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October 13, 1999

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445 Twelfth Street, N.W.
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Washington, D.C. 20554

Re: Experimental Progress Report, WA2XMY – Washington, D.C.

Dear Mr. Burtle:

We are very pleased to enclose two copies of the Progress Report for the above referenced license. An original and one copy have been filed with the Secretary. Please note that there are two volumes to the report. Volume One contains the primary text and related exhibits; Volume Two contains the field notes.

Please contact Carmen A. Tawil or the undersigned at (202) 737-5711 if you have any questions regarding this matter.

Sincerely yours,

Sophia Collier

Enclosures

Progress Report

WA2XMY

Northpoint - DBS Compatibility Tests

Washington, D.C.

October, 1999

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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.

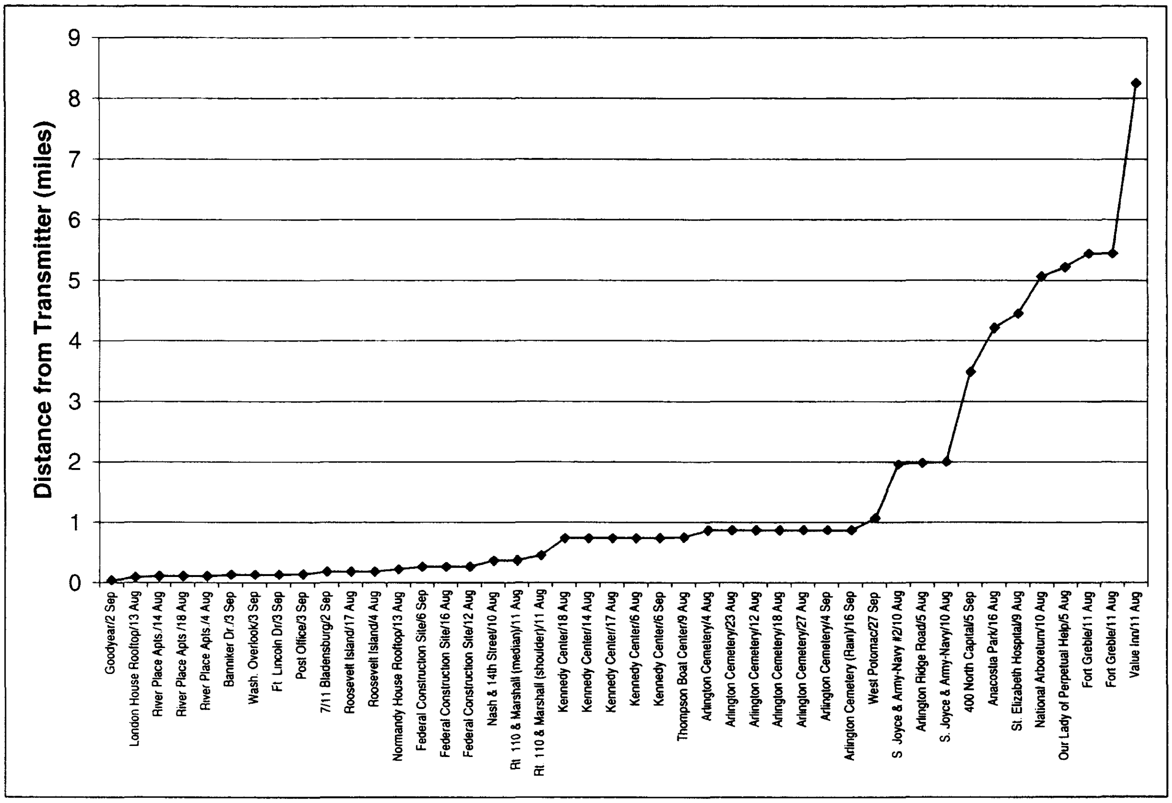

Figure 1. Measurements and Distance from Transmitter

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. <u>Very Close Range Tests</u>

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.

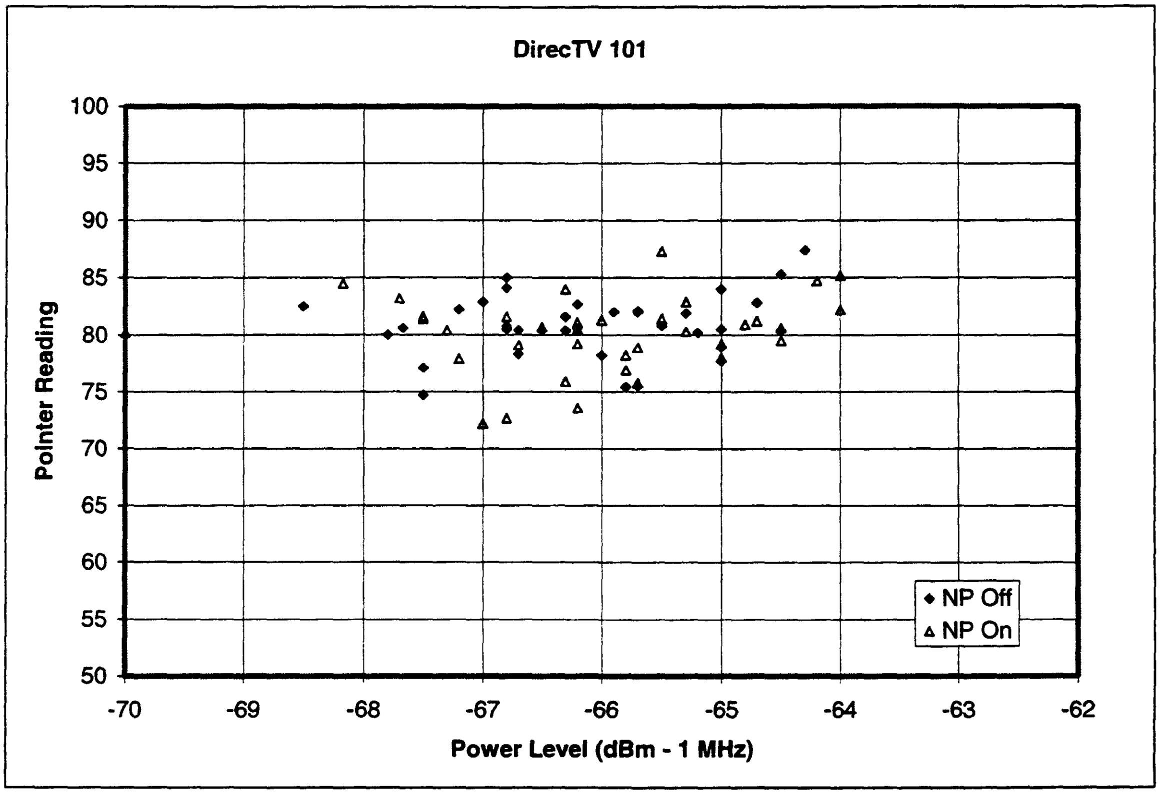

Figure 2. Plot of Pointer Reading vs. Power Density Level for DirecTV

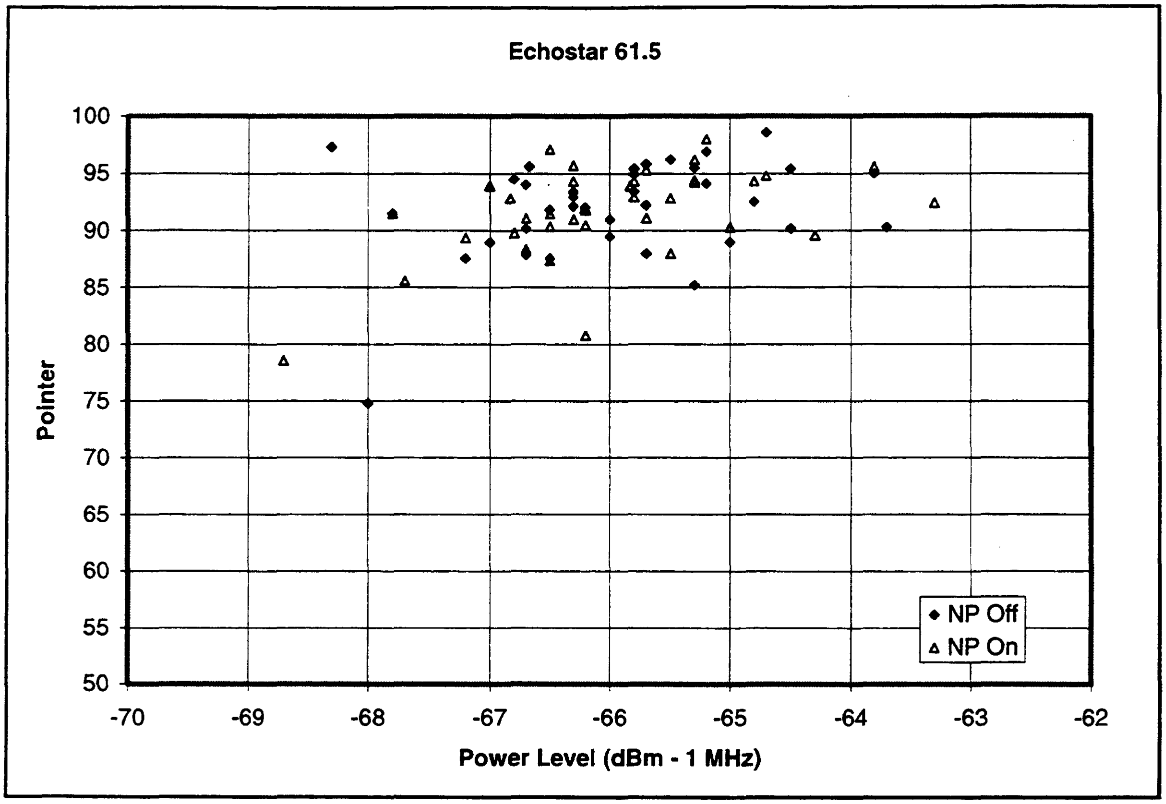

Figure 3. Plot of Pointer Reading vs. Power Density Level for Echostar 61.5

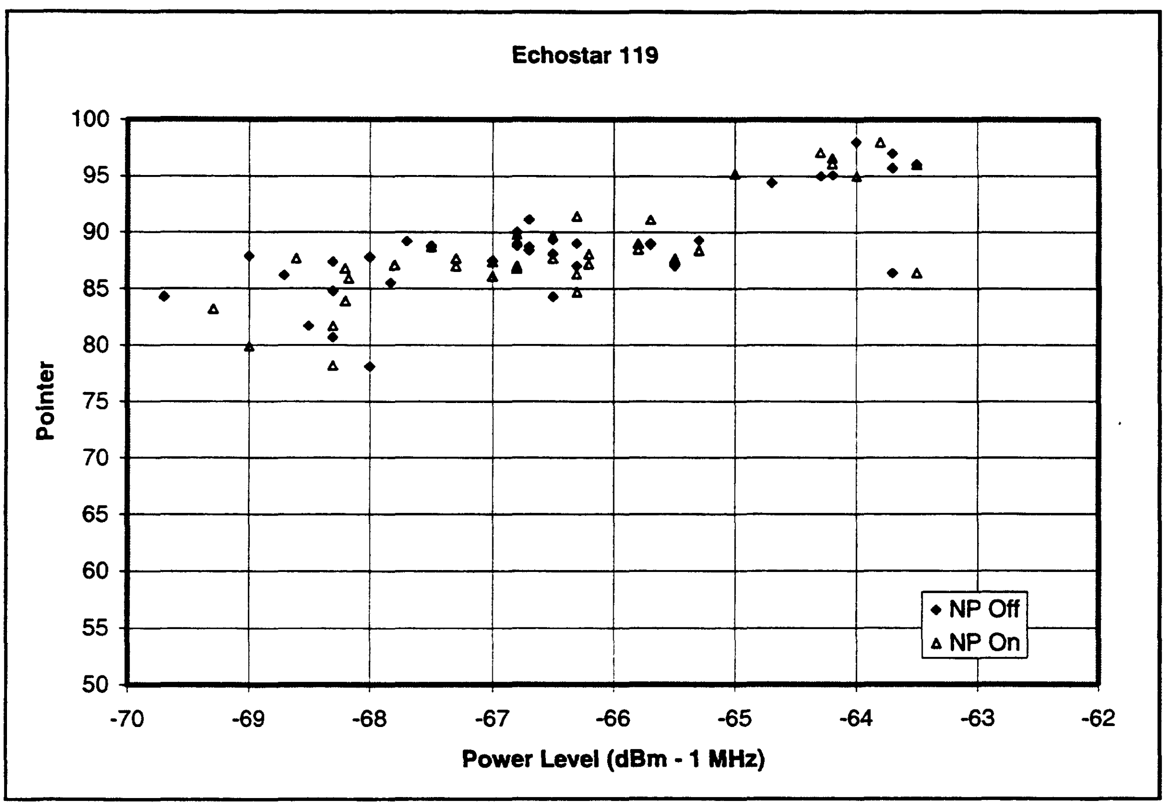

Figure 4. Plot of Pointer Reading vs. Power Density Level for Echostar 119

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.

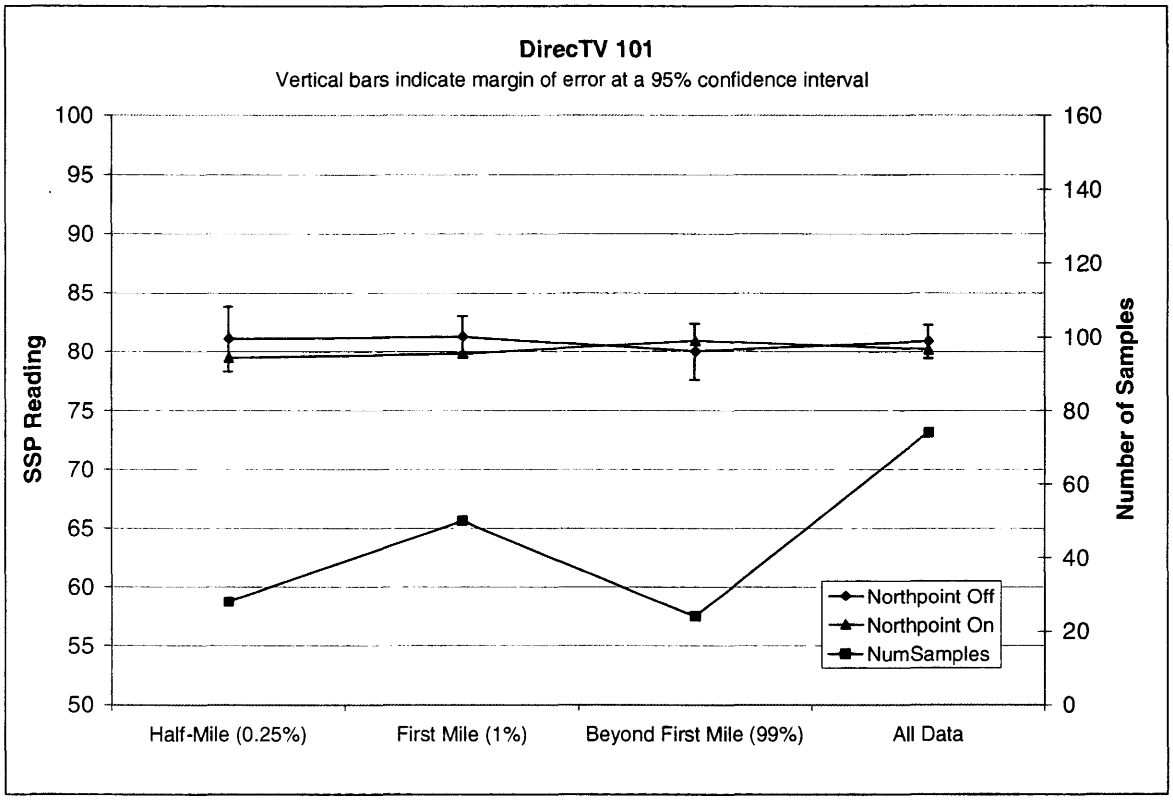

Figure 5. No Statistical Difference Between "On" and "Off" Conditions for DirecTV 101

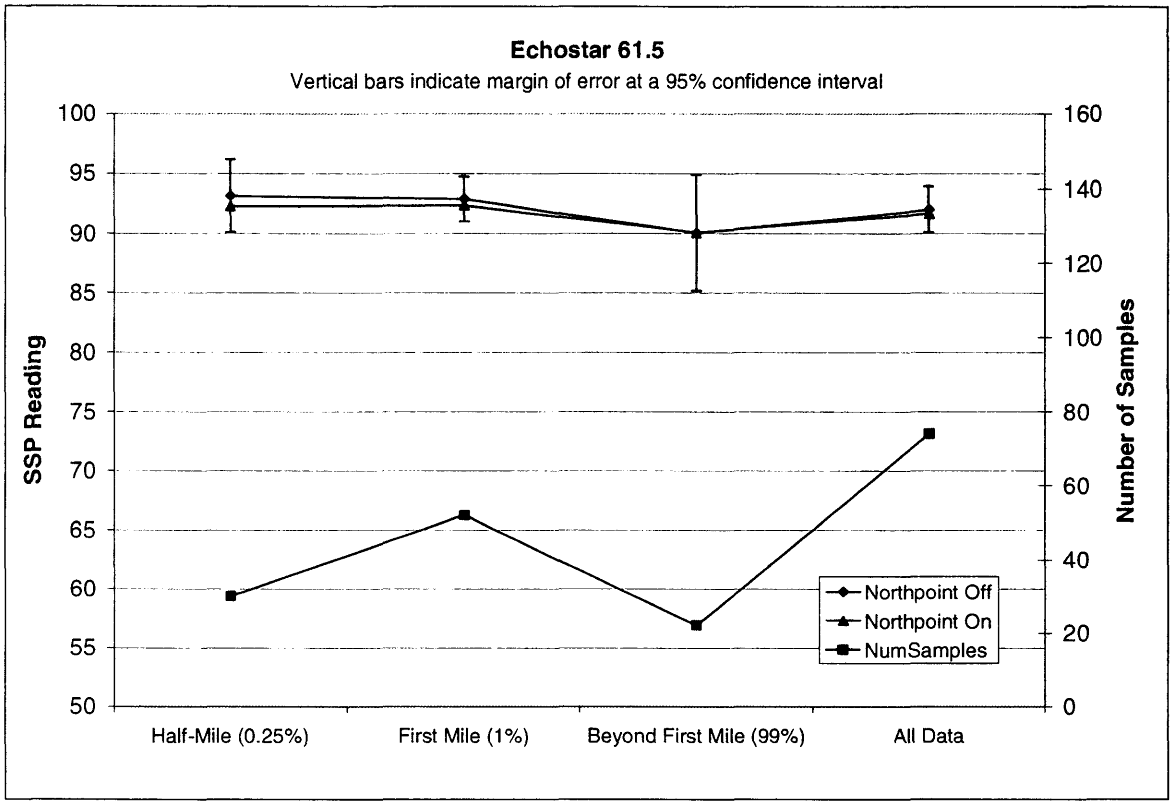

Figure 6. No Statistical Difference Between "On" and "Off" Conditions for Echostar 61.5.

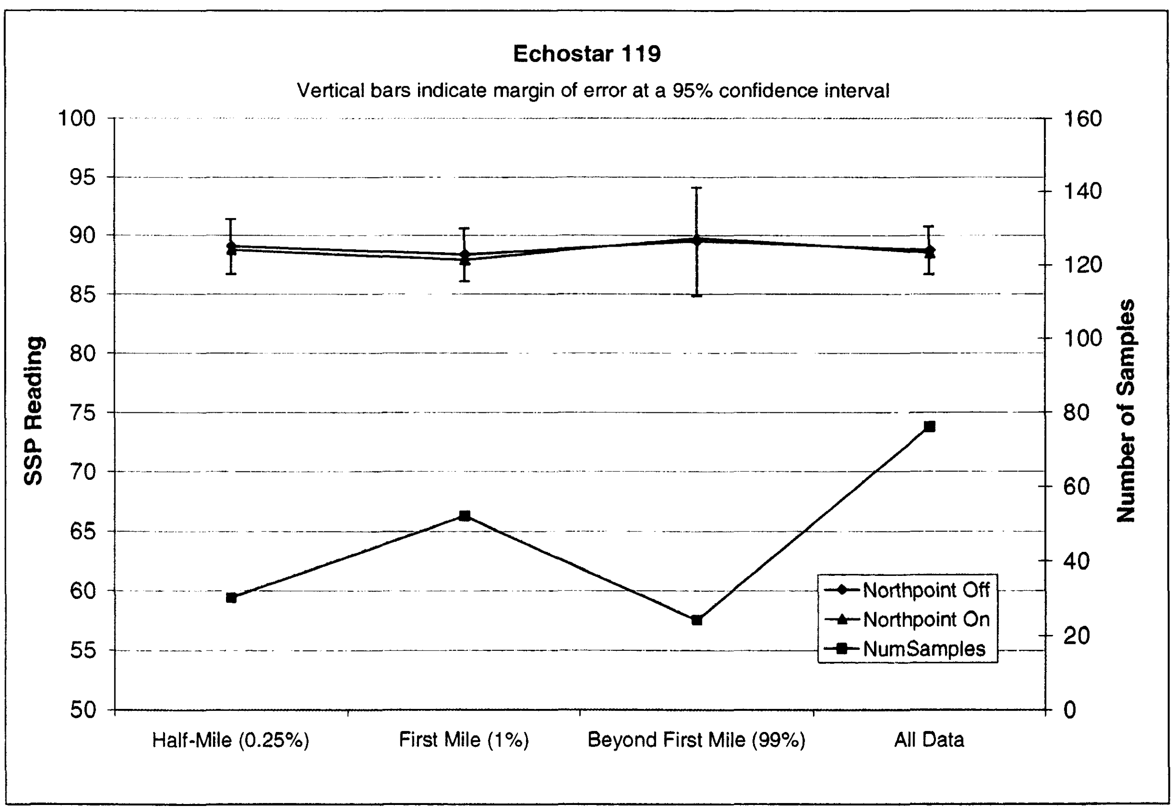

Figure 7. No Statistical Difference Between "On" and "Off" Conditions for Echostar 119

c. No Significant Link Degradation or Increase in BER Observed

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

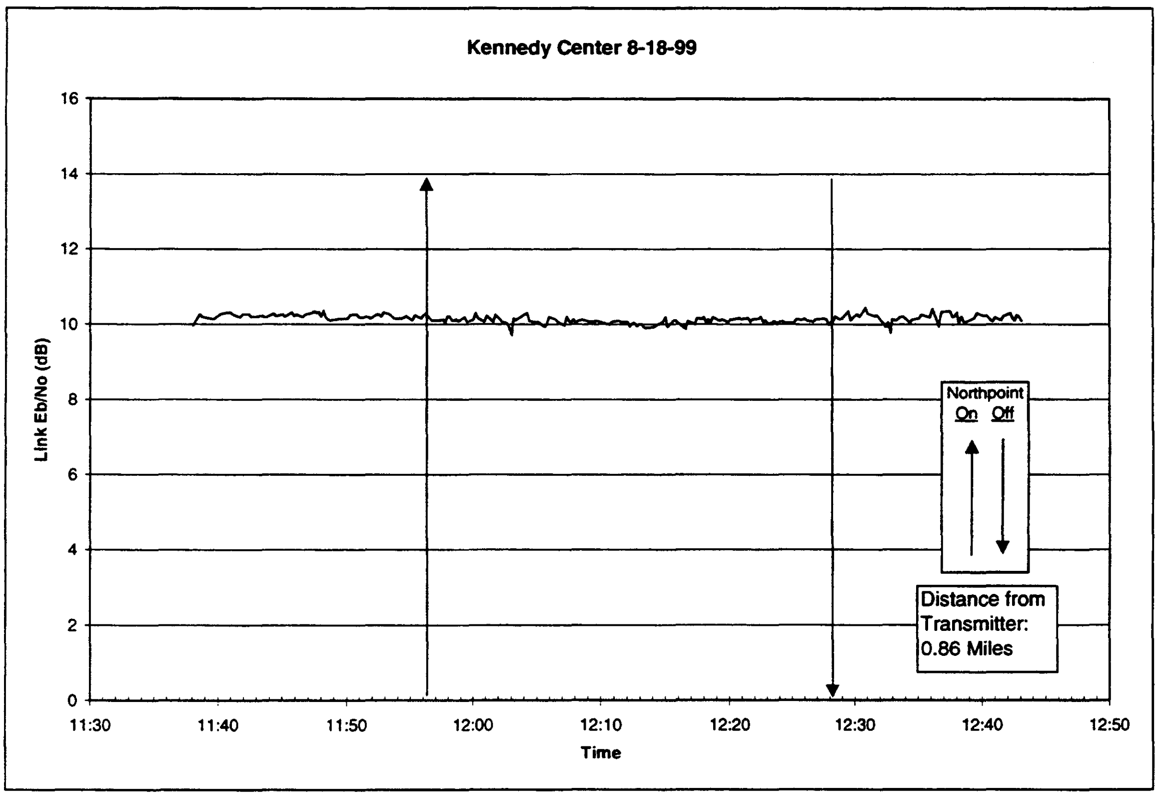

Figure 8. Link Degradation for Echostar 119, Kennedy Center

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.

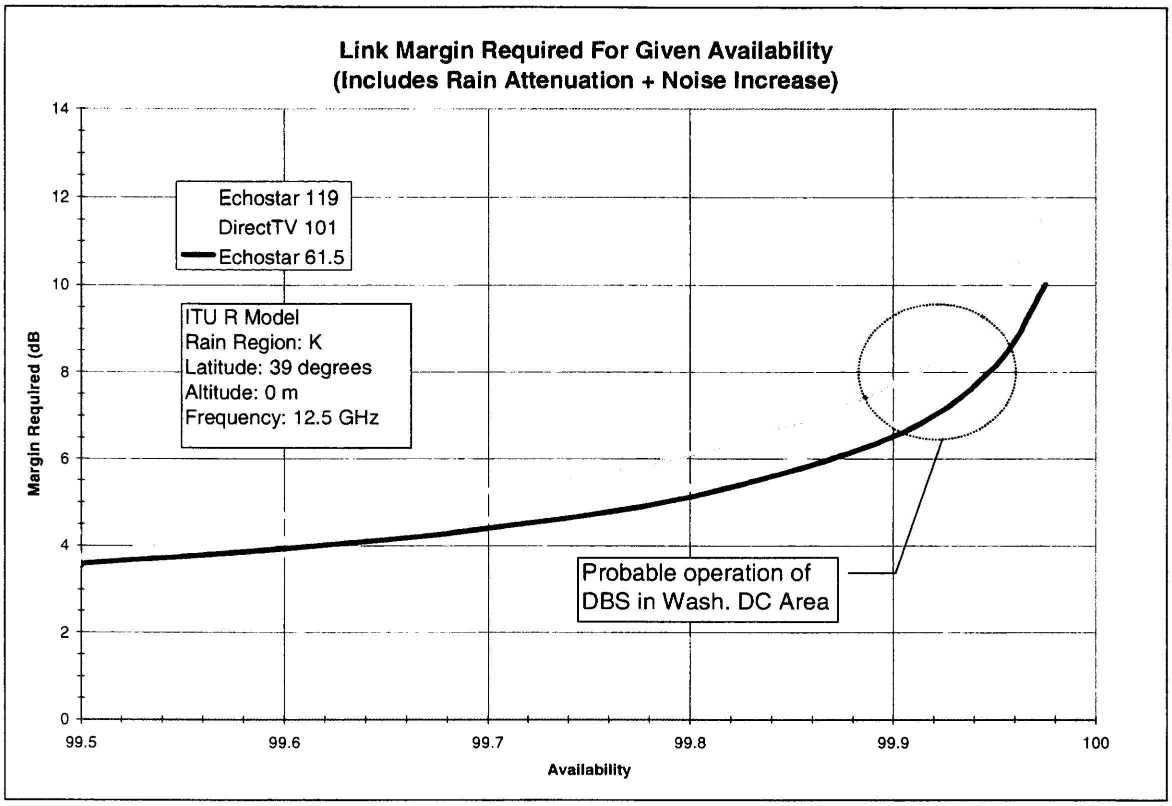

Figure 9 . Link Margin Required for Given Availability (rain attenuation + thermal noise increase).

d. Rain Tests - No DBS Outages during Hurricane Floyd

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°.

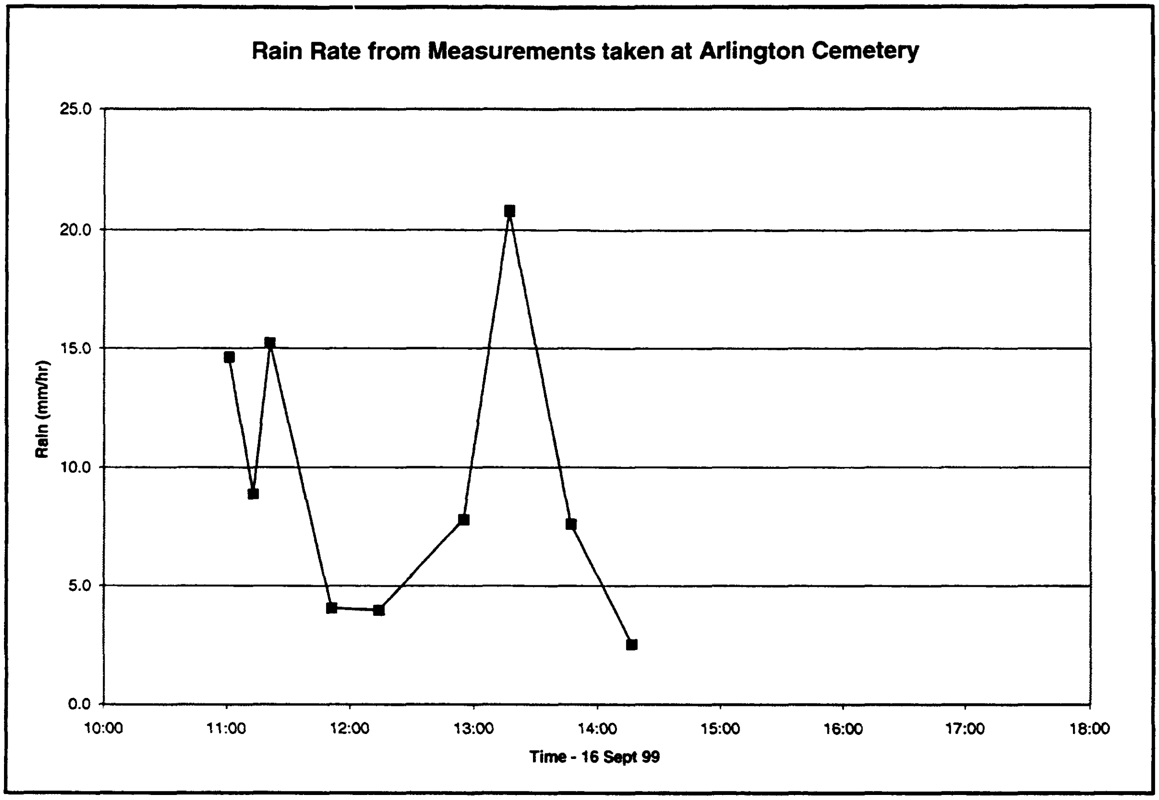

Figure 10. Rain Rates from Measurements taken at Arlington Cemetery

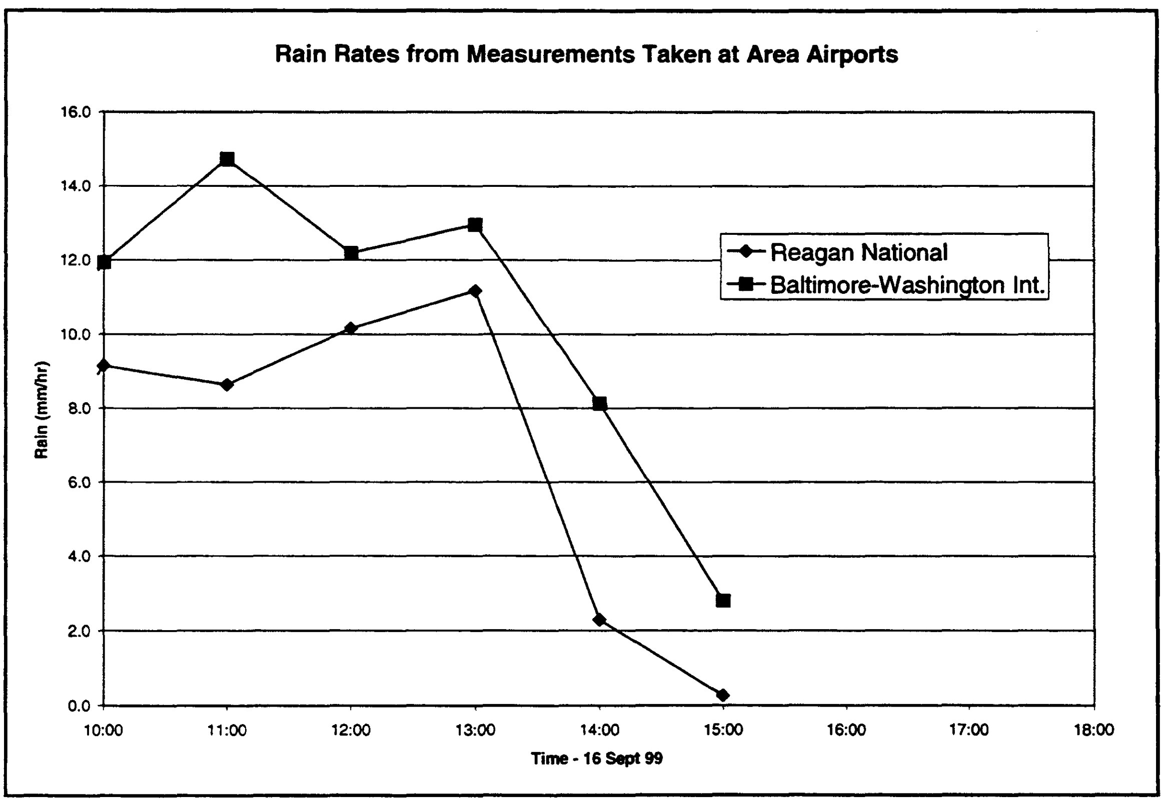

Figure 11. Rain Rates from NOAA Measurements at Area Airports

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.

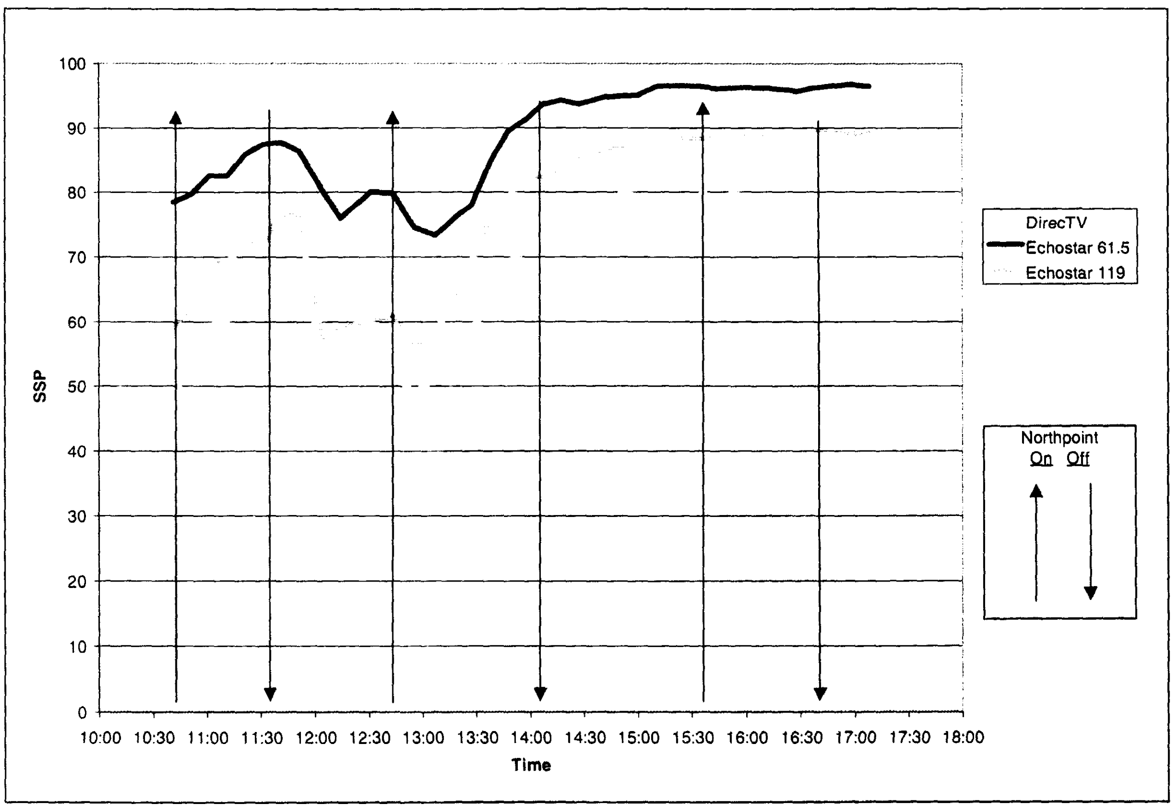

Figure 12. SSP Readings during Hurricane Floyd, September 16, 1999

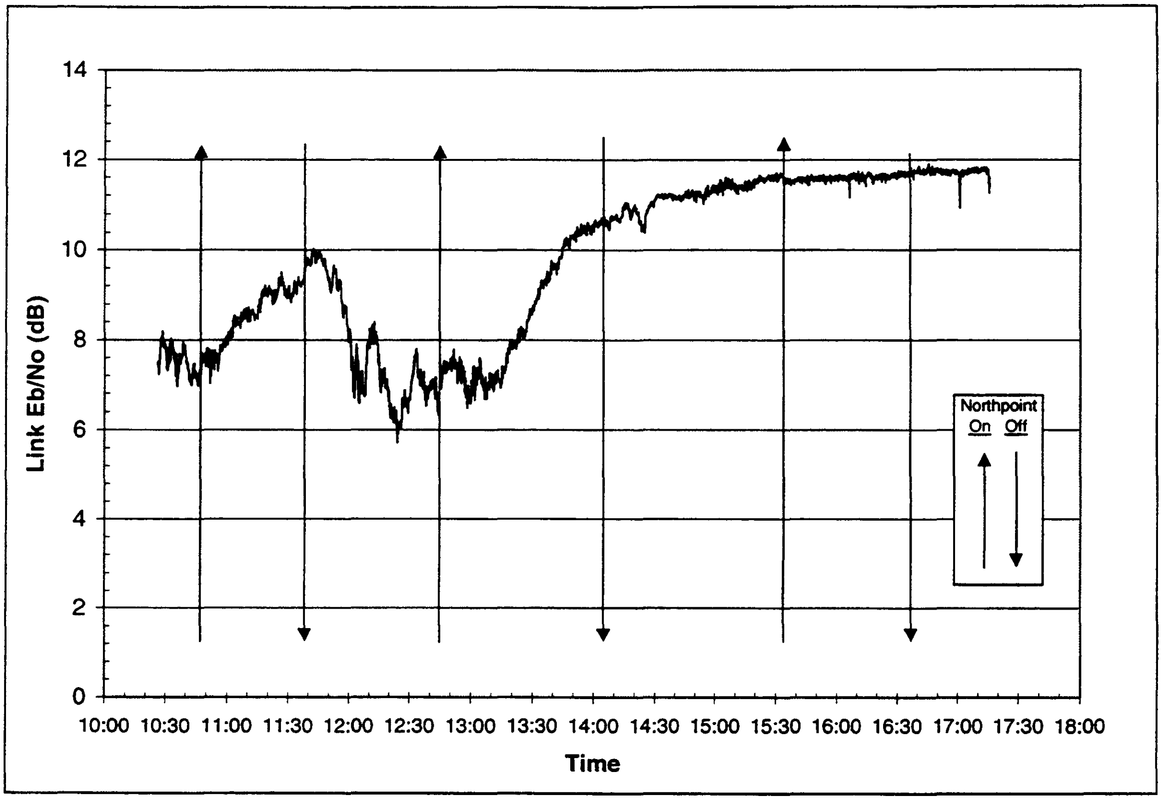

Figure 13. Observed Eb/No for Echostar @ 119 W, Hurricane Floyd

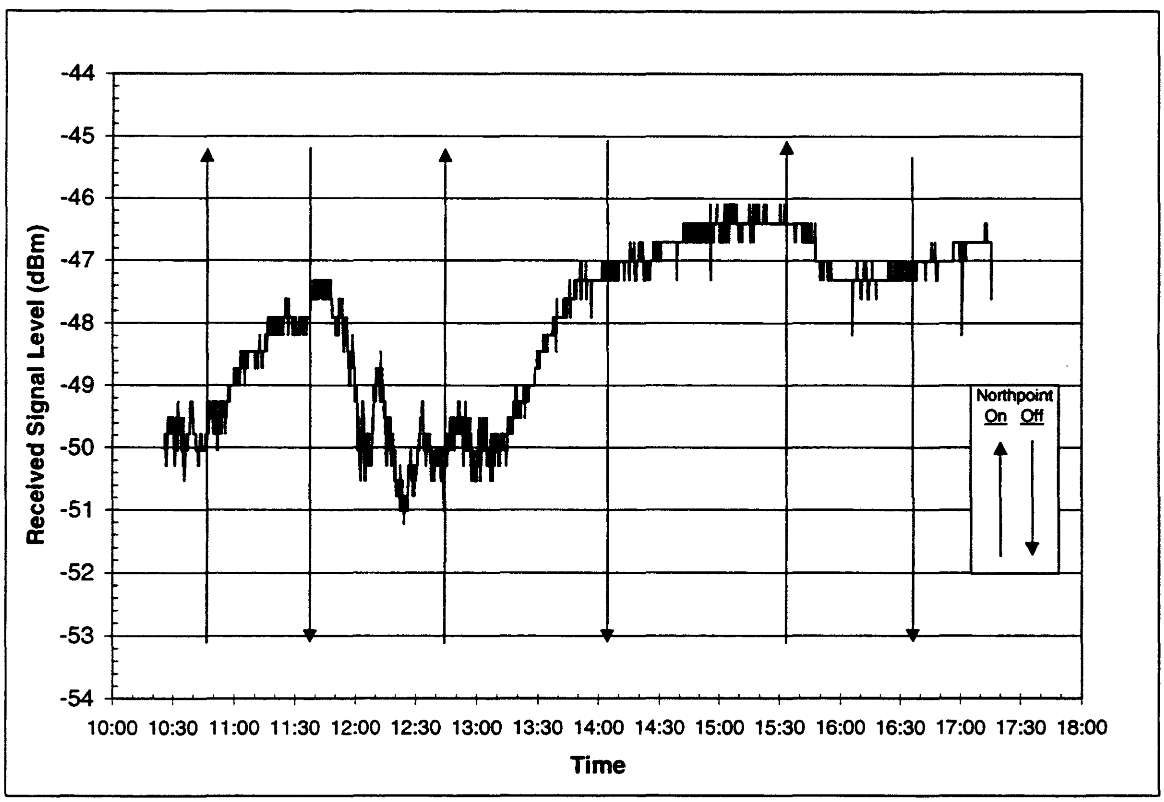

Figure 14. Echostar119 W Received Signal Level during Hurricane Floyd

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. <u>Superb Performance of Northpoint Technology</u>

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.

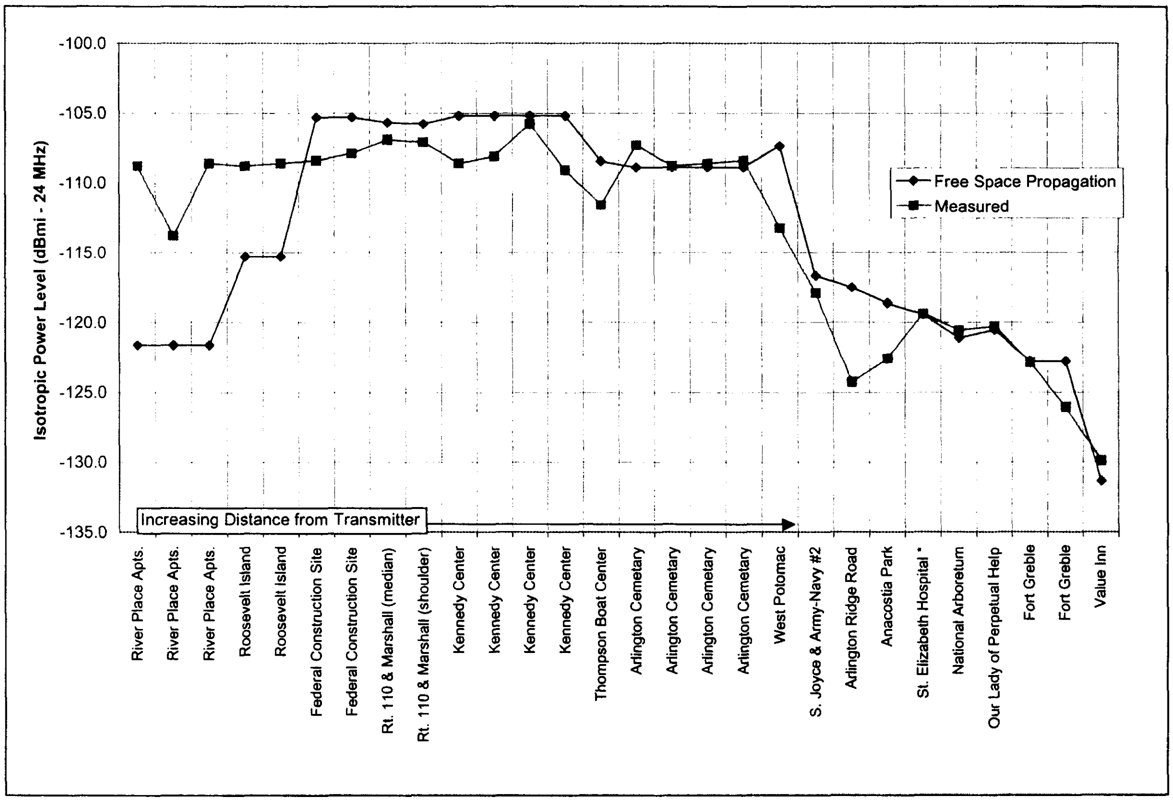

Figure 15. Northpoint Signal Strength

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.