, 96, 96, 96, 95, 95, 96, 95, 96, 96, 96, 95, 96, 95, 95, 96, 95, 96, 97, 95, 96, 96, 97, 96, 96, 97, 96, 95, 95, 96, 96, 95, 96, 96, 95, 97, 95, 95, 96, 95, 95, 96, 96,
Average 95.56
Std. Deviation 0.62

Echostar119 (Northpoint Off)
95, 95, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 95, 95, 95, 94, 95, 94, 95, 95, 95, 95, 95, 96, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 93, 95, 95, 95, 94, 95, 95, 95, 96, 95, 95, 95, 95, 95, 95, 94, 95, 95, 95, 96, 95, 96, 95, 95, 95, 95, 95, 95, 95, 96, 94, 95, 95, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 95, 95, 94, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 96, 95, 95, 96, 95, 94, 94, 95, 95, 95, 95, 95, 94, 95, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 96, 95, 95, 95, 94, 95, 95, 94, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 95, 94, 95, 95, 95, 94, 94, 95, 95.
Average 94.91
Std. Deviation 0.42

Appendix III

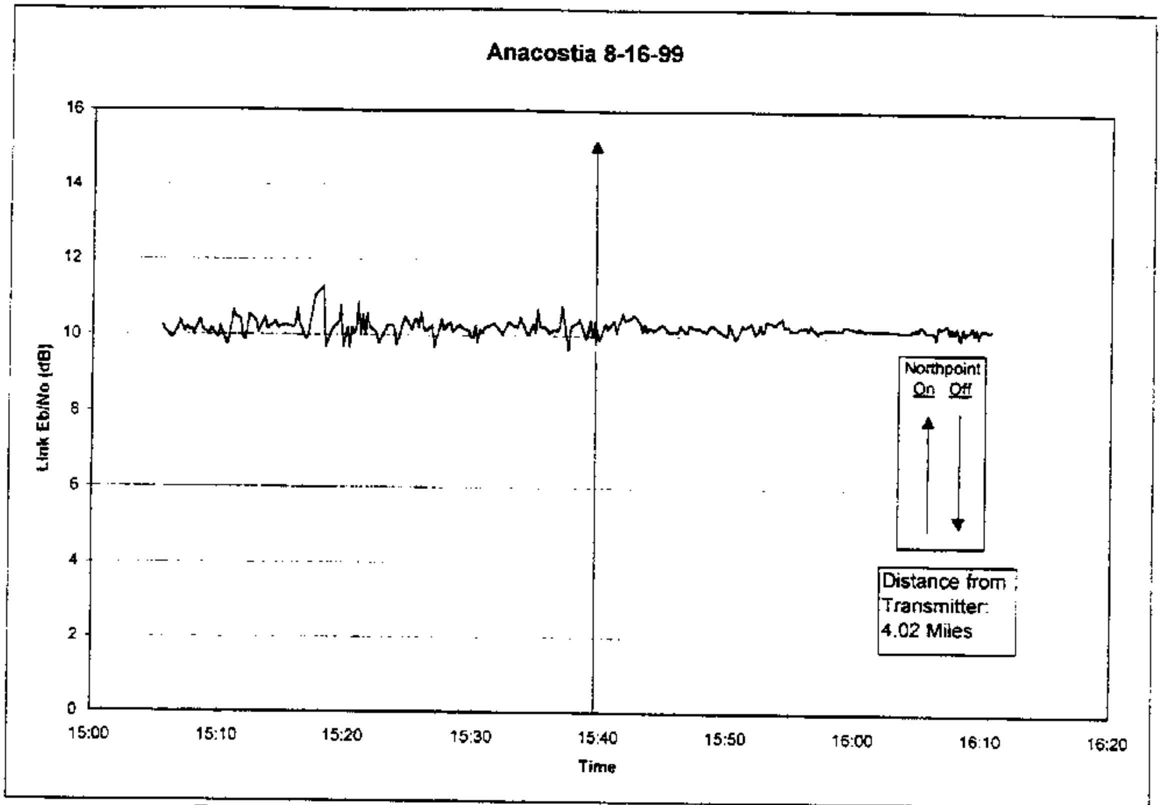


Figure III-1. Link Eb/No, Echostar at 119 W. Longitude, Anacostia

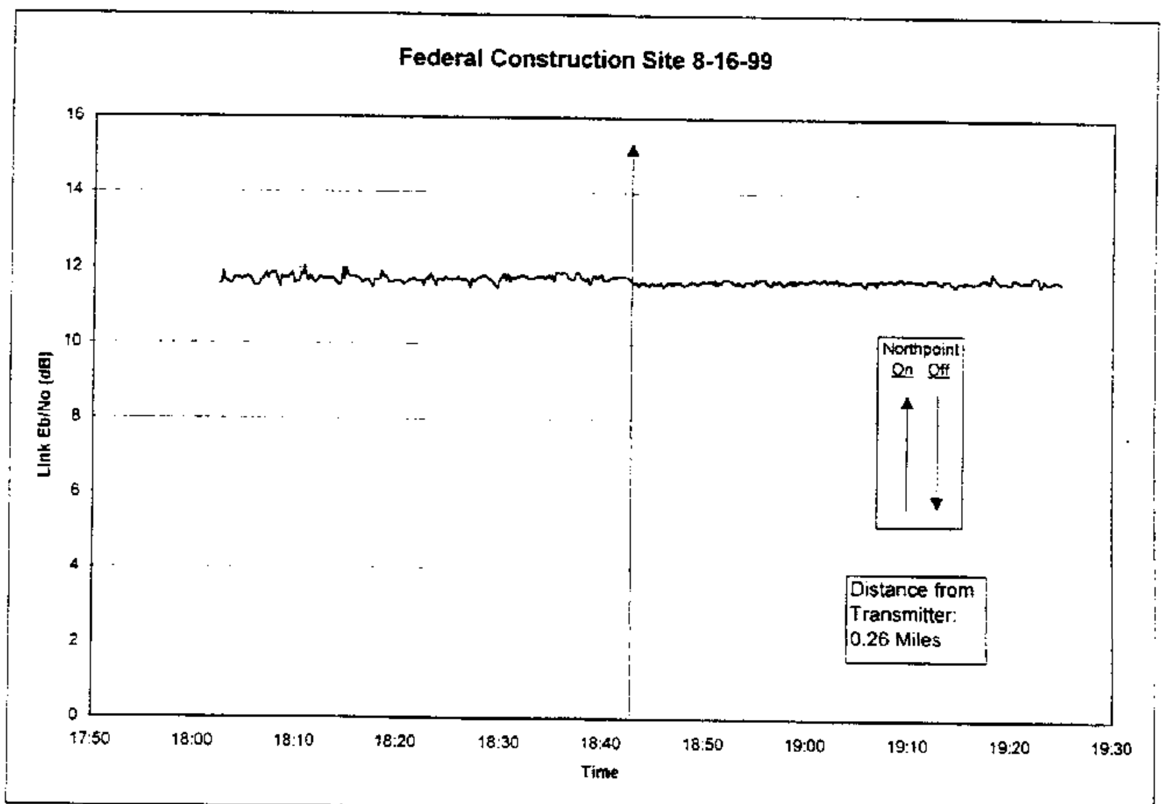


Figure III-2. Link Eb/No, Echostar at 119 W. Longitude, Federal Construction Site in Arlington

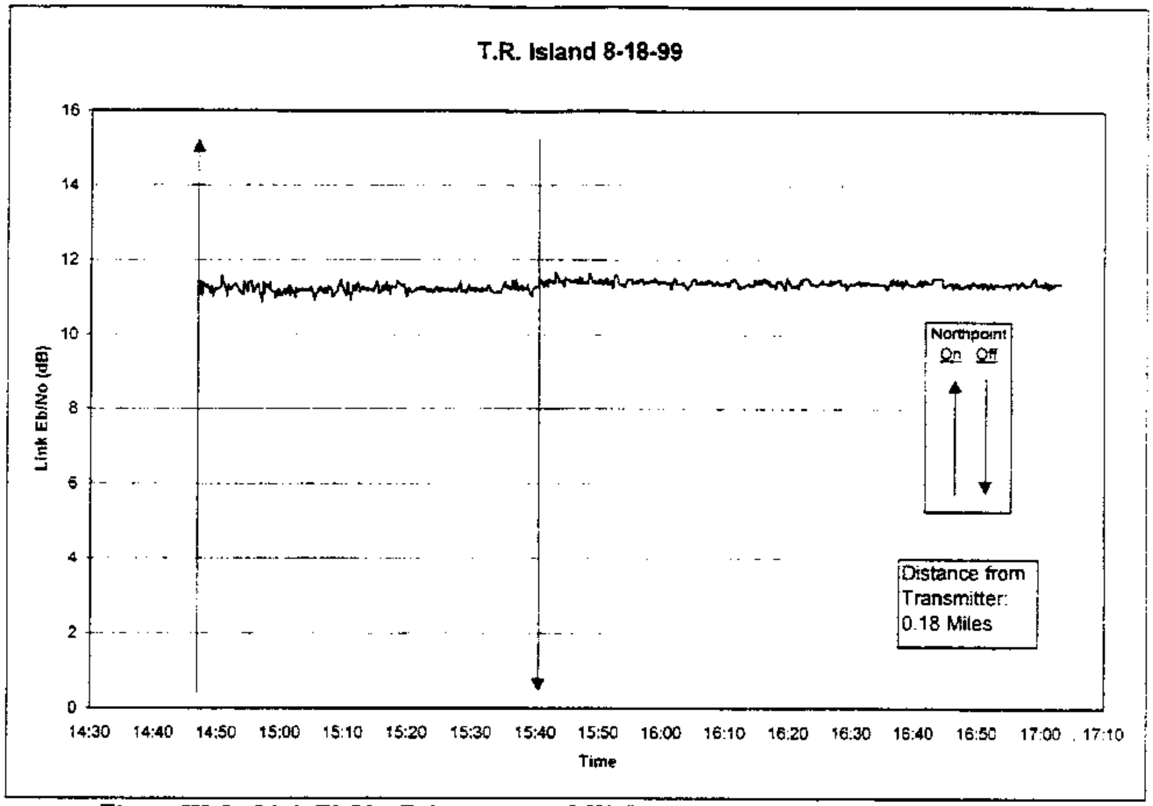


Figure III-3. Link Eb/No, Echostar at 119 W. Longitude, Theodore Roosevelt Island

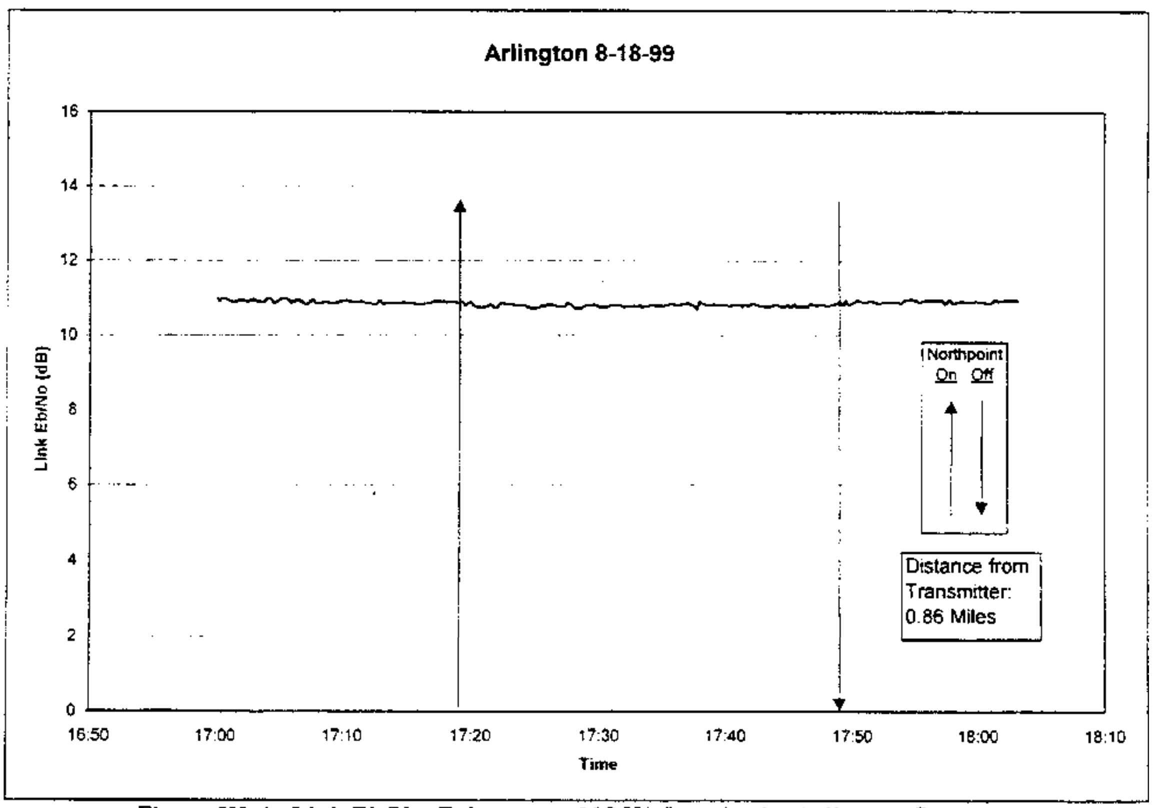


Figure III-4. Link Eb/No, Echostar at 119 W. Longitude, Arlington Cemetery

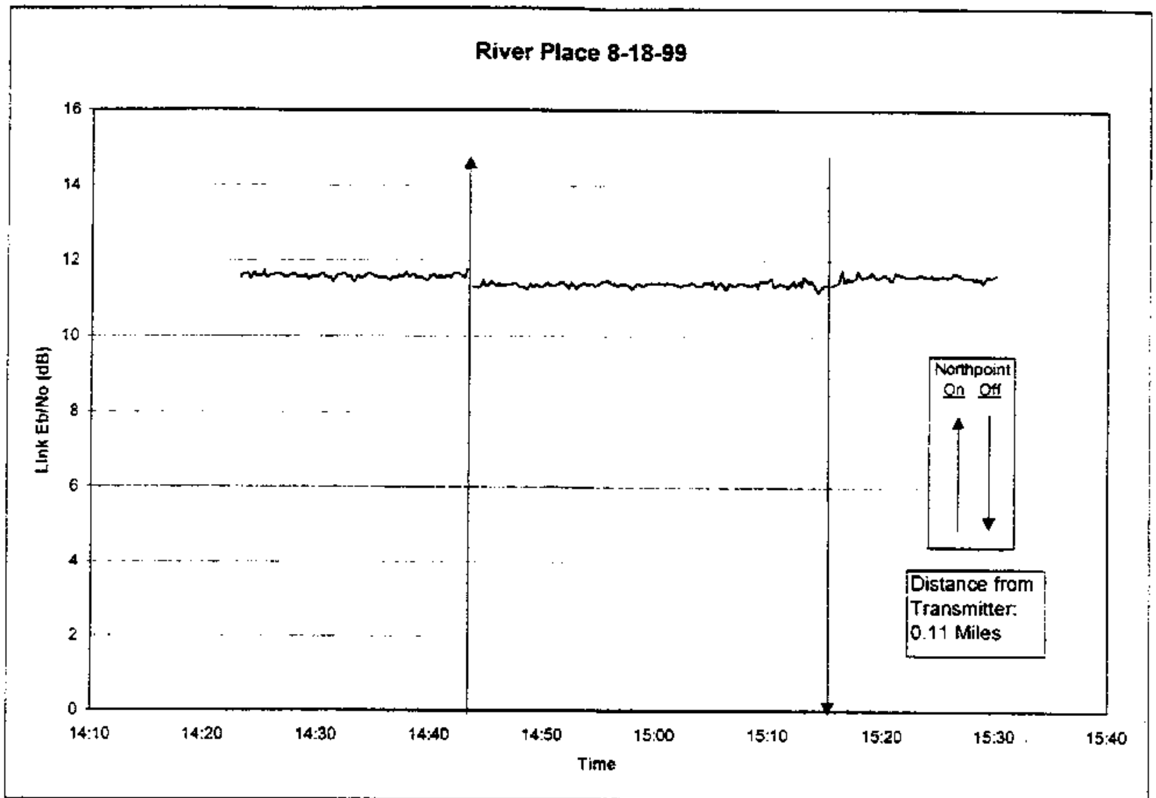


Figure III-5. Link Eb/No, Echostar at 119 W. Longitude, River Place

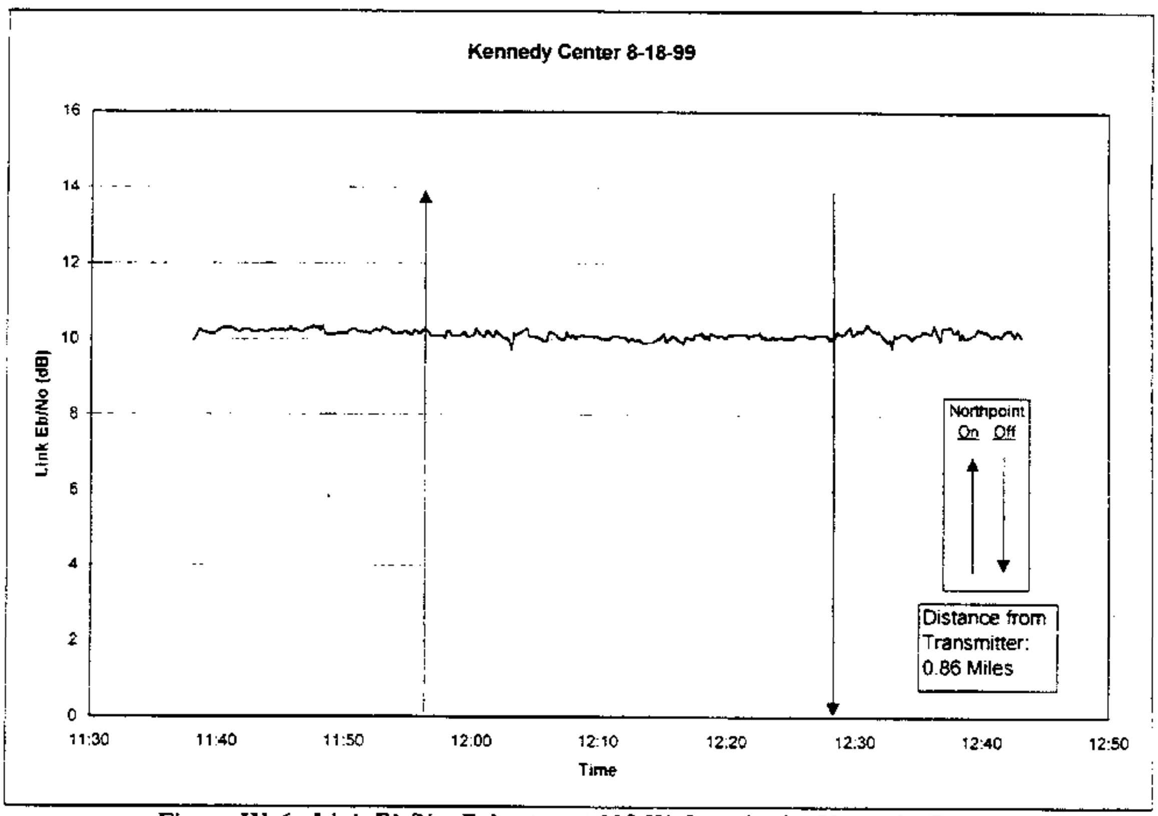


Figure III-6. Link Eb/No, Echostar at 119 W. Longitude, Kennedy Center

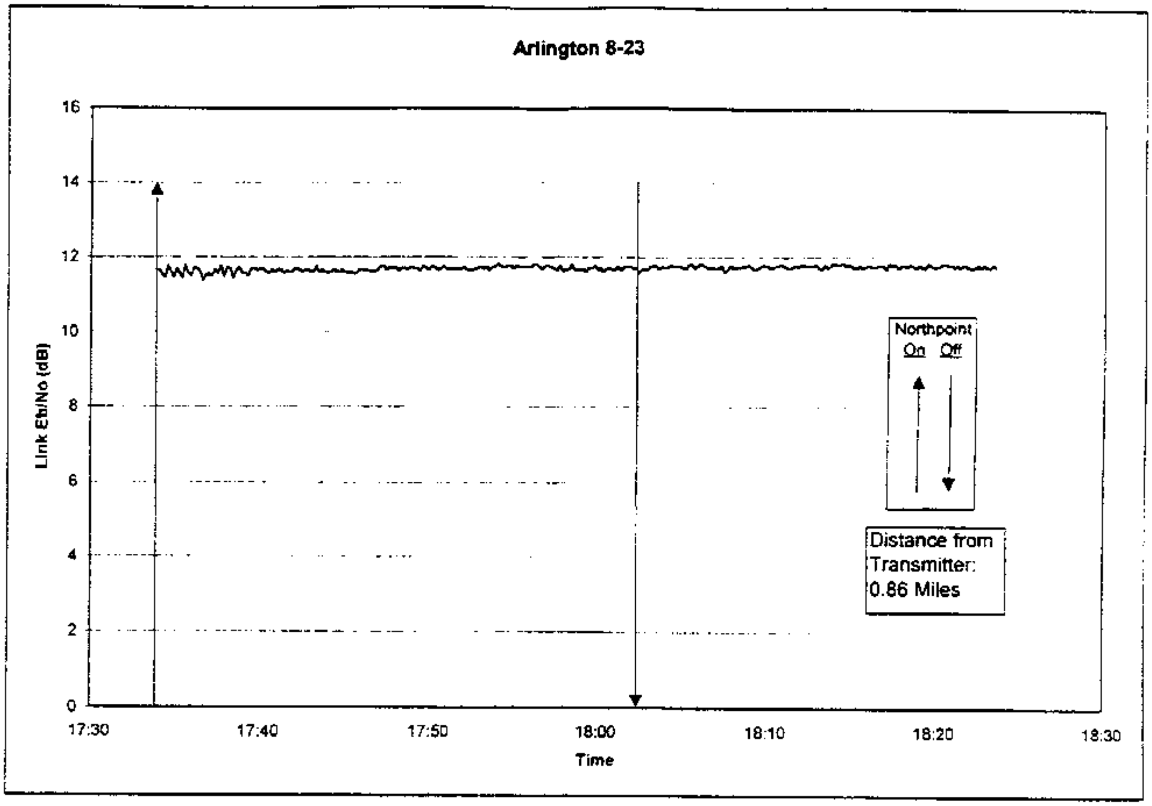


Figure III-7 Link Eb/No, Echostar at 119 W. Longitude, Arlington

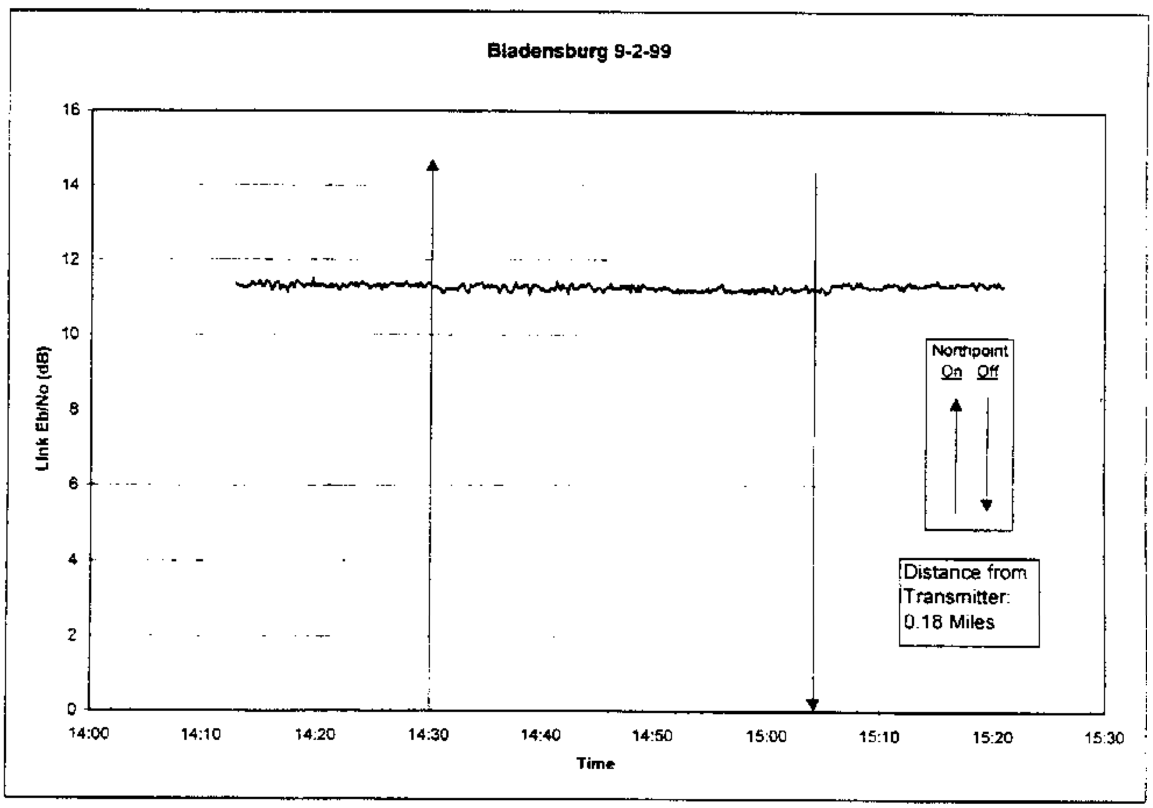


Figure III-8. Link Eb/No, Echostar at 119 W. Longitude, Bladensburg

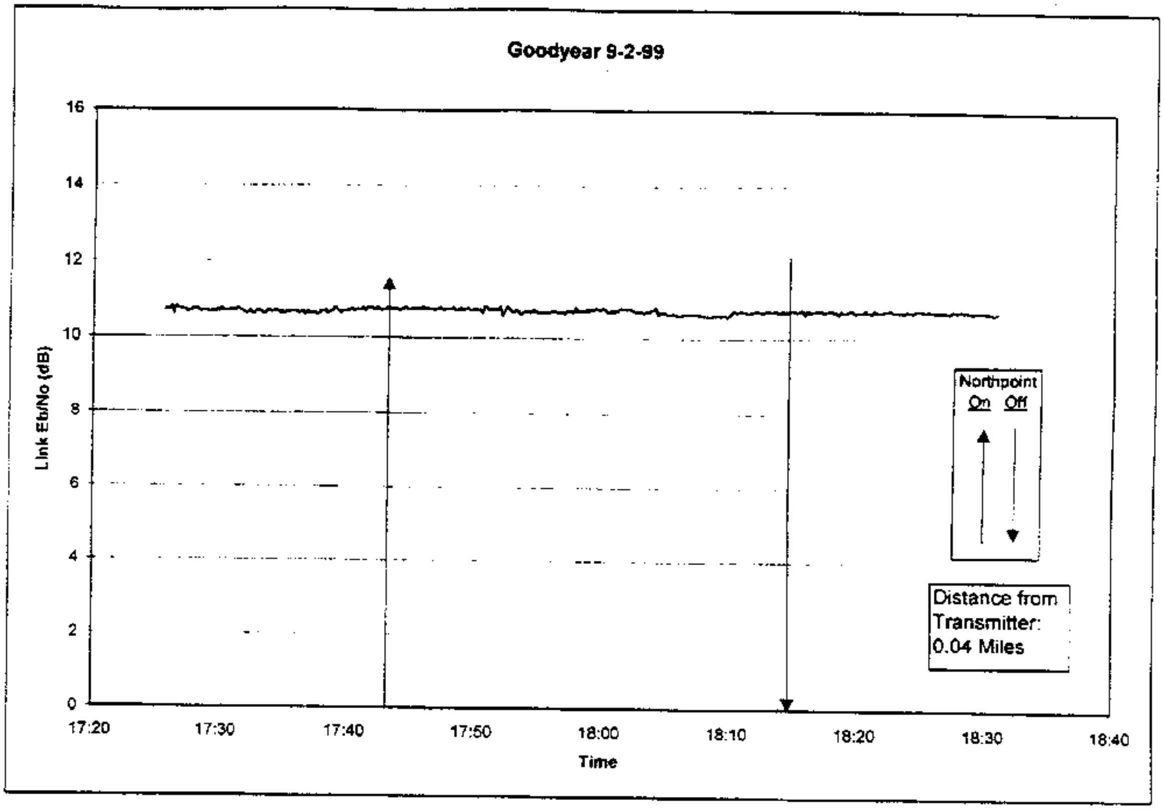


Figure III-9. Link Eb/No, Echostar at 119 W. Longitude, Goodyear

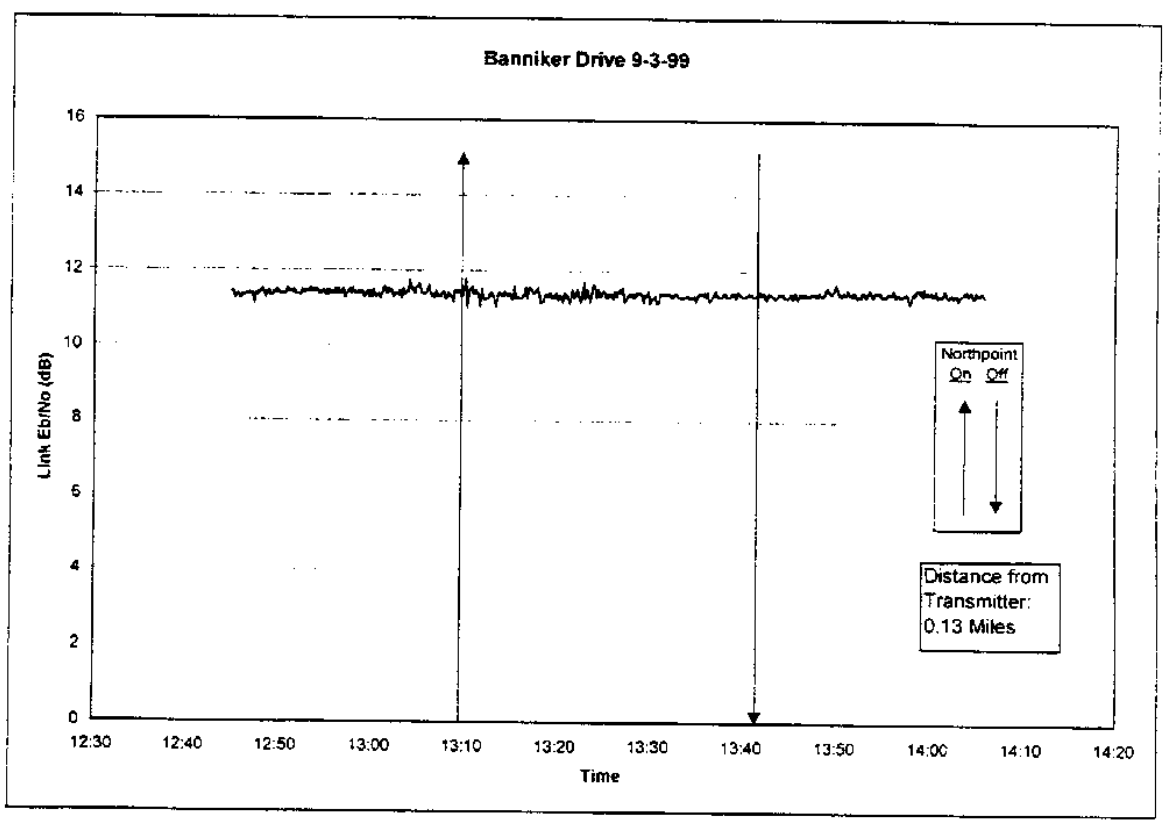


Figure III-10 Link Eb/No, Echostar at 119 W. Longitude, Banniker

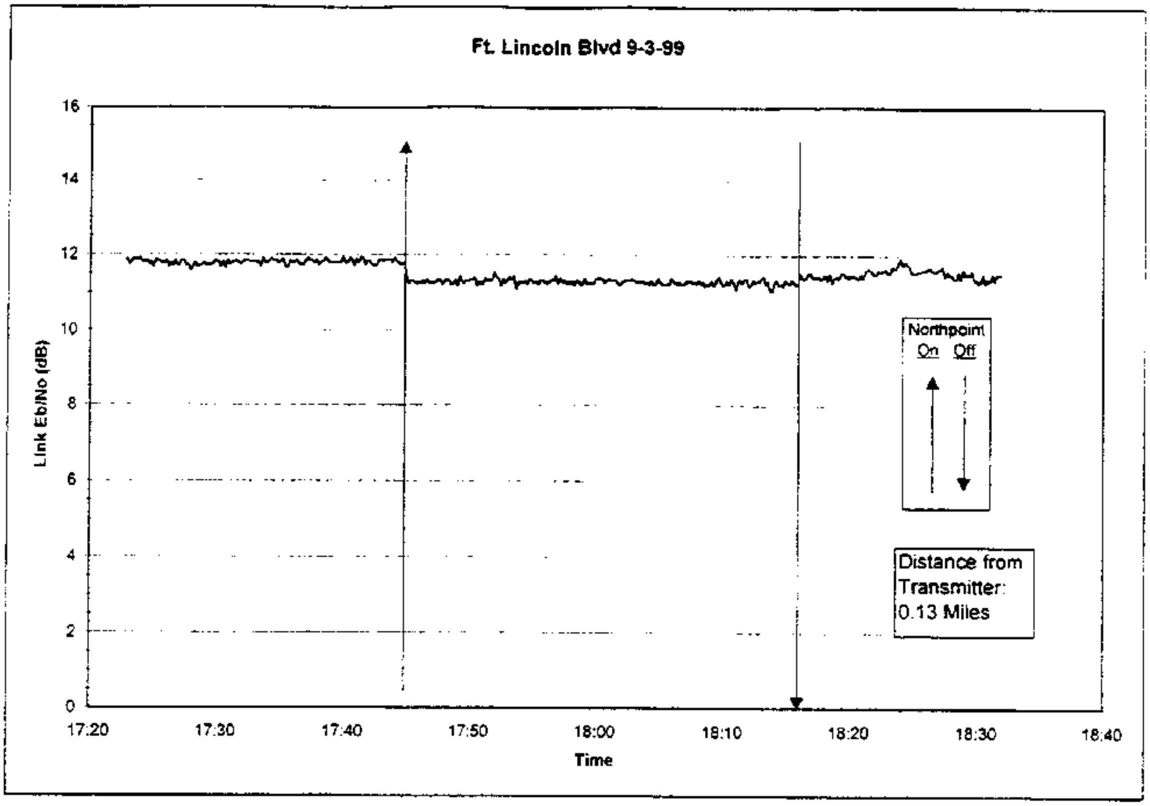


Figure III-11. Link Eb/No, Echostar at 119 W. Longitude, Ft. Lincoln Blvd

BPB BENNETT, PETTS & BLUMENTHAL

TO: Broadwave, USA
FROM: Bennett, Petts & Blumenthal
RE: Methodology and Major Findings
DATE: July 20, 1999

METHODOLOGY

The following results are a report of a national telephone survey of 400 DBS satellite dish owners. The survey was conducted from July 17 - 19, 1999 by trained, professional interviewers following procedures established by Bennett, Petts & Blumenthal. The sample for this survey was drawn from a nationwide list of identified DBS satellite dish owners. The list was obtained from the national list vendor, Donnelly Marketing, of Ames, Iowa. Respondents were randomly selected from a total list universe of 157,220 satellite dish-owning households.

All polls are subject to errors caused by interviewing a sample of persons, rather than the entire population. In 95 cases out of 100, the responses to this survey should fall within plus or minus 4.4 percentage points of those that would have been obtained from interviewing the entire universe of DBS dish owners included in the total list universe.

MAJOR FINDINGS

Fully 86% of DBS satellite dish owners report there is something, either directly behind their dish or within 100 feet of the back of their dish, which shelters or shields their dish. We asked respondents a series of questions to determine the precise location and extent of shielding surrounding their dish.

1. Initially, 55% report there is something directly behind their satellite dish, such as part of a roof, a chimney, part of a house or building, a tree or another building, or something else.

2. When probed further, an additional 24% report there is something behind their dish, within one hundred feet, such as large trees, a tall building or some other large structure.

3. Finally, an additional 7% report that if they were to rotate their dish to face the opposite direction, keeping the angle the same, the path to the dish would be blocked by something such as a roof, chimney, part of a building, trees, or something else.

1010 WISCONSIN AVENUE NW SUITE 208 WASHINGTON DC 20007 PHONE: 202-342-0700 FAX: 202-342-0330 E-MAIL: BPBPOLLS@AOL.COM

Appendix V

Technical Annex
to
Comments of Northpoint Technology

Bob Combs & Associates
Telecommunications Consulting
March 2, 1999

OUTLINE

INTRODUCTION

In this report, compatibility between Northpoint technology and a variety of satellite systems is examined. In section 1, the technical and operational characteristics of the Northpoint system are identified. With the exception of the discussion on availability, all of the information is taken from sources readily available and in the Public Record. In section 2, it is shown that Northpoint is fully compatible with DBS, and will not cause harmful interference into DBS systems. In section 3, interference from NGSO FSS systems is examined using both static and dynamic methods, and found to be significant from three systems (Hughes Net, Hughes Link and SkyBridge). An analysis of interference from Northpoint into NGSO FSS systems is performed in section 4, where it is shown that NGSO FSS systems are compatible with Northpoint, given that coordination is required.

1 OVERVIEW OF NORTHPOINT TECHNOLOGY SYSTEM[1]

The Northpoint Technology is an advanced low-power digital wireless technology to operate in the 12.2 - 12.7 GHz band under allocations to the fixed service (or broadcast service). A broadcast antenna is employed, which would be located on hills, mountains, towers or buildings, and can provide service to a southerly radius of 10-20 kilometers, depending on local conditions. For reception, the typical installation employs a 34 dBi gain antenna (ITU R F.1245). The system is designed to disseminate television, video and entertainment information. It is envisioned (subject to establishing a return link) that the Northpoint Technology could also be used for such high data rate applications such as video conferencing, and Internet connectivity.

1.1 System Characteristics of Northpoint Technology

The transmission parameters are similar to those parameters found in recommendation ITU-R F.755-1, Point-to-Multipoint Systems Used in the Fixed Service. The nominal technical parameters are given in Table 1.

[1] Information about Northpoint system is taken from references 8 and 9.

Table 1. Technical Parameters of the Northpoint Technology[2]

Parameter	Typical Value	Range	Units
Channel bandwidth	24	.001 - 500	MHz
Frequency	12.5	12.2 - 12.7	GHz
Polarization	H	H/V/C	-
Transmit antenna gain	10	9 - 13	dBi
Transmit Power	-25	-30 to 6	dBW
EIRP	-17.5	-21.5 to -7.5	dBW
Transmit height above average terrain	150	30 - 4500	meters
Transmit height above ground level	150	5 - 500	meters
Transmitter tilt above horizontal	3	0 - 5	deg
Required Signal Strength at edge of cell	-156	-155 to -160	dBi (24 MHz)
Cell Size	16	10 - 20	km
Receive antenna gain	34	34 - 38	dBi
Thermal noise floor	-144.1	-144.1	dBW/MHz
Availability objective	99.7	99.7 - 99.995	%

1.1.1 Transmitter Characteristics

The Northpoint Technology employs a transmit antenna with a peak gain of 10 dBi. Transmissions are oriented toward the South, facilitating sharing with geostationary systems. Typical radiation patterns (elevation and azimuth) are given in Figure 1and Figure 2. The typical transmitter tilt is 3 degrees above the horizon, and the typical transmitter height above average terrain (HAAT) is 150 meters.

[2] The parameters in the "Range" column are intended to provide guidance as to the typical range of values used in the majority of installations. The actual values will be determined by local conditions and specific application, (e.g. video, data, etc.). This is not to limit in any way the possibility of other values being used. For example, in cases of transmitters on mountaintops, the transmitter height above the average terrain could be 2000 meters. In this case, the allowable EIRP may be much higher, and the transmitter tilt may be less than zero.

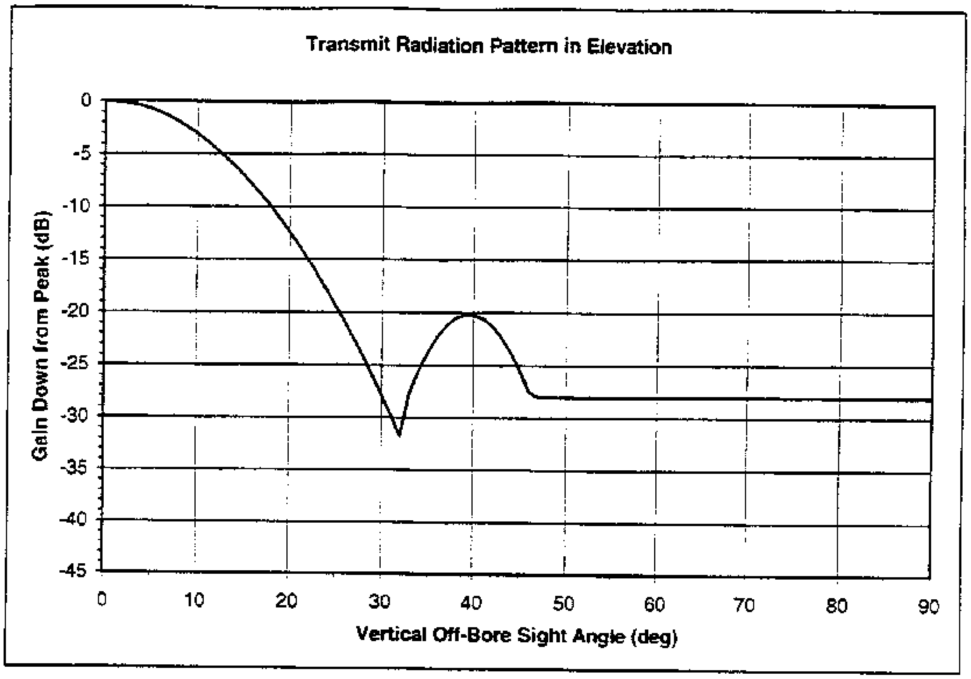


Figure 1. Transmitter Radiation Pattern in Elevation

The equations for computing relative transmit antenna radiation (from Gmax = 10 dBi) in elevation are given in Table 2.

Table 2. Northpoint Transmitter Radiation Pattern in Elevation

Off-Bore Sight Angle	Gain Down from peak (dBi)
$0 \leq \varphi < 32$	$0.031(\varphi)^2$
$32 \leq \varphi < 46.2$	$293.2 + 13.825(\varphi) + 0.175(\varphi)^2$
$46.2 \leq \varphi < 180$	28

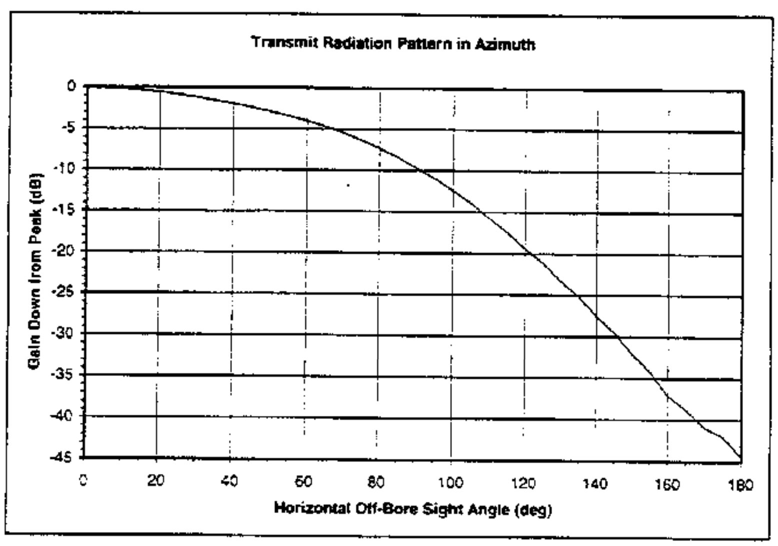


Figure 2. Transmitter Horizontal Radiation Pattern

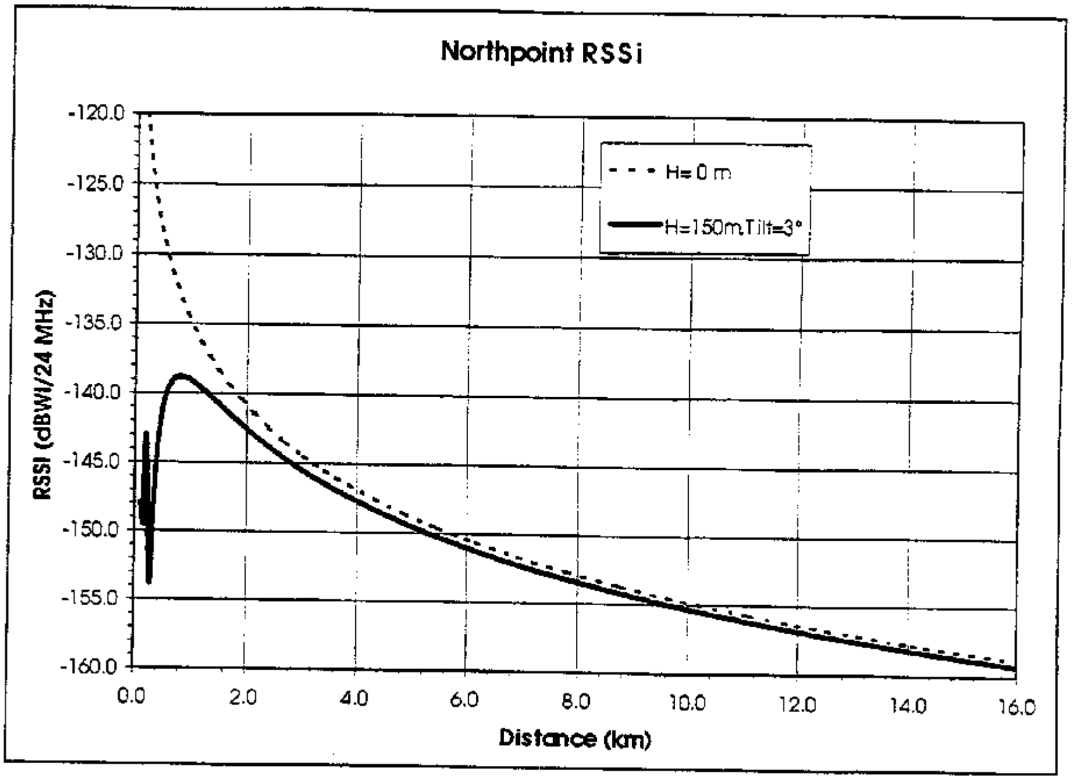


Figure 3. Northpoint Isotropic Signal Level, 24 MHz Bandwidth

Figure 3 depicts the Northpoint isotropic received signal level in a 24 MHz bandwidth, due south of the transmitter, for two cases:

(1) At transmitter height = 0 meters, no tilt

(2) At transmitter height = 150 meters, 3 degrees of beam tilt.

As can be clearly seen, the isotropic signal level peak value is about -139 dBWi/24 MHz, (or -152 dBWi/MHz).[3] The Northpoint Technology interference mitigation techniques reduce the power density levels near the transmitter significantly and are more fully explained in section 1.1.2.

1.1.2 Interference Mitigation from Northpoint Technology.

Northpoint Technology employs a variety of interference mitigation techniques to minimize interference and enhance the sharing environment.

Directional Transmission — Generally southward to minimize interference into satellite receivers.

[3] Figures 3 and 4 include 3 dB of isolation between linear and circular polarizations.

Transmit Antenna Discrimination in the Vertical Plane — The Northpoint transmitter antenna pattern allows for 20 - 30 dB of discrimination in the area near the transmitter (See antenna pattern in Figure 1).

Beam Tilting— By tilting the transmitter up from the horizon, signal level is further reduced in the area of the transmitter, as shown in Figure 4.

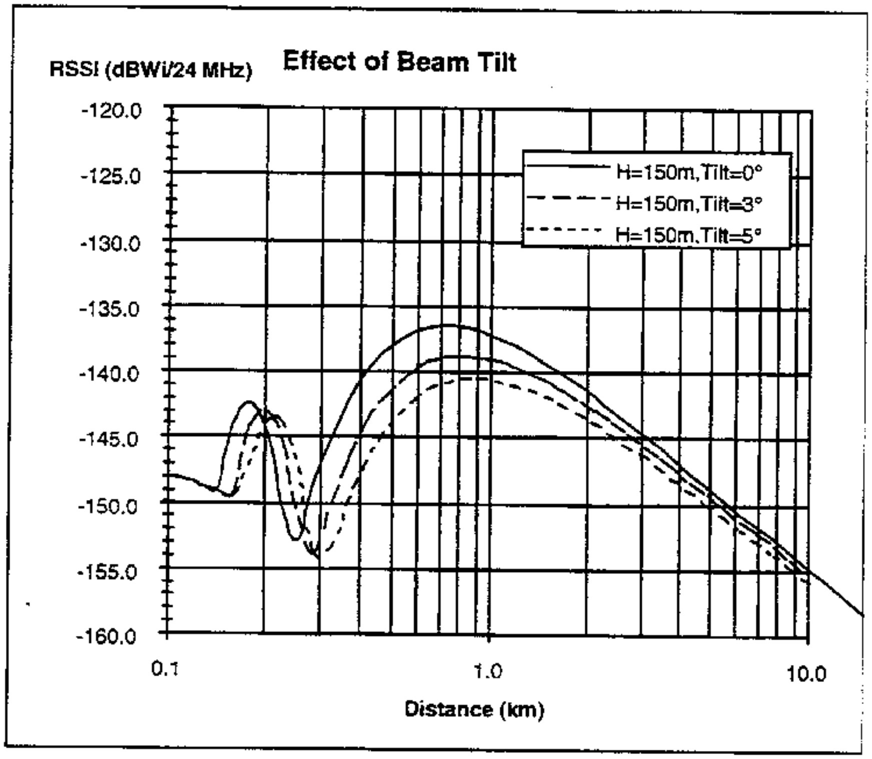


Figure 4. Effect of Beam Tilt on the Received Signal Strength relative to isotropic (RSSi).

Maximum Height Antenna Placement— Increased free space loss at transmitter heights of 50 meters or more (see Figure 5) significantly reduce the signal power in the area of the transmitter, by 15 - 30 dB.

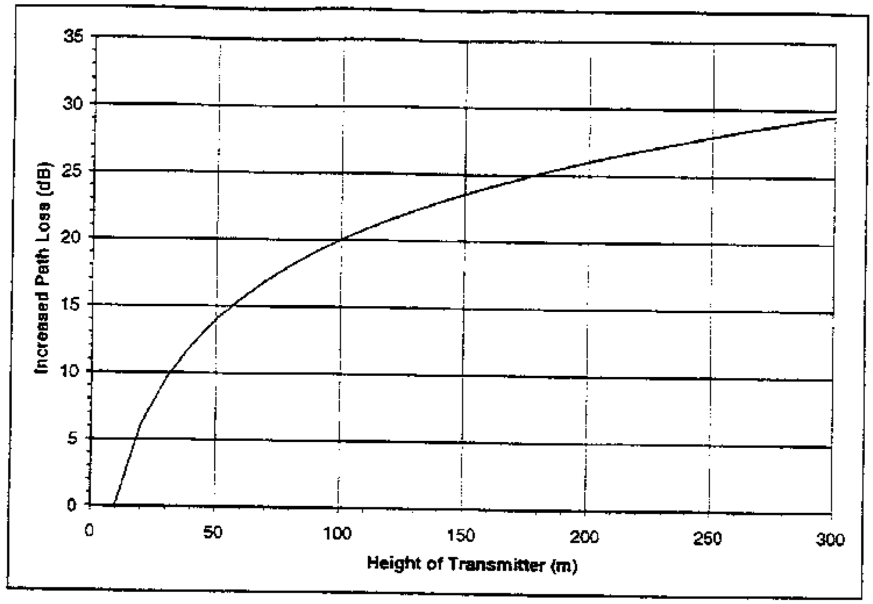


Figure 5. Increased Path Loss over 10 meter Transmitter Height

1.2 Northpoint Link Budget

The baseline Northpoint link budget is given in Table 3 for both clear air and rain, and for the variation on antenna gain.

Table 3 Northpoint Link Budget

Item	Clear Air	Rain, G = 34 dBi	Rain, G = 38 dBi	Units
Channel Bandwidth	24.0	24.0	24.0	MHz
Frequency	12.5	12.5	12.5	GHz
Availability	99.7%	99.7%	99.7%	%
Transmit Power	-25.0	-25.0	-25.0	dBW
Transmit Power	0.0032	0.0032	0.0032	Watts
Line Losses	-2.5	-2.5	-2.5	dB
Transmit Gain	10.0	10.0	10.0	dBi
EIRP	-17.5	-17.5	-17.5	dBW
Path Length	16.0	16.0	16.0	km
Path Loss	-138.4	-138.4	-138.4	dB
Atmospheric Loss	-0.2	-0.2	-0.2	dB
Rain Loss	0.0	-2.6	-6.6	dB
Isotropic RSS	-156.1	-158.7	-162.7	dBW
Receive Antenna Gain	34.0	34.0	38.0	dBi
Pointing Loss	-0.3	-0.3	-0.3	dB
C Received	-122.4	-125.0	-125.0	dBW
System Temp	284.0	284.0	284.0	°K
System Temp	24.5	24.5	24.5	dB-°K
G/T	9.5	9.5	13.5	dB/K
Boltzmann's	-228.6	-228.6	-228.6	dBW/Hz-K
Noise Figure kTB	-130.3	-130.3	-130.3	dB
Theoretical C/N Received	7.9	5.3	5.3	dB
C/N Required	5.0	5.0	5.0	dB
Theoretical	2.9	0.3	0.3	dB
Interference C/I	20	20	20	dB
Interference Degradation	0.3	0.3	0.3	dB
Margin	2.6	0.0	0.0	dB

1.3 System Availability and Service Area

In this section, the contributions to unavailability are examined and the service area is defined for various ITU-R rain regions. The service area is defined by the ability to receive a quality signal at the edge of coverage and at an availability between 99.7 and 99.9% or higher, depending on local rain region and topography.

1.3.1 Atmospheric Effects on Link Availability

Certain atmospheric effects, such as rain attenuation and other types of fading, influence link availability.

Rain Attenuation and Gaseous Absorption — The Northpoint link is designed for robust availability (99.7 - 99.9%), at the edge of coverage, throughout the U.S. In Figure 6 the rain margin, as a function of distance from the Northpoint transmitter, is shown taking into account variations in free-space loss. The Northpoint link budget, with a 34 dBi gain antenna, allows for 2.6 dB of degradation due to rain attenuation. At this level, reliable service can be provided everywhere in the U.S. at 10 -16 km from the transmitter, and more than 16 km in rain regions E, D and B, which comprise about 50% of the U.S.

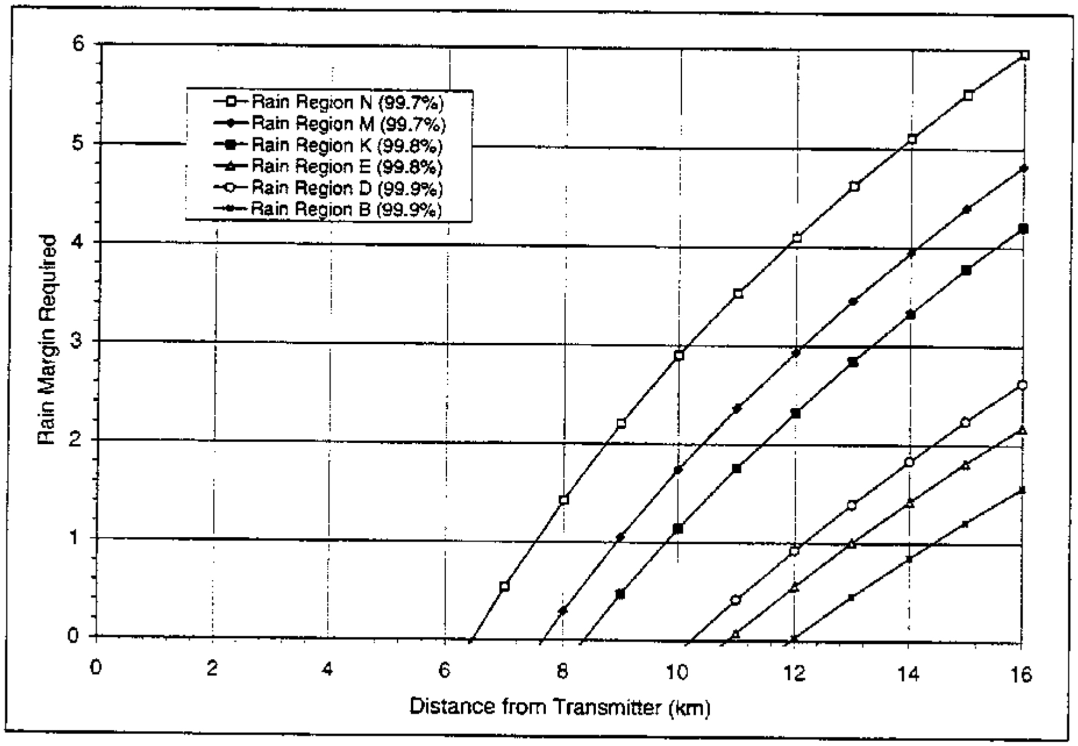


Figure 6. Rain Margin Requirements for all ITU-R rain regions in the U.S.

Moreover, the design of the Northpoint system provides an higher gain of 38 dBi in some circumstances. For those customers at the edge of coverage and in the higher rain attenuation areas, where the cell geometry dictates need for increased gain, a higher gain antenna provides for 4 dB of additional fade margin. With a higher gain receive antenna, cell sizes of 16 km throughout the country are assured. In any case, there is clearly sufficient margin to mitigate rain attenuation for all areas of the U.S.

Fading— Recommendation ITU-R P.530-7 provides a conservative estimate of fading, as described in Equation 1.

$$p_w = K\, d^{3.6} f^{0.89} (1 + |\varepsilon_p|)^{-1.4} \times 10^{-A/10} \quad \% \qquad \text{(Equation 1)}$$

where:

p_w : Percent time of unavailability

$$K = 5.0 \times 10^{-7} \times 10^{-0.1(C_0 - C_{Lat} - C_{Lon})} pL^{1.5} \qquad \text{(Equation 2)}$$

C_o : term to describe the terrain, ranges between 0 and 8 in the U.S.

pL, : The climatic variable (i.e., the percentage of time that the refractivity gradient in the lowest 100 m of the atmosphere is more negative than – 100 N units/km in the estimated average year.[4] For Northpoint in the U.S., p_L N varies between 5 and 15 on a yearly average basis.

f : frequency (GHz)

d : path length (km)

From the antenna heights h_e and h_r (m above sea level or some other reference height), calculate the magnitude of the path inclination $|\varepsilon_p|$ (mrad) from:

$$|\varepsilon_p| = |h_r - h_e| / d.$$

The results are plotted in Figure 7.

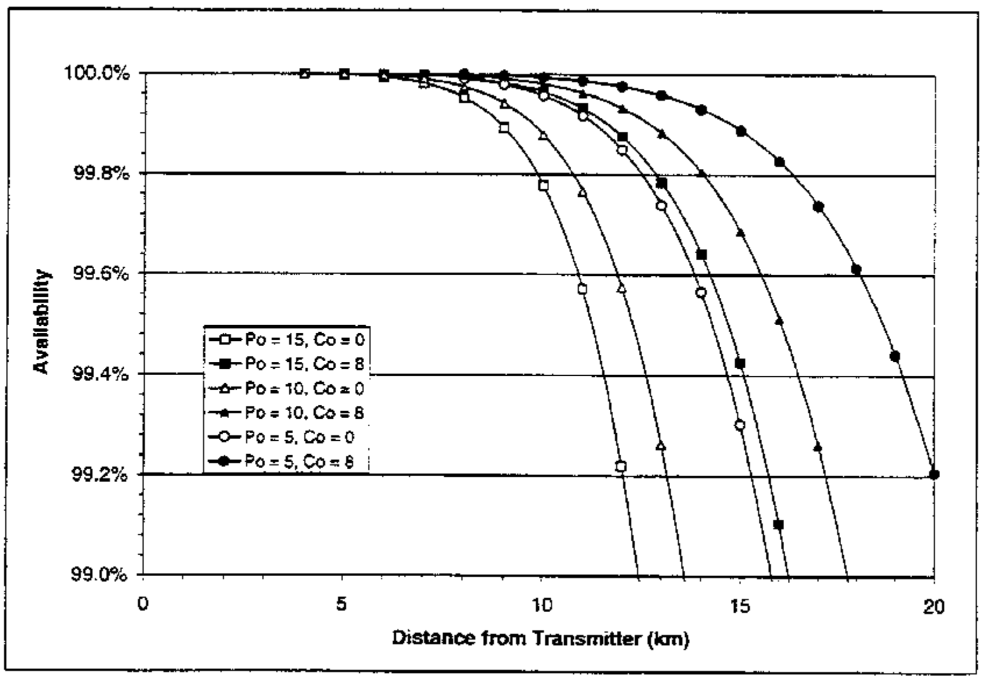


Figure 7. Northpoint Availability in Point-to-Point Fading Conditions

Clearly, Northpoint offers sufficient availability for cell sizes greater than 10 km, and in many parts of the country, for cell sizes of up to 18 km. Again, Northpoint has the option

[4] Point-to-point applications design to worst-month unavailability. However, for this type of service it is more appropriate to design to a yearly average.

of using a 38 dBi gain antenna to provide additional fade margin, should this be necessary. With this option, cell sizes of 16 km throughout the country are assured.

However, note the heavy dependence on the refractivity gradient of equation 1. It is believed that the broadcast nature of Northpoint is sufficiently different from point-to-point systems. All fading estimates are based upon empirical data taken with much higher gain transmit antennas. Northpoint will not be as affected by fading as much as point-to-point systems are, which both transmit and receive with highly focused energy. As such, the estimate provided by Rec. P.530-7 overestimates the required fade margin. However, this can only be proven through the generation of empirical data over time.

Thus, a 2-3 dB margin for atmospherics provides sufficient margin for atmospheric effects at 99.7% availability and greater. In rare cases where additional fade margin is required, a higher gain antenna can be employed.

1.3.2 Availability Reduction due to Interference.

The Northpoint Link Budget allows 0.3 dB degradation due to fixed sources of interference. The rain margin of 2.6 dB can also be used to mitigate time varying sources of interference.

Interference due to GSO BSS and FSS systems— As discussed in reference 6, where an estimate on the amount of interference from GSO systems is made, Northpoint receiver elevation angles at edge of coverage will be below 2 degrees. At this elevation, the off bore-sight discrimination to the GSO arc from a Northpoint receiver will be between 35 and 50 dB, depending on the relative azimuth of the GSO to the antenna boresight. At the edge of the service area, the received isotropic signal levels are equivalent for the GSO systems and for Northpoint, and therefore, the C/I ratio will be at least 35 - 50 dB. Even with as many as ten GSO systems in view, the aggregate C/I would be no greater than 30 dB, and this will be at least 20 dB below the noise level of the Northpoint receiver. Thus, signal degradation due to interference from the GSO will be less than 0.1 dB, even at the edge of coverage. This level of link degradation will cause less than 0.01% reduction in availability.

Interference due to NGSO FSS— The rain and fade margin of 2.6 dB can also be used to mitigate time varying sources of interference. If NGSO FSS systems meet the interference criteria presented in section 3 then the aggregate interference from NGSO FSS systems will contribute to less than 0.01% of the total unavailability.

Interference due to other terrestrial systems— There is a general paucity of terrestrial systems in the band. Interference from other terrestrial sources of interference is assumed to be at C/I of 30 dB or greater, and thus will not cause a reduction in availability of more than 0.01%.

1.3.3 Reduction in availability due to equipment outages.

Transmit equipment technology is mature, and an equipment availability of 99.99% or higher can be expected.

1.3.4 Northpoint System Availability

The previous sections demonstrated that the Northpoint link budget is designed to provide a minimum 99.7% of availability at edge of coverage, which is the same as DBS. However, all customers within the service area will experience higher availability, and the average availability is higher than 99.95%. Northpoint has the option of providing higher gain antennas to edge-of-service customers in certain parts of the country where additional fade margin may be desired.

1.3.5 Northpoint Service Area.

The Northpoint Service area is shown in Figure 8 for Rain Regions B, D and E. For other parts of the country, the maximum distance may be slightly shorter, but in all cases will be at least 10 km.

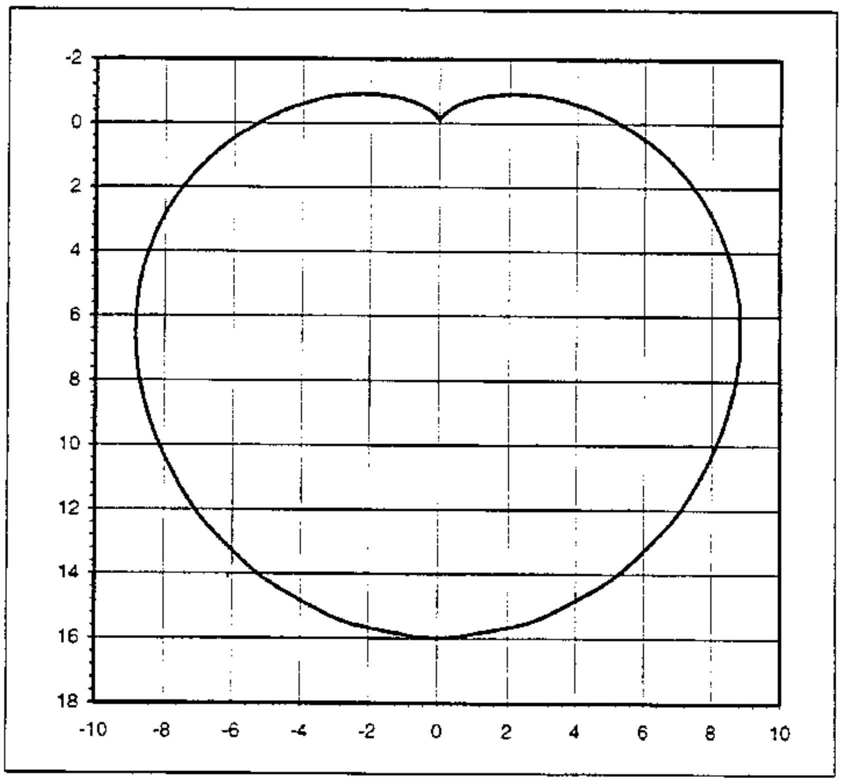


Figure 8. Northpoint Service Area, (ITU Rain Regions B, D and E)

1.4 Possible Implementation of Multiple Northpoint Systems In the Same Band

As shown in the previous section, interference from other terrestrial emissions was assumed to be at C/I values of 30 dB or greater. In Figure 8, it is clear that if there were another broadcast transmitter in the cell, there would be interference. Given the broadcast nature of the system, with a second broadcast transmitter in the cell, there will be geometry where there is line of sight and main-beam on main-beam interference. Moreover, segmentation of the band will not provide sufficient capacity to offer a competitive service. If less than 500 MHz could be used to provide a competitive service, then DBS could use less than 500 MHz as well.

2 NORTHPOINT COMPATIBILITY WITH DBS

In this section it will be demonstrated that a terrestrial interference value of C/I = 8 dB will not cause harmful interference into DBS. Moreover, that in our reference design, Northpoint minimum C/I will be 20 dB in 99.8% of the service area, and 17 dB of isolation in 100% of the service area. A careful examination is made of the typical DBS link budget, throughout the U.S, in a variety of rain regions and latitudes.

2.1 DBS Interference Criteria

The Commission requested comment on protection criteria for DBS. Harmful interference is defined as repeatedly interrupting or seriously degrading service. In order to cause harmful interference, a terrestrial service would need to repeatedly interrupt or seriously degrade the signal. DBS availability is specified as a minimum of 99.7%[5], for an unavailability of 0.3%, or 26.3 hours per year. A serious degradation of the DBS signal would significantly increase the outage level beyond 26.3 hours per year. In *Terrestrial Interference in the DBS Downlink Band*, DirecTV asserts that a 20% increase in unavailability (an increase to 31.5 hours per year) would seriously degrade the signal reception. As demonstrated herein, noise from Northpoint will be significantly below that level that would cause a 20% increase in unavailability.

Based upon a stated availability of 99.7%, a 0.01% decrease in availability equates to an increase of 3.4% in unavailability. Recent documents from the ITU JTG 4-9-11[6] and ITU WP 10-11S[7] identifies that an aggregate 10% increase in unavailability from NGSO FSS systems is acceptable, and has been accepted by the experts in the U.S. DBS industry. If a 10% unavailability allocation to NGSO FSS were acceptable, then a 10% unavailability from terrestrial systems would also be acceptable. This would be below the 20% increase in unavailability deemed acceptable by DTV in the 1994 report on terrestrial interference. However, Northpoint will be below a 10% increase in unavailability.

Further, as demonstrated herein, an increase in unavailability occurs in a mitigation zone that is less than 0.2% of DBS households. It should be taken into account that the vast majority (>99%) of DBS households will have link degradation less than 0.1 dB. If average degradation in the service area would be taken into account, then Northpoint would cause an average decrease availability far less than 0.0001%. Assume that terrestrial systems would cause a 10% increase in unavailability (reduction in availability of 0.03%, or 2.6 hours per year) in 0.2% of the service area. Then, the average DBS customer would have an increase in outage time of (2.6 hours * 0.2%) 18 seconds per year.

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[5] Terrestrial Interference in the DBS Downlink Band, page 5.

[6] Reference 6

[7] Reference 5.

2.1.1 DBS Link Budget, With Rain

In order to understand the potential impact of terrestrial interference on a DBS signal, refer to the link budgets in Table 4. The bullets following the link budget describe the important assumptions therein. All of the assumptions contained in the link budgets were taken from DBS industry publications, FCC applications, and ITU documents.

Table 4. DBS Link Budget, With Rain.

	Austin	Bangor	Chicago	Los Angeles	Miami	Seattle	units
1. EIRP[8]	51.0	50.0	51.0	50.0	54.0	50.0	dBW
2. Downlink Path Loss	-205.6	-206.1	-205.9	-205.8	-205.7	-206.0	dB
3. Elevation Angle	54.6	29.3	39.3	46.3	52.0	31.3	deg
4. DBS Availability[9]	99.80%	99.70%	99.80%	99.90%	99.70%	99.85%	%
5. Atmospheric Loss[10]	-0.08	-0.13	-0.12	-0.09	-0.08	-0.13	dB
6. Rain Loss[11]	-1.8	-1.0	-1.6	-1.1	-3.6	-1.1	dB
7. Rain Temp Increase[12]	-2.5	-1.7	-2.3	-1.8	-3.6	-1.8	dB
8. Pointing Loss[13]	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	dB
9. Ground G/T	13.0	13.0	13.0	13.0	13.0	13.0	dB/K
10. Bandwidth	-73.8	-73.8	-73.8	-73.8	-73.8	-73.8	dB
11. Boltzmann's	228.6	228.6	228.6	228.6	228.6	228.6	dBW/Hz-K
12. Downlink C/N (Thermal)	8.5	8.7	8.6	8.7	8.5	8.4	dB
13. Uplink C/N	24.2	24.2	24.2	24.2	24.2	24.2	dB
14. Crosspol	22.7	22.6	22.5	22.8	22.1	22.6	dB
15. Adjacent Satellite Interference	25.0	25.0	25.0	25.0	25.0	25.0	dB
16. Total C/(N+I)	8.1	8.3	8.2	8.3	8.1	8.1	dB
17. Terrestrial Interference	8.0	8.0	8.0	8.0	8.0	8.0	dB
18. Total C/(N+I)	5.0	5.1	5.1	5.2	5.1	5.0	dB
19. C/N Required	5.0	5.0	5.0	5.0	5.0	5.0	dB
20. Link Degradation from Terrestrial	3.06	3.16	3.10	3.19	3.08	3.04	dB
21. Residual Margin	0.0	0.1	0.1	0.2	0.1	0.0	dB

<u>Lines 1-10</u> - This information is contained in DirecTV authored documents on terrestrial interference, and in other sources.

<u>Line 13. Uplink C/N</u> - In the 1994 report this is given as 25 dB[14]. Recent communication from DirecTV indicates this value is 27.2 dB, [15] but a more conservative value of 24.2 dB is used[16].

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[8] Reference 3 at 8.

[9] Minimum of 99.7%, as given in References 3 and elsewhere.

[10] Will be below 0.15 dB for all elevation angles above 20 degrees, ITU-R model.

[11] Crane Rain Model.

[12] Reference 3 at 5.

[13] Reference 3 at 5. It is noted that in some documents this value is given as 0.5 dB, but in those cases no atmospheric loss is taken.

[14] Reference 2 at 5

[15] Reference 2 at 3.

Line 14- Isolation due to depolarized signal will be at least 22.1 dB down from the carrier. The calculation is given in Table 5, and explained in the bullets following the table.

Table 5. Calculation of minimum depolarization isolation, DBS Satellite at 101 W.

Line	Item	Value	Reference
A	Uplink	30	Appendix S30a
B	Satellite Transmitter Depolarization	30	Appendix S30, Annex 5, figure 10
C	Depolarization due to Rain (Worst Case)	29.7	Appendix S30, Annex 5, Section 2.3
D	Receiver Antenna Depolarization	25	Appendix S30, Annex 5, Figure 8[17]
E	Total	22.1	Power Sum of all Depolarization Sources

- Line A—Assuming rain on only the downlink. The joint probability of rain on both uplink and downlink is sufficiently low and can be ignored.
- Line B—30 dB minimum transmit isolation.
- Line C—Appendix S30, Annex 5, Section 2.3 calculation for rain depolarization. This is the worst-case scenario, as represented in Miami, FLA.
- Line D—The figure of 25 dB for the receiver antenna depolarization given in Appendix S30 clearly applies for interference studies into the 45 cm dish currently in use in the U.S
- Line E—Power sum or all depolarization sources. Worst-case minimum isolation is 22.1 dB. The variation is dependent on depolarization due to rain, which is calculated for each specific site and rain attenuation, according to Appendix S30[18]

Line 15. Interference from adjacent satellites, at least 9 degrees longitude away will be at between 9.5 - 10.5 degrees off boresight. The BSS reference antenna pattern given in JTG 4-9-11/356-E, which is recommended for interference studies of this type, shows a minimum of 30 dB discrimination at 9 degrees off boresight. This value was also stated by DirecTV as 28.7 dB in Reference 2[19]. However, a more conservative value of 25 dB is used in these calculations, to account for satellites spaced every nine degrees, an unreasonably overly-conservative assumption.

Line 19 - C/N required. The required C/N for the lower convolutional coding rate is 5 dB as stated in multiple DTV documents, most recently in Reference 3.[20] There is no degradation in bit error rate at this value. This value has also been verified in testing by Northpoint. Note that for the higher convolutional coding rate of 6/7, DBS operates transmitters at higher power to compensate. These link calculations are done for the

[16] Reference 3 at 36.
[17] Recently Revised at WRC-97, the international standard is the most conservative.
[18] Appendix S30, Section 2.3, Annex 5
[19] Reference 2 at 3.
[20] Reference 3 at 36.

lower convolutional rate, but the terrestrial effect on interference is the same in both cases.

Therefore, all of the information contained in the link budget is accurate, is referenced to the ITU, FCC or to the DBS industry as a source, and in some cases has been verified in testing. Moreover, the most conservative values are used in all cases. Unequivocally, it is highly unlikely for all of the worst-case values to occur at the same time for any DBS user. In any case, even at all the worst-case values, a C/I of 9 dB will not cause harmful interference into DBS.

2.1.2 Maximum Allowable Link Degradation due to Terrestrial Interference.

The DBS link tolerates a carrier to interference level of 8 dB (as shown in Figure 10, and Table 4), in rain, at the stated availability of 99.7% or greater. That is to say, a C/I of 8 dB from terrestrial sources will neither cause an outage, nor seriously degrade the signal of DBS customers, even during rain. Although a C/I of 8 dB will not cause harmful interference, Northpoint Technology will provide a much higher level of protection throughout the service area.

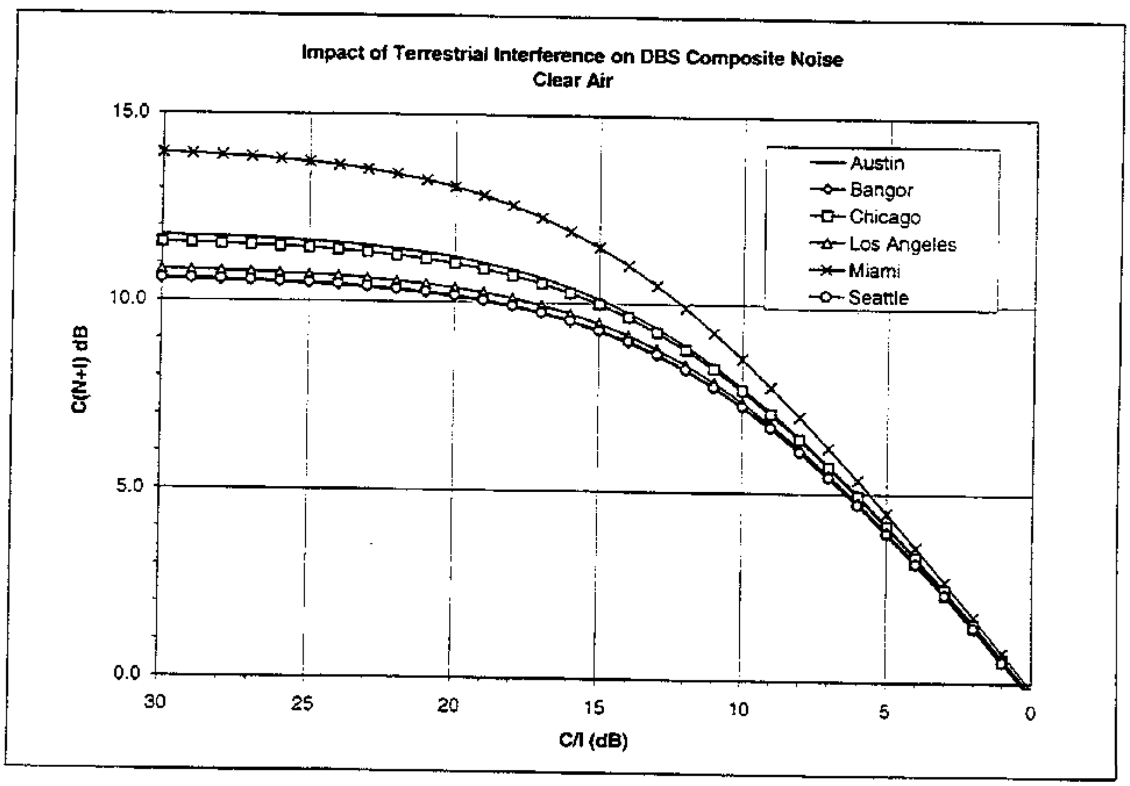

Figure 9. Terrestrial effect on C/(N+I), Clear Air

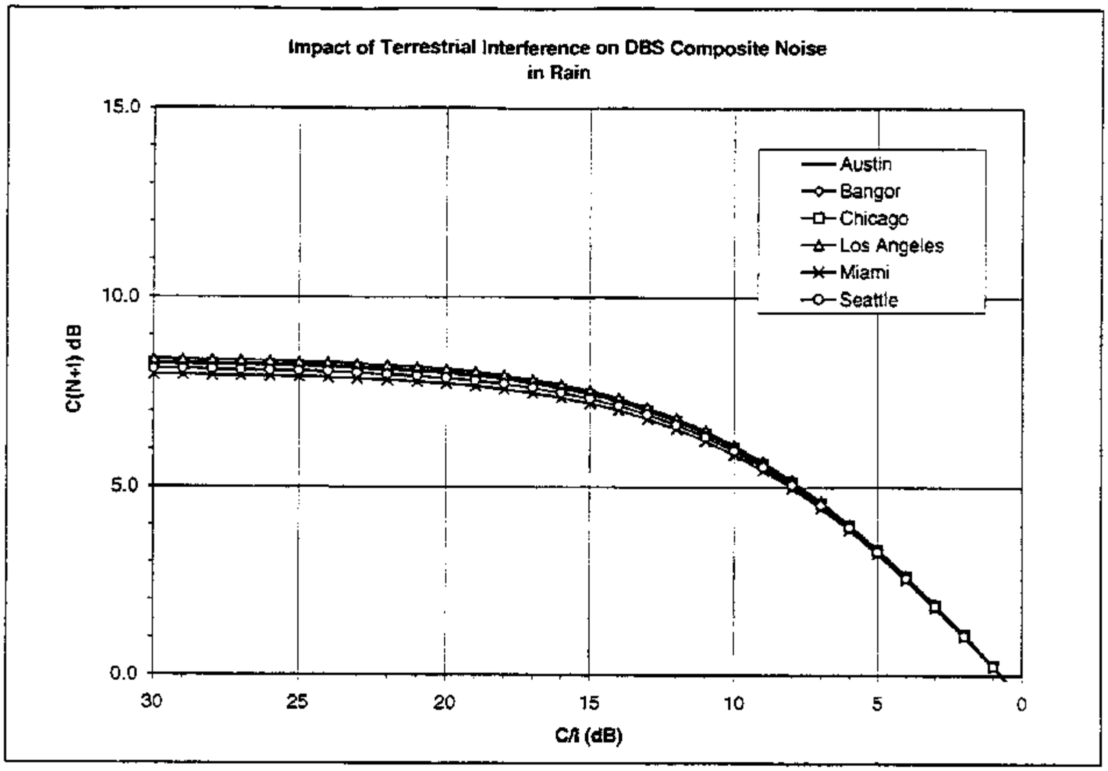

Figure 10. Terrestrial Interference Effect on DBS Link C/(N+I) In Rain

2.1.3 Maximum Link Degradation Due to Interference from Northpoint.

Northpoint Technology will automatically provide a minimum carrier to interference ratio of 24 dB to 99% of all DBS customers, 20 dB to 99.5%, and 17 dB to 100% of DBS customers. As seen in Table 6, a C/I of 20 dB from terrestrial sources causes a noise increase of only 0.3 dB. For all DBS links, a noise increase of 0.3 dB equates to a reduction of availability of less than 0.01%, or less than 0.9 hours per year. Put in other terms, an increase in noise of 0.3 dB might cause loss of a DBS signal 1 or 2 seconds earlier during a rain outage. This is nearly impossible to detect.

Table 6. Link Degradation, In Rain, Terrestrial C/I = 20 dB

	Austin	Bangor	Chicago	Los Angeles	Miami	Seattle	units
EIRP	51.0	50.0	51.0	50.0	54.0	50.0	dBW
Downlink Path Loss	-205.6	-206.1	-205.9	-205.8	-205.7	-206.0	dB
Elevation Angle	54.6	29.3	39.3	46.3	52.0	31.3	deg
Availability	99.80%	99.70%	99.80%	99.90%	99.70%	99.85%	%
Atmospheric Loss	-0.08	-0.13	-0.12	-0.09	-0.08	-0.13	dB
Rain Loss	-1.8	-1.0	-1.6	-1.1	-3.6	-1.1	dB
Rain Temp Increase	-2.5	-1.7	-2.3	-1.8	-3.6	-1.8	dB
Pointing Loss	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	dB
Ground G/T	13.0	13.0	13.0	13.0	13.0	13.0	dB/K
Bandwidth	-73.8	-73.8	-73.8	-73.8	-73.8	-73.8	dB
Boltzmann's	228.6	228.6	228.6	228.6	228.6	228.6	dBW/Hz-K
Downlink C/N (Thermal)	8.5	8.7	8.6	8.7	8.5	8.4	dB

	Austin	Bangor	Chicago	Los Angeles	Miami	Seattle	units
Uplink C/N	24.2	24.2	24.2	24.2	24.2	24.2	dB
Crosspol Interference	22.7	22.6	22.5	22.8	22.1	22.6	dB
Adjacent Satellite Interference	25.0	25.0	25.0	25.0	25.0	25.0	dB
Total C/(N+I)	8.1	8.3	8.2	8.3	8.1	8.1	dB
Terrestrial Interference	**20.0**	**20.0**	**20.0**	**20.0**	**20.0**	**20.0**	dB
Total C/(N+I)	7.8	8.0	7.9	8.1	7.9	7.8	dB
C/N Required	5.0	5.0	5.0	5.0	5.0	5.0	dB
Link Degradation from Terrestrial	0.27	0.28	0.28	0.29	0.27	0.27	dB
Residual Margin	2.8	3.0	2.9	3.1	2.9	2.8	dB

Terrestrial interference at a maximum value for C/I of 20 dB will neither repeatedly interrupt nor seriously degrade DBS service. A C/I of 20 dB will cause no more than 0.3 dB of degradation to the DBS link, even in rain. A C/I of 24 dB causes no more than 0.1 dB of degradation. It is worth repeating that the Northpoint Technology automatically provides a C/I value of 20 dB or greater to more than 99.8% of DBS customers within the Northpoint service area. Note moreover, that natural shielding will protect the majority of DBS customers from terrestrial emissions to the North. For the remaining 0.2%, in the case of problems with customer equipment (i.e., poorly pointed or positioned DBS receive antenna) Northpoint Technology can ameliorate the interference through one or more of the techniques stated in Section 2.2.1.

2.2 Northpoint Technology will not interfere with DBS.

The Northpoint technology will not interfere with DBS. Northpoint Technology will never cause a loss of signal in clear air, and any modest increase in background noise from Northpoint Technology will not seriously degrade the DBS signal reception.

2.2.1 Interference Mitigation

The minimum carrier to interference isolation in the worst case is plotted in Figure 11. The worst case for DBS is a 0 dBi gain towards the Northpoint transmitter, and this is a rare and unusual circumstance. Most DBS customers will have isolation far greater than 0 dBi, up to -16 dBi or higher. Note the C/I ratios given in Figure 12.

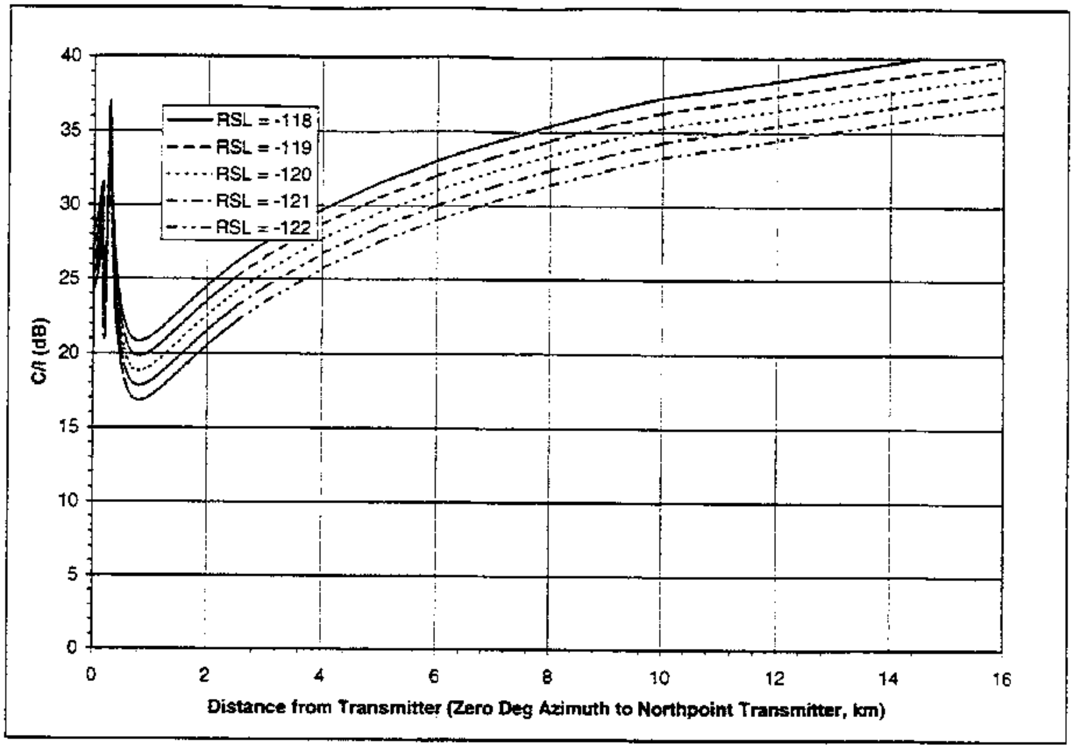

Figure 11. Worst-case C/I ratios

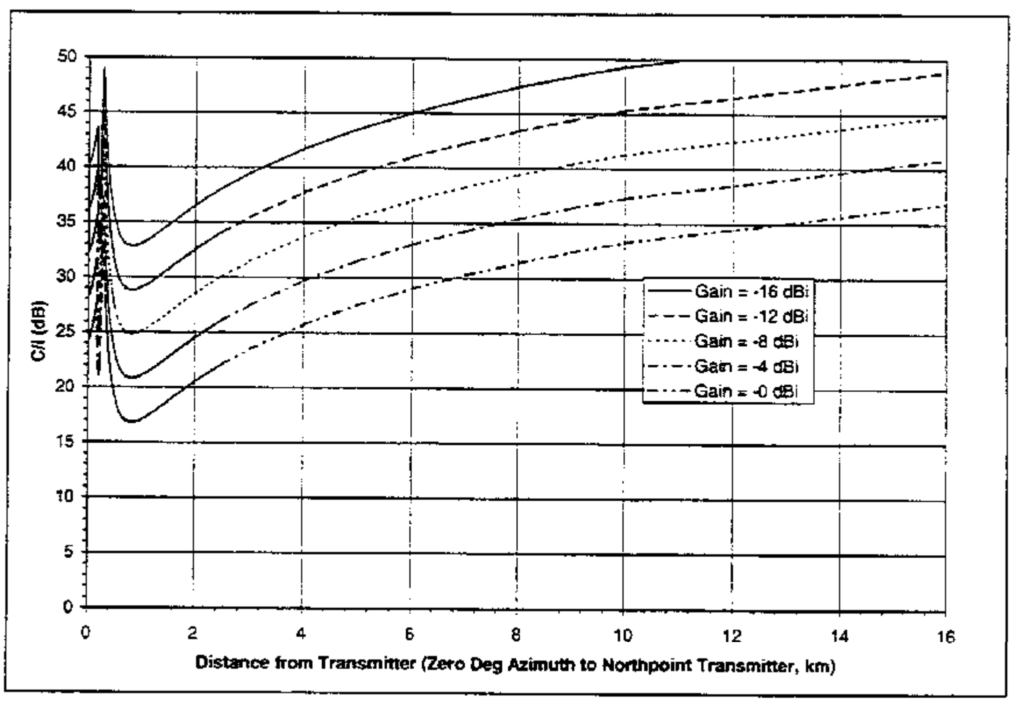

Figure 12. Typical C/I for variation in DBS gain towards Northpoint Transmitter

In section 2.4 it is shown that the worst-case of about C/I = 17 cannot occur for more than 0.2% of DBS customers. Therefore, in addition to the techniques identified in section 1.1.2, terrain blockage, and if necessary, modification of DBS customer equipment will completely eliminate any interference of DBS signals, as explained in the following paragraphs.

Natural Shielding and Terrain Blockage— It is important to note that in any mitigation zone that might exist, attenuation due to terrestrial blockage will also contribute in reducing interference.[21] Importantly, Most DBS antenna installations are placed below the roofline, to the south of the customer dwelling. The antenna manufacturers, as well as DBS receiver manufacturers Sony and RCA, recommend roof-top installations only as a last resort. Attenuation due to terrestrial blockage will also protect a significant percentage of DBS users. If one assumes, conservatively, that only half (50%) of the possible installations in the mitigation zone are below roof top (lack of line of sight), this further reduces the number of affected DBS subscribers in any mitigation zone.

Modification of Customer Equipment— As described in section 2.4, 99.5% of all DBS customers in the service area will automatically have 100% protection from all Northpoint emissions. In the extremely rare case where there is interference, the licensee will bear the burden of preventing interference to the few users affected. Specifically, the licensee will modify, upgrade or otherwise protect any affected DBS customer, at its own expense. The use of these techniques can add sufficient margin to eliminate any interference. The techniques employed in these cases include:

- *Repositioning poorly pointed DBS antennas to eliminate pointing losses.*
- *Replacing the standard DBS antenna with one with better rejection characteristics.*
- *Relocating DBS subscriber receivers away from line-of-sight of the Northpoint transmitter.*
- *Installation of shielding to protect DBS customers.*

2.2.2 Maximum background noise increase from Northpoint Technology.

The interference mitigation techniques employed by Northpoint Technology automatically provide a wide safety margin, as discussed elsewhere in the document. Refer to the figures in Appendix B and the summary in Section 2.4. It can be seen that for 99% of the service area, Northpoint provides a C/I greater than 24 dB, which adds less than 0.1 dB to the noise floor. In some areas of the country, in 0.2% of the service area, a modest increase of 0.3 dB in the thermal noise floor may be seen for those DBS receivers with direct line of sight to the Northpoint transmitter. Again, natural shielding from line-of-sight with the Northpoint transmitter will preclude interference into most DBS installations.

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[21] DIRECTV agrees that "Natural shielding will occur and reduce interference levels, but cannot be counted upon" Terrestrial Interference in the DBS Downlink Band. Northpoint agrees and asserts that where natural shielding does not protect DBS consumers Northpoint will employ other mitigation techniques to alleviate interference.

2.3 Northpoint Automatic Level Control

The Northpoint Technology does believe that automatic level control will be required to reduce the EIRP to avoid interference into DBS customers.

2.4 Comprehensive Review of DBS Sharing with DBS throughout the U.S.

Appendix B provides C/I contours for the entire U.S., covering all rain regions, geographical locations and GSO arc locations. Tables 7-9 summarize the information contained in Appendix B. Table 7 identifies the percent of the service area at C/I less than 24 dB, table 8 shows the percent of the service area at C/I less than 20 dB, and Table 9 lists the minimum C/I values. The analysis shows that in there will be no harmful interference into DBS.

Table 7. % Service Area with less than 20 dB Isolation

Satellite Longitude	148	119	101	85	61.5
Austin	0.07%	0.08%	0.00%	0.04%	0.10%
Bangor		0.18%	0.12%	0.08%	0.03%
Chicago		0.11%	0.04%	0.00%	0.09%
Los Angeles	0.17%	0.02%	0.12%	0.19%	
Miami		0.00%	0.00%	0.00%	0.00%
Seattle	0.14%	0.04%	0.14%	0.19%	

Table 8. % Service Area with less than 24 dB Isolation

Satellite Longitude	148	119	101	85	61.5
Austin	0.63%	0.53%	0.31%	0.40%	0.63%
Bangor		0.91%	0.72%	0.61%	0.52%
Chicago		0.69%	0.43%	0.36%	0.58%
Los Angeles	0.92%	0.56%	0.71%	0.92%	
Miami		0.18%	0.15%	0.03%	0.15%
Seattle	0.80%	0.60%	0.73%	0.98%	

Table 9. Minimum C/I isolation

Satellite Longitude	148	119	101	85	61.5
Austin	18.5	18.5	20.3	18.8	17.9
Bangor		17.4	17.4	17.8	19.0
Chicago		18.1	18.8	20.0	18.0
Los Angeles	17.3	19.5	17.4	17.0	18.8
Miami		21.2	20.8	22.7	21.4
Seattle	17.0	19.1	17.1	17.2	

2.5 Summary of sharing between Northpoint and DBS.

In this section, it was demonstrated that Northpoint Technology is fully compatible with DBS. Northpoint will never cause an outage to DBS in clear air, and Northpoint will not significantly degrade DBS signal reception. Indeed, Northpoint power levels are far below degradation levels, and therefore Northpoint will not cause harmful interference into DBS. DBS can tolerate a terrestrial interference C/I level of 8 dB, even in rain and for worst-case assumptions. Interference contours for the entire U.S. are presented in Annex 1. It is seen that Northpoint interference levels are maintained 17 dB below the DBS carrier in 100% of the service area, and 20 dB below carrier in 99.8% of the service area. Terrain blockage will further reduce interference levels. The maximum link degradation due to Northpoint in 99.5% of the service area will be less than 0.1 dB, and less than 0.3 dB in 100% of the service area. In the extremely rare case where 0.3 dB degradation causes interference (due to problems with customer equipment), the licensee can bear the burden of preventing interference to the few users affected.

Appendix A—References

[1] DirecTV, *Terrestrial Interference in the DBS Downlink Band*, Analysis Submitted to the FCC 11 April 1994.

[2] DirecTV, Inc. *Petition for Reconsideration of DirecTV, Inc.*, Aug 1998.

[3] ITU-R Document JTG 4-9-11/321-E, Revised EPFD Interference Protection Limits for Digital GSO BSS Systems in Region 2, United States of America, 12 January 1999.

[4] ITU-R Document JTG 4-9-11/356-E, Three-Dimensional Templates for Offset Fed 45 cm Antenna Deployed in Region 2 BSS receiving Earth Stations, Canada. 15 January 1999.

[5] ITU-R Document 10-11S/TEMP 41 Rev 1; Preliminary Draft New Recommendation, *Protection of the Broadcasting-Satellite Service in the 12 GHz Band and Associated Feeder Links in the 17 GHz band from Interference Caused by NGSO FSS Systems*, 23 October 1998.

[6] ITU-R Document US RCG9A-Int/1, *NGSO Interference Criteria for Terrestrial Point-To-Multipoint Systems in the Band 12.2 - 12.7 GHz*, Jan 4, 1999.

[7] ITU-R Recommendation F.1245.

[8] ITU-R Document JTG 4-9-11/88, *Characteristics of a Ku Band Terrestrial Point-To-Multipoint System.*

[9] ITU-R Document JGT 4-9-11/125, *Preliminary Analysis of Provisional Power Flux Density Limits for NGSO-FSS Systems To Protect Terrestrial Point-To-Multipoint Services in the Bands Near 12 GHz.*

[10] ITU-R F.755-1, *Point-to-Multipoint Systems Used in the Fixed Service.*

[11] ITU-R Recommendation P.530-7, *Propagation Data and Prediction Methods Required for the Design of Terrestrial Line-of-Sight Systems.*