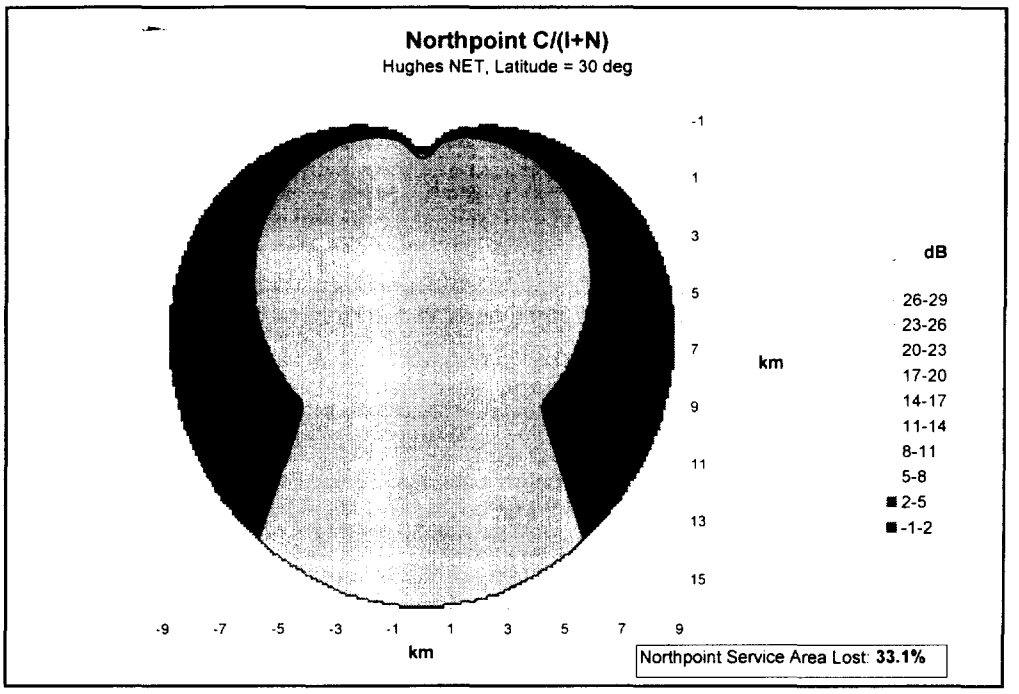


Figure 17. Hughes Net Interference into Northpoint

The previous figures show that a significant portion of the Northpoint service area could be affected by repeated outages from SkyBridge, Hughes Link and Hughes Net systems. The data are summarized in the following table.

Table 12. NGSO FSS Impact on Northpoint Service Area

System	% Northpoint Service Area Affected
SkyBridge	27.6%
Hughes Net	33.1%
Hughes Link	5.9%

3.3 Dynamic Analysis

A number of dynamic analyses were performed to determine the severity of interference into Northpoint. The simulation calculates the I/N ratio using Equation 1. Simulation duration was 4 days at 1 second intervals (345,000 points). Principle assumptions about the SkyBridge satellite system are as listed in Appendix E and Table 13. Northpoint distance from the transmitter was at the maximum service distance, as shown in Figure 8.

Table 13. Interference into Northpoint - SkyBridge Dynamic Analysis Assumptions

System	Parameter	Value	Units
	Frequency	12.5	GHz
	Atmospheric Loss	Per ITU Model	
	U.S. Standard Atmosphere		
SkyBridge			
	Radiation Pattern	Bessel	
	Range Power Compensation	Yes	
	Peak Gain	22.8	dBi
	Minimum 3-dB beamwidth	5.1	deg

Maximum 3-dB beamwidth	18	deg
Maximum number of transmitters per satellite	20	
Target Cell Selection	Highest Elevation Satellite	
GSO Arc Avoidance	Yes	
Cell Diameter	350	km
Northpoint		
Receiver Noise Level	130.3	dBW
Receiver Azimuth to Transmitter	0 to 125	deg
Transmitter Height above ground level	150	meters
Station Latitudes	30, 40	deg
Radiation Pattern	ITU-R F.1245	
Peak Gain	34	dBi

The results of the simulation are presented in Figure 18. As predicted, the interference is severe for azimuth angles between 40 and 125 degrees.

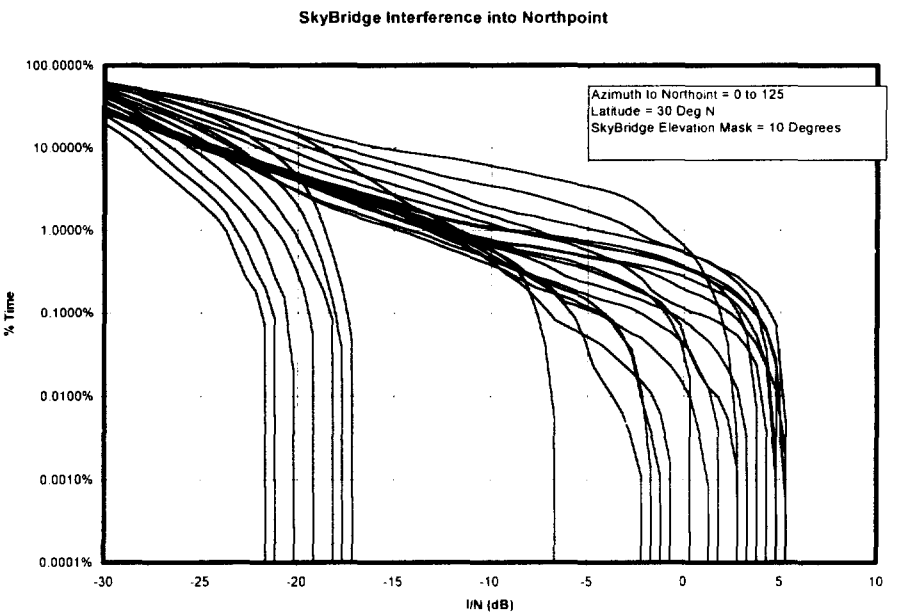


Figure 18. I/N into Northpoint from SkyBridge

Additional information on the two Hughes systems, Hughes Link and Hughes Net (e.g. cell size) is required to perform dynamic analysis on these systems. However, the Hughes Net system shares many characteristics with SkyBridge, and interference is expected to be similar. For Hughes Net, the static analysis in section 3.2 showed that Net operates inside the interference envelope of SkyBridge (see Figure 18). Therefore, it is expected that the interference environment from Hughes Net would be less severe than SkyBridge.

3.4 Power Flux Density Mask to Protect Northpoint

The provisional PFD mask in the 12.2 - 12.7 GHz band is given in the following table.

Table 14. Provisional PFD Limits for given angle of arrival, δ.

Angle of Arrival	0-5°	5-25°	25-90°	Units
12.2 - 12.7 GHz	-148	-148+0.5(δ-5)	-138	dB(W/m²/4kHz)

The Interference to Noise ratio (I/N) is calculated from the provisional PFD as follows:

$$I/N = PFD + B + G(1m^2) + G(\theta) - N\text{-}gas$$

Where:

- δ : Elevation Angle to Satellite
- I/N : Interference to Noise ratio, dB;
- PFD : Power Flux Density, dBW/m²/4kHz;
- B : Ratio of noise floor reference bandwidth to PFD reference bandwidth, dB;
- $G(1m^2)$: Gain of 1 meter square antenna = $\lambda^2/4\pi$, m², (difference between the spreading loss and the path loss);
- $G(\theta)$: Gain of receive antenna as function of θ in degrees, dBi;
- N : Noise floor in reference bandwidth, dBW.
- gas : Gaseous attenuation (according to ITU-R).

Table 15 provides sample calculations.

Table 15 Sample Calculations of I/N

Item	Symbol	TFMS	Units
Noise floor reference bandwidth	*Bn*	24000	kHz
PFD reference bandwidth	*Bpfd*	4	kHz
Lambda	λ	0.025	meters
Power flux density	*PFD*	-148	dBW/m²/4 kHz
B = 10log(Bn/Bpfd)	*B*	37.8	dB
Gain of 1 m² antenna	$G(1m^2)$	-43.0	dB
Gain of receive antenna	*G*	34	dBi
Noise floor in reference bandwidth	*N*	-130.3	dBW
Gaseous Absorption	*gas*	1.5	dB
Interference to noise ratio	*I/N*	9.6	dB

Thus, the maximum I/N ratio from a single satellite operating at the PFD limit would be 9.6 dB. If peak interference from multiple NGSO FSS systems is independent and is not cumulative, only an additional 10 dB of protection is required at the low elevation angles to prevent loss of synchronization. The maximum PFD that can be tolerated at zero degrees elevation is -158 dBW/m2/4 kHz. To determine an appropriate PFD at other elevation angles with multiple NGSO FSS systems, a further analysis is required.

Preliminary dynamic analysis with SkyBridge shows that for elevation angles greater than 5 degrees, the existing limit is adequate to protect Northpoint technology. Pending further review and the outcome of studies in the ITU-R, the Northpoint PFD mask is listed in the following table:

Table 16. PFD Limit to protect Northpoint Technology

Angle of Arrival (δ)	0-2°	2-5°	5-25°	25-90°	Units
12.2 - 12.7 GHz	-158	-158 + 3.33(δ-2)	-148 + 0.5(δ-5)	-138	dB(W/m^2/4kHz)

Plotted in Figure 19. PFD Mask for Northpoint, are the provisional limits, the PFD mask to protect Northpoint and the PFD for SkyBridge. As shown, only a modest reduction in PFD is required, and only below five degrees in elevation. Satellite systems do not provide service below ten degrees in elevation, and such a modest reduction in PFD can easily be met by satellite system designers.

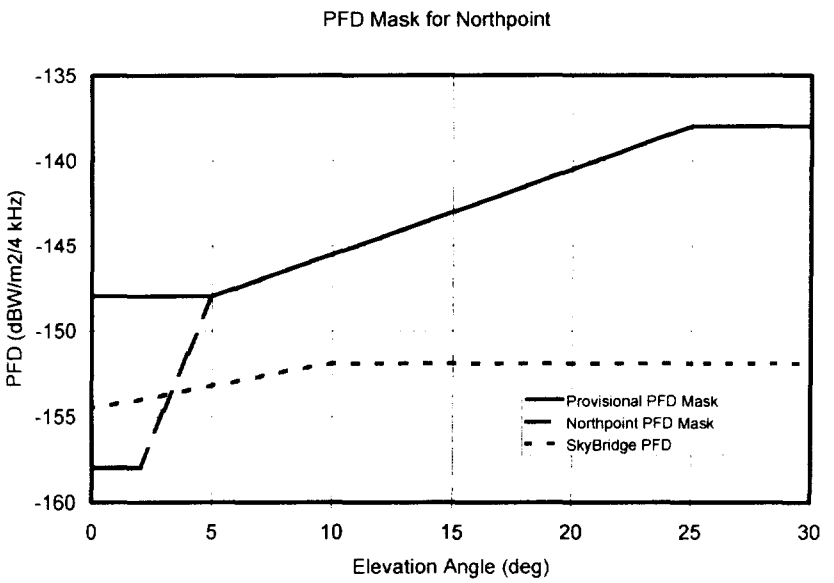


Figure 19. PFD Mask for Northpoint

The following table provides sample calculation for the SkyBridge power flux density level.

Table 17 SkyBridge PFD Calculation

Item	Value	Units
Frequency	12.2	GHz
Lambda	0.025	meters
Power	6.4	dBW
Gain Tx Side	22.8	dBi
EIRP Tx Side	29.2	dBW/22.6 MHz
Rx Bandwidth	0.004	MHz
Tx Bandwidth	22.6	MHz
Bandwidth Ratio	-37.5205	dB
Elevation Angle	10.0	deg
OrbRadius	7847.0	km
PathLoss	-185.4	dB
PFD	-150.6	dBW/m2/4kHz
Atmospheric Degradation	-1.5	dB
PFD	-152.1	dBW/m2/4kHz

In conclusion, this section identified the PFD mask (Table 16) required to protect Northpoint from NGSO FSS transmissions. As shown, only a modest reduction in PFD is required, from the provisional limit, and only below 5 degrees in elevation. As previously stated, NGSO satellite systems do not propose to provide service below 10 degrees in elevation, and such a modest reduction in PFD can easily be met by satellite system designers, as discussed in the following section.

3.5 Terrestrial Arc Avoidance

There are a number of methods to protect Northpoint from interference from NGSO FSS, discussed in the following paragraphs. As previously depicted in Figure 14, a maximum of 5 dB of attenuation is required to meet the short-term I/N. Dynamic analysis with SkyBridge showed that if SkyBridge meets the short-term limit, the long-term limit will also be met.

All of the following methods reduce the power flux density below 5 degrees, an elevation angle that no NGSO FSS proposes to serve under any conditions. Therefore, the reduction methods need not have an impact on NGSO FSS operations. Of the three methods discussed, *reducing the radiation levels* towards elevation angles below 5 degrees appears to have the most merit for co-frequency sharing. *Frequency separation* of course eliminates interference, as does an *increase in the elevation mask* of the NGSO FSS system.

3.5.1 Increase in the elevation mask

One method to meet the PFD limits identified in section 3.4 is to increase the transmit mask in elevation above the 9-10 degrees proposed by Hughes and SkyBridge. By increasing the elevation mask, the power transmitted towards the horizon is reduced. (As shown in Figure 14, the maximum elevation mask for the NGSO FSS systems would be between 15 and 20 degrees.) It should be noted that all the proposed systems, except Hughes and SkyBridge meet or exceed this requirement.

Note that the orbit geometry of these systems dictates a naturally occurring elevation mask. For example, at a latitude of 30 degrees North, all of these systems would operate according to an elevation mask of between 15 and 60 degrees, due to orbit geometry (see figures in Appendix C). Moreover, naturally occurring obscura would require elevation mask greater than ten degrees in some locations. Therefore, such a moderate change in mask would have minimal impact on NGSO FSS systems.

In the case of SkyBridge, the static analysis in section 2.2 predicted that an elevation mask of 18 degrees would sufficiently protect Northpoint. The simulation in section 2.3 was repeated using an elevation mask of 18 degrees, the results are presented in Figure 20. The dynamic analysis confirms that at an elevation mask of approximately 18 degrees, the SkyBridge system meets the interference criteria for Northpoint.

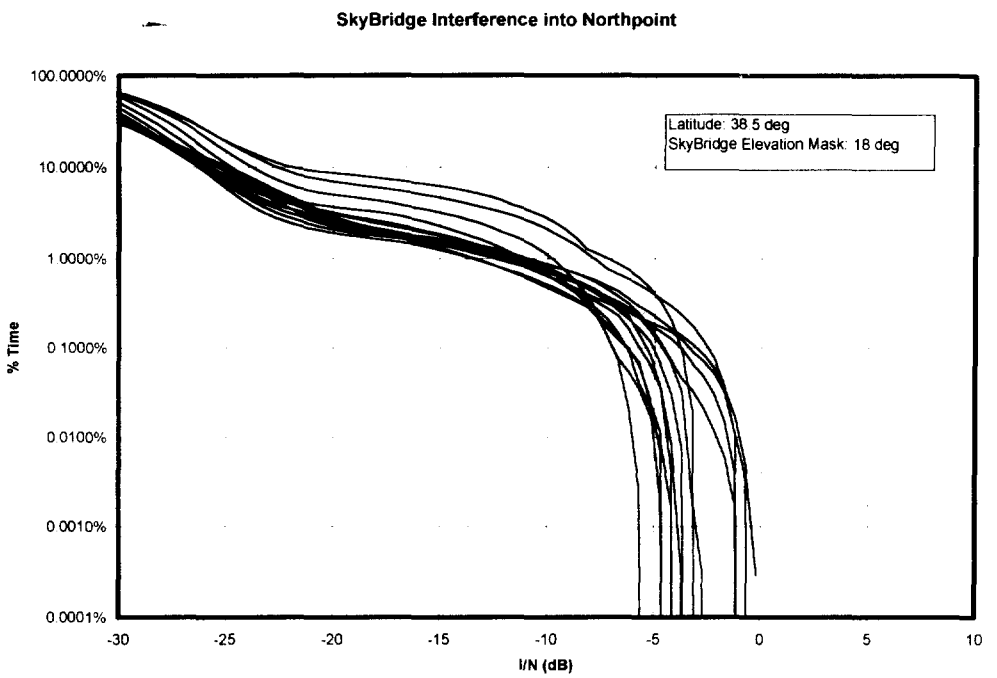


Figure 20. I/N into Northpoint from SkyBridge, Elevation Mask = 18 degrees

3.5.2 Increase Antenna Discrimination Towards the Horizon

Another method for reducing interference would be to increase the antenna discrimination of the NGO FSS antenna in the direction of the horizon. NGSO FSS systems do not offer service below five degrees, and there is no reason not to further attenuate power in this direction. As the typical NGSO FSS system is three-axis stabilized, the installation of shielding on the satellite to reduce radiation in this direction would also be a low-cost solution, and would not affect throughput or availability.

3.5.3 Frequency Separation

A certain method for eliminating interference into Northpoint would be for those NGSO FSS systems that do not offer compatibility with Northpoint to operate in another band. NGSO FSS systems have the option of operating service links in bands outside of the 12.2 - 12.7 GHz band.

3.6 Conclusions

In this section, interference from NGSO FSS systems into Northpoint was analyzed. It was demonstrated that most of the proposed systems (i.e. *Boeing IDS, Boeing BDS, Denali, Virgo, and Teledesic*) would not cause interference into Northpoint. In the cases of the *SkyBridge*, *Hughes Net* and *Hughes Link* systems, a loss of up to 33% of the Northpoint service area would occur absent some form of *terrestrial arc avoidance*. Co-frequency operation is possible given the implementation of interference mitigation techniques, the most promising of these is *reducing antenna radiation* towards the horizon.

An aggregate PFD mask was also developed. Slight changes in the WRC-97 provisional PFD mask, below 5 degrees in elevation, should protect Northpoint from the aggregate interference of NGSO FSS systems. Further work is required to identify a single entry mask, and is dependent upon the number of proposed systems that will operate and their characteristics. Again, five of the proposed systems (*Boeing IDS, Boeing*

BDS, Denali, Virgo, and Teledesic) would meet the proposed PFD limit by a wide margin and should not cause interference into Northpoint.

It should be noted that it was not possible without additional information to perform a dynamic analysis on the two Hughes systems. However, Hughes Net is so similar to SkyBridge that similar results should apply to Hughes Net. As long as the NGSO FSS systems meet the PFD limit, they should not cause interference into Northpoint.

4 NORTHPOINT INTERFERENCE INTO NGSO FSS

In this section, interference from Northpoint into NGSO FSS is analyzed. In section 4.1, assumptions are identified. The worst-case I/N values, for interference into NGSO FSS systems from Northpoint, are developed in Section 4.2. In section 4.3, dynamic analysis is used to determine the interference levels, at various percentages of time, for the SkyBridge system. In section 4.4, various methods for mitigating interference are examined.

4.1 Assumptions

Table 18. Interference into NGSO FSS - Northpoint Assumptions

Parameter	Value	Units
Frequency	12.5	GHz
Atmospheric Loss	None	
Transmit Power	-25	dBW
Receiver Azimuth to Transmitter	0 to 180	deg
Transmitter Height above ground level	150	meters
Station Latitudes	30	deg
Radiation Pattern in Elevation	Figure 1	
Radiation Pattern in Azimuth	Figure 2	
Polarization Loss	Rec. F.1245 (Note 7)	

The NGSO FSS systems studied in this analysis were identified in Appendix 4. All information contained in the tables was taken from recent filings to the FCC, or derived from information therein.

4.1.1 Interference Criteria for NGSO FSS Systems

A fixed transmitter is a time-varying source of interference into NGSO FSS systems, much like rain attenuation. Making the assumption that interference and rain are independent, and occur for small percentages of the time (< 1%), then the joint probability of rain and interference is very small, and can be ignored. In this case, rain margin can be used to mitigate interference. This assumption is supported by current ITU-R efforts to define interference criteria for time-varying sources of interference into FSS systems in general. Although the carrier power also typically varies as a function of time, the noise power is constant.

If one assumes that a loss of signal in clear air occurs at I/N values of 0 dB, then this can be used as a trigger for short term interference. For link degradation due to increased noise, an I/N of -12.2 dB increases the noise only 6%. Thus, in this analysis the following interference criteria are assumed:

Table 19. Interference criteria for NGSO FSS

I/N Level (Clear Air)	Percent of Time
0 dB	0.01
-12.2	20

It is true that different modulation techniques, such as CDMA, provide much higher levels of protection against interference noise, and therefore these values would be conservative. It is not asserted that NGSO FSS systems coming into the band should be afforded protection from terrestrial services. Indeed, to do so would unduly constrain the development of terrestrial services in the band.

4.2 Static Analysis

Interference into NGSO FSS systems was calculated using Equation 3, repeated here:

$$I/N = P + 10*\log(B/b) + Gtx(theta1) - pathloss(x) + Grx(theta2) - gas - N \qquad \text{(Equation 3)}$$

Where:

P	: Transmit Power and includes polarization isolation according to Rec. ITU-R F.1245 (note7),
B	: Victim receiver bandwidth,
b	: Northpoint system transmit bandwidth of 24 MHz,
Gtx(theta1)	: Gain of transmitter according to radiation pattern in the azimuth and elevation
x	: range from Northpoint transmitter,
Grx(theta2)	: gain of the victim receiver in the direction of the Northpoint transmitter,
gas	: 0 (Gaseous absorption is negligible),
N	: Victim noise level, dBW per Appendix E.

The results are presented in Appendix D— Coordination area contours for all NGSO FSS systems., and summarized in Table 20. The total area (km^2), and percent of the Northpoint service area are given where I/N values exceed 0 dB.

Table 20. Summary of Appendix 3, Coordination Area for NGSO FSS Systems

System	Area (km^2)	% of Northpoint Service Area	Peak I/N
Skybridge	19.46	8.25%	23.0
Hughes NET	10.87	4.61%	36.5
Hughes LINK	3.72	1.58%	33.7
Teledesic	1.34	0.57%	22.2
Denali	0.16	0.07%	27.4
Boeing IDS	0.13	0.06%	21.2
Boeing BDS	0.13	0.06%	28.0
Virgo	0.12	0.05%	18.7

As can be seen in Table 20, loss of a significant portion of the service area is possible for the SkyBridge, Hughes Net and Hughes Link systems. In contrast, for Teledesic, Denali, Boeing IDS & BDS and Virgo NGSO FSS satellite systems, there is potential for interference in only a very small area near the transmitter. Dynamic analysis in the next section will reveal the percent time of interference into SkyBridge. In section 4.4, methods for mitigating interference are discussed.

4.3 Dynamic Analysis

Interference from Northpoint into the SkyBridge system was simulated, according to the assumptions in Table 21. Simulation duration was 4 days at 1 second intervals (345,000 points). Principle assumptions about the SkyBridge satellite system are as listed in Appendix E. The distance from the Northpoint transmitter was varied from 1 to 4 kilometers. At 1 kilometer, the Northpoint isotropic signal level is at a maximum value.

Table 21. Dynamic Analysis Assumptions for Interference into NGSO FSS

System	Parameter	Value	Units
	Frequency	12.5	GHz
	Atmospheric Loss	Per ITU Model	
	U.S. Standard Atmosphere		
SkyBridge			
	Radiation Pattern	39-25log	
	Peak Gain	30.8, 36	dBi
	Distance from Northpoint Transmitter	0 - 4	km
	Azimuth to Northpoint Transmitter	40	deg
	Station Latitude	30	deg
	Target Satellite Selection	Highest Elevation Satellite	
	GSO Arc Avoidance	Yes	
Northpoint			
	Transmitter Power	-17.5	dBW
	Radiation Pattern	Per section 1	
	Transmitter Height above average terrain	150	meters
	Polarization Isolation[22]	Rec. F.1245 note 7	
	Peak Gain	10	dBi

The results of the dynamic analysis into SkyBridge are presented in Figure 21, taken for a worst-case azimuth for SkyBridge of 40 degrees. As illustrated, for distances outside 4 km, both the short and long term limits are met.

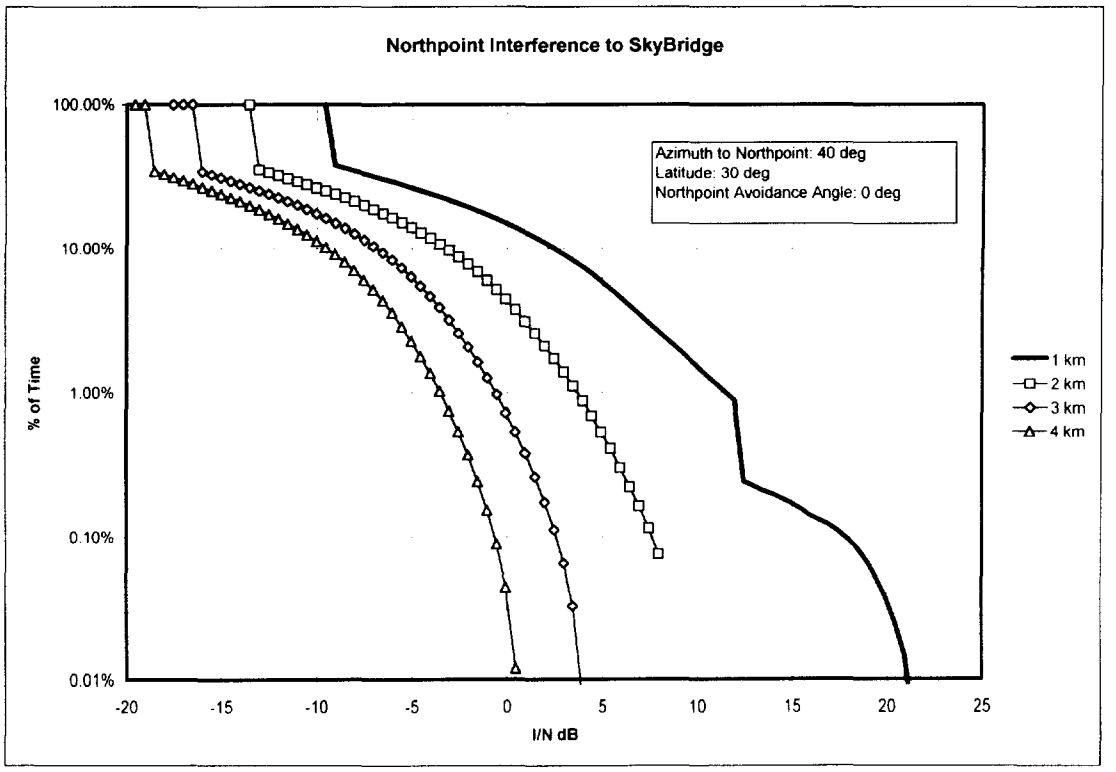


Figure 21 . Interference into SkyBridge

[22] Polarization isolation per Rec. ITU-R F.1245 note 7 is taken in the main beam of the Northpoint Transmitter, the first side-lobe of the transmitter is at 120 degrees off- boresight.

Noting from Figure 21 that if the short-term limit is met, then the long-term limit is also met, it can be concluded that the interference area for SkyBridge only encompasses the area where peak I/N values exceed 0 dB. (This phenomenon is also recognized for time-varying interference from NGSO systems into GSO systems.) Although more detail on the operational characteristics of the other NGSO FSS systems is required to perform a dynamic analysis, it can be assumed that the conclusions hold true about NGSO FSS systems in general.

4.4 Interference Mitigation for NGSO FSS Systems

It was shown in section 4.3 that only the peak I/N need to be considered to determine the size of the coordination area. Moreover, in section 4.2, it was shown that the size of the coordination area is very small for Boeing, Denali, and Virgo. For these systems, the coordination area is so small that it is unlikely there would be any NGSO FSS customers in the coordination area.

Before any discussion of NGSO FSS mitigation techniques, it should be pointed out that the Northpoint design includes a number of mitigation techniques designed expressly to share with satellite systems. These methods (as discussed in sections 1.1 and 2.2) include:

- Directional Transmission
- Maximum Altitude Transmit Antenna Placement
- Transmit Beam Tilting
- Antenna Radiation Discrimination
- Natural Shielding and Terrain Blockage

Varieties of methods are also available to NGSO FSS operators to minimize interference and coexist with Northpoint, such as:

- *Alternate Beam Assignment*—The use of alternate frequencies in the coordination area completely eliminates interference in the coordination area, at no loss in service capability for NGSO FSS.

- *Satellite Diversity,* the use of *higher gain receive antennas*, and *increasing elevation angle* can also reduce the size of the coordination zone.

4.4.1 Alternate Beam Assignment

Alternate Beam Assignment— The use of alternate frequencies in the coordination zone completely eliminates interference in the coordination area. All NGSO FSS systems have applied for over 1000 MHz in the downlink direction, and thus NGSO FSS systems propose to operate service links from 10.7 to 12.7 GHz. NGSO FSS systems will provide service to a given area with multiple beams of the same satellite. In fact, this re-use of the spectrum is crucial to providing efficient use of the spectrum by NGSO FSS. Even with five times frequency re-use (to avoid adjacent cell interference), each satellite will be able to serve each cell with up to eight beams across the (at least) 1000 MHz proposed to be allocated to NGSO FSS.

NGSO FSS systems *must* have sophisticated network management software to handle traffic loading and handovers between satellites.[23] As a matter of course, up to 100 times a day, or more, network management will assign each NGSO FSS customer to a specific frequency, and to a specific satellite. These assignments will need to consider many factors, including local obscura, GSO arc avoidance, and satellite elevation to name but a few. The location of all NGSO FSS customers is known to NGSO FSS operators. It is therefore a simple matter to assign those few customers in the Northpoint coordination area to a frequency outside of 12.2 - 12.7 GHz.

[23] For example, SkyBridge and other LEO systems with an average of 15 minutes in-view time, must make a minimum of 100 satellite handovers per day, even in ideal conditions.

The implementation of this interference mitigation technique does not impact NGSO FSS systems. The size of the largest coordination zone for NGSO FSS is less than 10% of the Northpoint service area. Even if this figure were as large as 50%, NGSO FSS operators would not be impacted, as more than 50% of the NGSO FSS spectrum is allocated outside of the 12.2 - 12.7 GHz band.

Therefore, NGSO FSS systems have the option of serving their customers in the coordination area from outside of the 12.2 - 12.7 GHz band. As previously stated, these coordination areas are small. Even if they were as much as 50% of the service area, this would be a viable no-impact solution to prevent interference into NGSO FSS systems from terrestrial systems. The sophisticated network management software responsible for assigning frequencies and managing handovers on an operational basis can be programmed to serve customers in the Northpoint coordination area from frequencies outside of the 12.2 - 12.7 GHz range.

4.4.2 Satellite Diversity

NGSO FSS systems also have the option of using satellite diversity to mitigate interference. Each point in the U.S. typically has more than one satellite in view at all times and usually more than two satellites in view, thus having the option of using satellite diversity to mitigate interference. This method is also minimal impact, as NGSO FSS systems must perform already handovers, at least 100 per day for LEO systems.

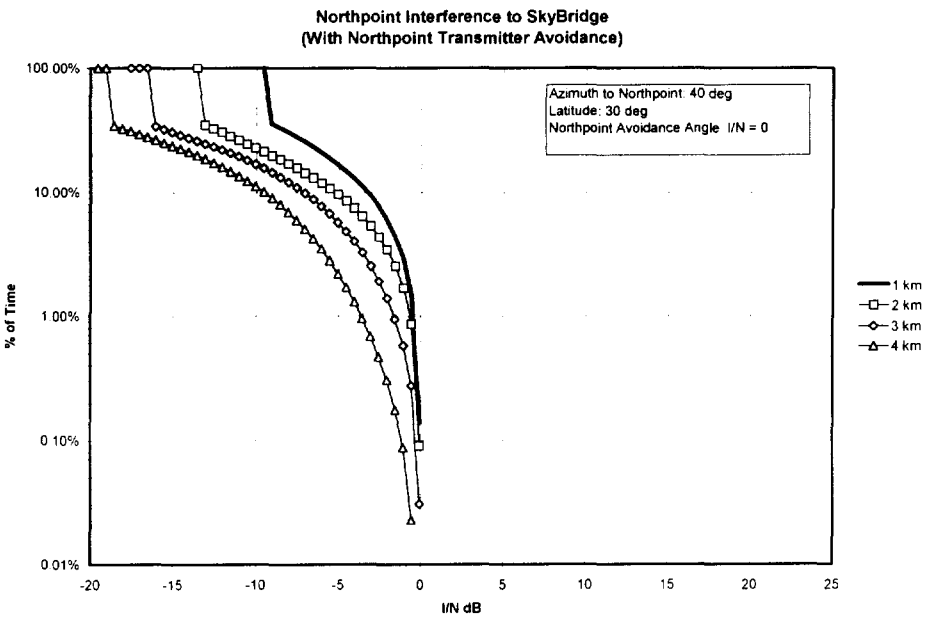


Figure 22 . Interference into SkyBridge using Satellite Diversity

As seen in Figure 22, I/N interference at values greater than 0 dB can be avoided using satellite diversity. However, the low side-lobe levels of the SkyBridge receive antenna does not provide enough signal rejection to minimize interference inside of a 2 km radius. Therefore, satellite diversity can be used to mitigate interference, but in the case of SkyBridge, primarily outside of a 2 km radius. However, as discussed further in Section 4.4.3, the use of a higher gain receive antenna within the coordination area will help mitigate interference for SkyBridge.

4.4.3 Increase Antenna Gain

Increasing antenna gain in the coordination area can mitigate interference and shrink the size of the coordination area. Increase in antenna gain has the following effects: (1) Increased carrier power reduces the effect of background noise, and (2) decreased side-lobe levels reduces the amount of background noise. The results are seen in Table 22. Effect of increased antenna gain on NGSO FSS coordination area.

Table 22. Effect of increased antenna gain on NGSO FSS coordination area.

System	Area (km^2)	% of Northpoint Service Area
Skybridge	6.45	2.7%
Hughes NET	5.04	2.1%
Hughes LINK	2.0	0.85%
Teledesic	0.7	0.30%

Increasing antenna gain reduces the coordination area but does not eliminate it.

4.4.4 Increase Minimum Elevation Angle (In conjunction with increased receiver gain)

Increase in minimum elevation angle can also mitigate interference. This method significantly reduces the size of the coordination area when used in conjunction with increased antenna gain.

Table 23. Effect of 20 degree minimum elevation angle on NGSO FSS coordination area.

System	Area (km^2)	% of Northpoint Service Area
Skybridge	1.8	0.76%
Hughes NET	1.4	0.59%
Hughes LINK	0.26	0.11%

4.5 Conclusions

It was shown in this section that coordination between NGSO FSS systems and Northpoint is required.[24] The size of the coordination area varies among the proposed systems, from about 200 meters in the case of Denali, Virgo and Boeing to about 4 kilometers for Hughes and SkyBridge. A 200 meter coordination area is unlikely to be populated with NGSO FSS customers, as Northpoint transmitters will typically be placed on towers, hills and tall buildings.

Terrestrial interference into NGO-FSS systems is time varying, and as such the dynamic atmospheric margin can be used to mitigate interference. Interference criteria for NGSO FSS systems are proposed, and these are similar to criteria used for NGSO FSS systems in other bands. Dynamic analysis was used to verify that the coordination area is limited by the short-term criteria, and that if the short-term criterion is met, the long-term criterion will also be met.

This is not to assert that NGSO FSS systems coming into the band should be afforded protection from terrestrial services. Indeed, to do so would unduly constrain the development of terrestrial services in the band.

However, coordination between terrestrial systems and NGSO FSS will allow ubiquitous operation of NGSO FSS services. Varieties of interference mitigation techniques are available to NGSO FSS operators.

[24] Even with the variety of interference mitigation techniques employed by Northpoint.

These techniques can be employed at low-cost and no-impact to service and availability. The most promising of these techniques is *Alternate Beam Assignment*, which eliminates interference.

With *Alternate Beam Assignment*, NGSO FSS systems have the option of serving the customers in the coordination area with a beam not affected by Northpoint. The coordination area is small, (i.e. between 0.05% and 10% of the service area). Even if they were as much as 50% of the service area, *Alternate Beam Assignment* would be a viable no-impact solution. Other mitigation techniques, such as *satellite diversity*, the use of *higher gain antennas*, and *increasing elevation angle*, were examined. These techniques can also reduce the size of the coordination zone.

Therefore, it can be concluded that Northpoint is compatible with NGSO FSS systems, although coordination is required. Interference can be mitigated on a no-impact basis to allow ubiquitous operation of all types of NGSO FSS systems.

5 SUMMARY AND CONCLUSIONS

In this report, the compatibility between Northpoint Technology and a variety of satellite systems was 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. It was demonstrated that Northpoint has sufficient availability to be offered on a commercial basis.

In section 2, it is shown that Northpoint is fully compatible with DBS technologies, and will not cause harmful interference into DBS systems. Northpoint will provide a minimum C/I ratio of 20 dB to 99.8% of all DBS customers and a C/I ratio of 17 dB or greater to 100% of all DBS customers. Even using the lower ratio of 17 dB, this value is well above the harmful interference criteria of 8 dB.

In section 3, interference from NGSO FSS into Northpoint systems was examined using both static and dynamic methods. This was found to be significant from three systems (Hughes Net, Hughes Link and SkyBridge). This interference can be mitigated by NGSO FSS with *Terrestrial Arc Avoidance.* NGSO FSS system implementers have several no-impact techniques readily available.

An analysis of interference from Northpoint into NGSO FSS systems is performed in section 4, where is it is shown that some coordination between NGSO FSS and Northpoint is required. The size of the coordination area varies among the proposed systems, from about 200 meters in the case of Denali, Virgo and Boeing to about 4 kilometers for Hughes and SkyBridge. Various mitigation techniques were examined and demonstrated to reduce interference. The most promising mitigation technique, *Alternate Beam Assignment* would eliminate interference at <u>no impact to NGSO FSS operations</u>.

The concept of coexistence can best be visualized in Figure 23, which is a 'sky-pie' chart. Northpoint Technology operates in the Terrestrial arc, GSO systems operate in the GSO arc, and NGSO FSS systems operate in the NGSO arc. Note the NGSO arc is by far the largest portion of the sky-pie.

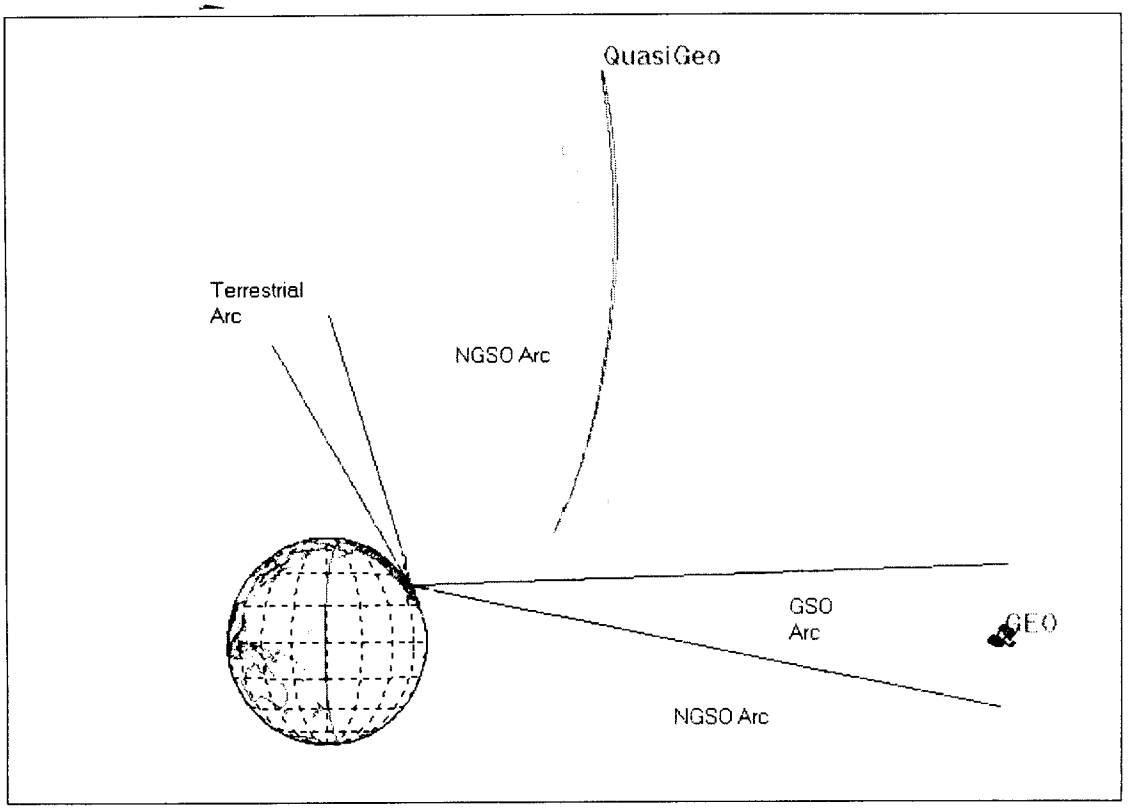


Figure 23. Global View of Sharing

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.*

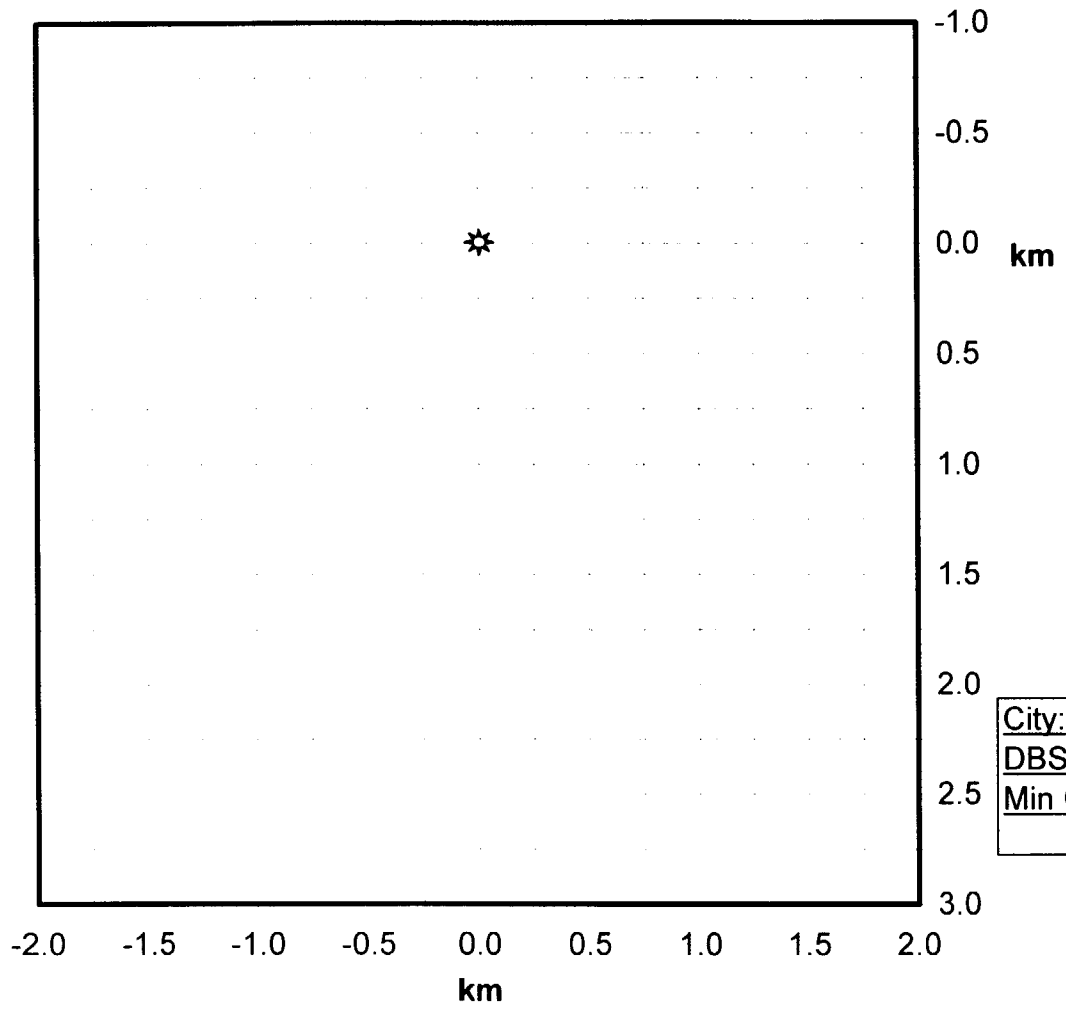
[10] ITU-R F.755-1, *Point-to-Multipoint Systems Used in the Fixed Service.*

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

APPENDIX B— C/I CONTOURS FOR ALL DBS SYSTEMS

City	DBS Longitude	Page
Austin	101	B-1
Austin	119	B-2
Austin	148	B-3
Austin	61.5	B-4
Austin	85	B-5
Bangor	101	B-6
Bangor	119	B-7
Bangor	61.5.	B-8
Bangor	85	B-9
Chicago	101	B-10
Chicago	119	B-11
Chicago	61.5	B-12
Chicago	85	B-13
Los Angeles	101	B-14
Los Angeles	119	B-15
Los Angeles	148	B-16
Los Angeles	61.5	B-17
Los Angeles	85	B-18
Miami	101	B-19
Miami	119	B-20
Miami	61.5	B-21
Miami	85	B-22
Seattle	101	B-23
Seattle	119	B-24
Seattle	148	B-25
Seattle	85	B-26

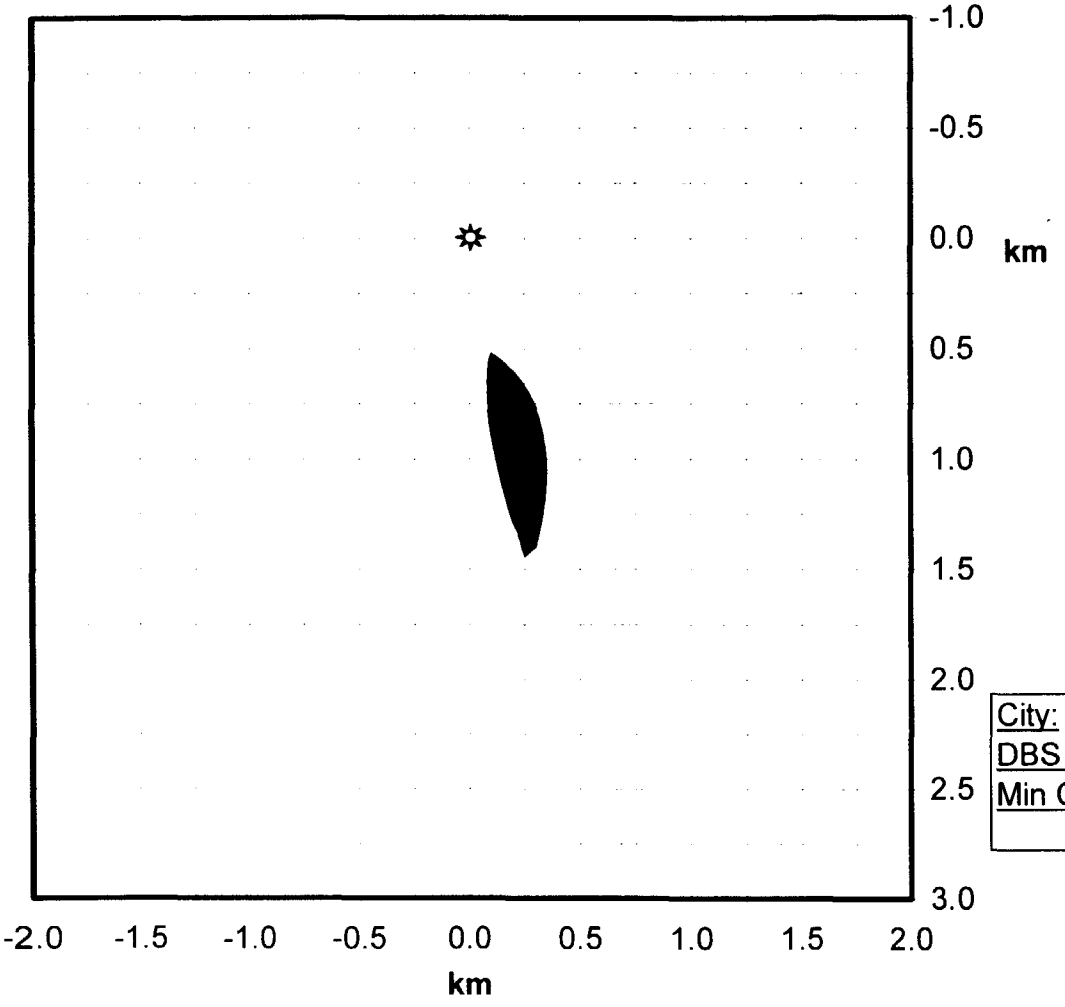
DBS C/I CONTOURS



C/I
22-24
20-22
■ 18-20
16-18

City:	**Austin**
DBS Sat. Long:	**101 W**
Min C/I Ratio:	**20.1 dB**

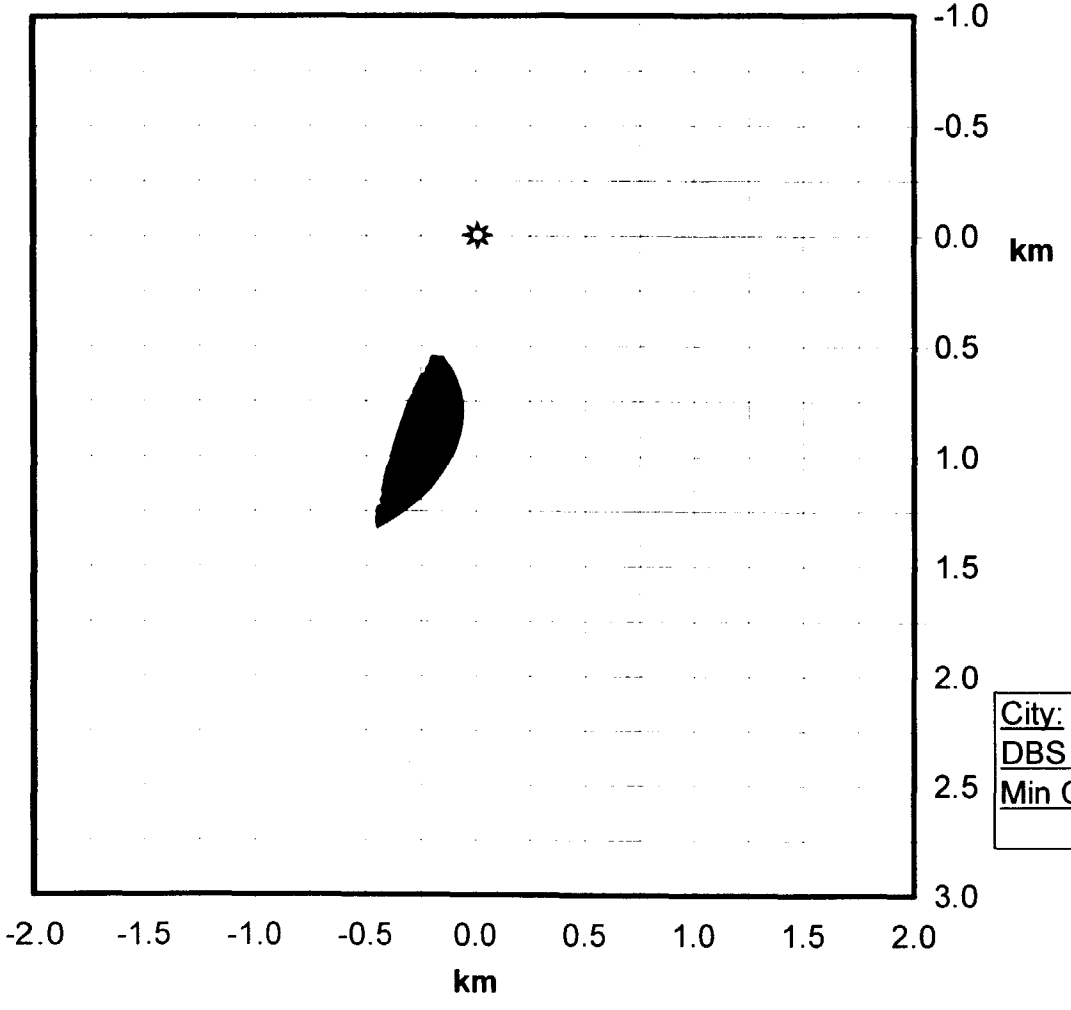
DBS C/I CONTOURS



C/I
22-24
20-22
18-20
16-18

City:	**Austin**
DBS Sat. Long:	**119 W**
Min C/I Ratio:	**18.5 dB**

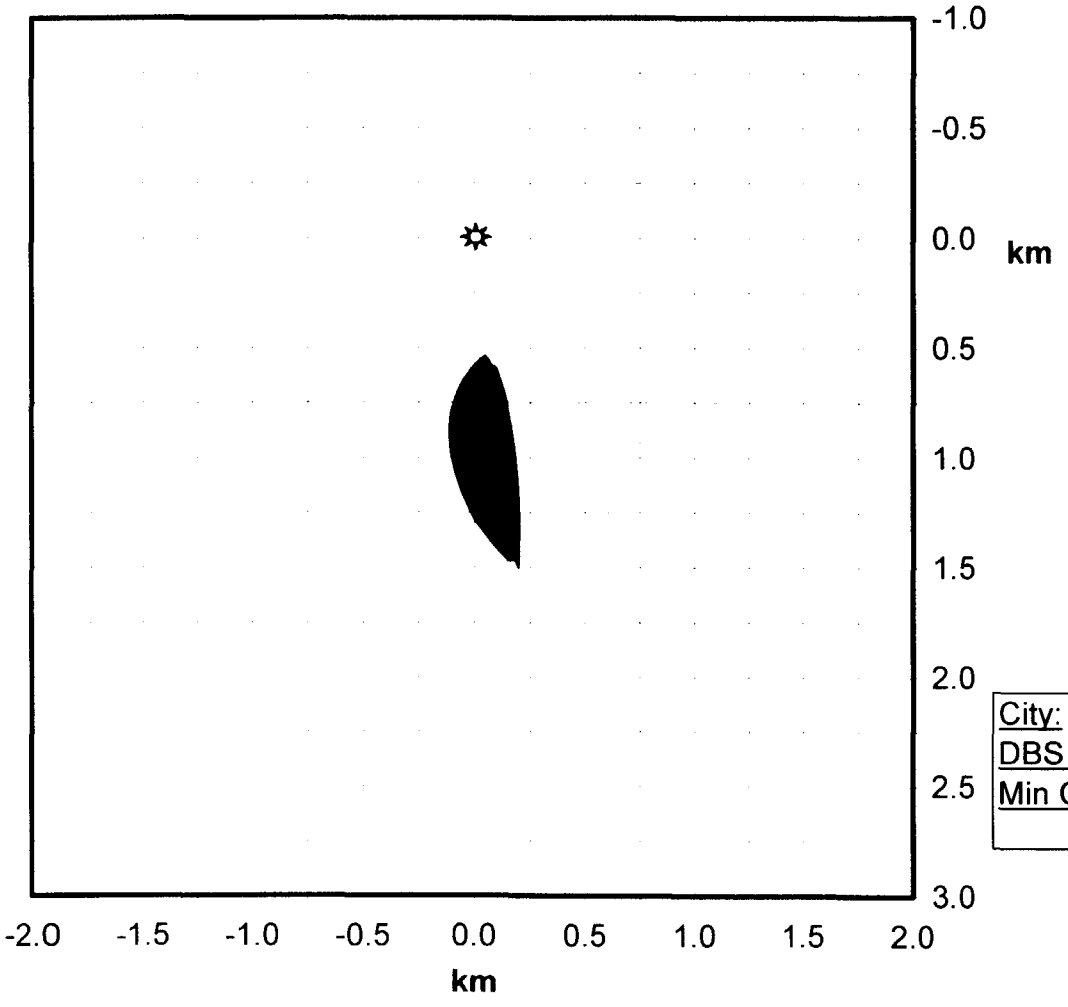
DBS C/I CONTOURS



C/I
22-24
20-22
18-20
16-18

City:	**Austin**
DBS Sat. Long:	**148 W**
Min C/I Ratio:	**18.5 dB**

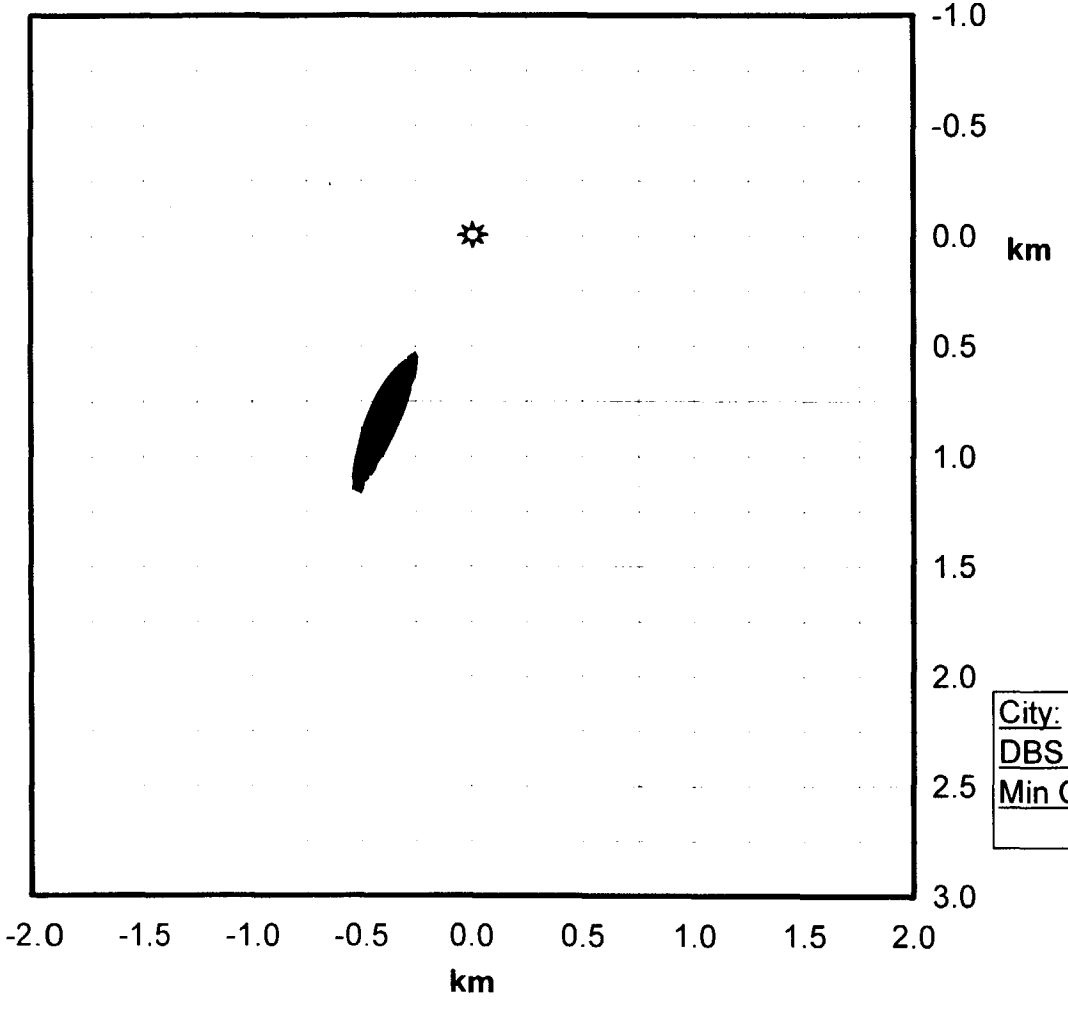
DBS C/I CONTOURS



C/I
22-24
20-22
18-20
16-18

City:	**Austin**
DBS Sat. Long:	**61.5 W**
Min C/I Ratio:	**17.9 dB**

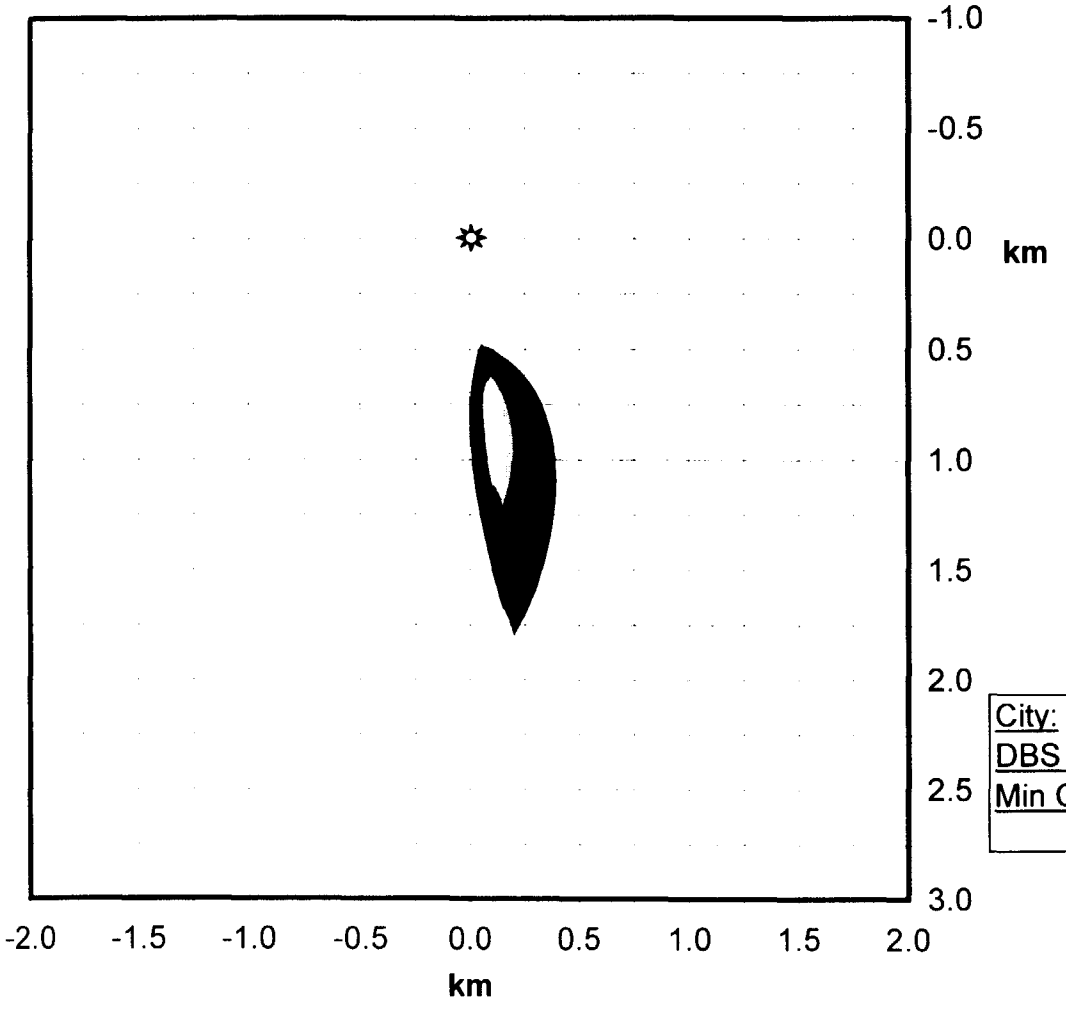
DBS C/I CONTOURS



C/I
22-24
20-22
18-20
16-18

City:	**Austin**
DBS Sat. Long:	**85 W**
Min C/I Ratio:	**18.8 dB**

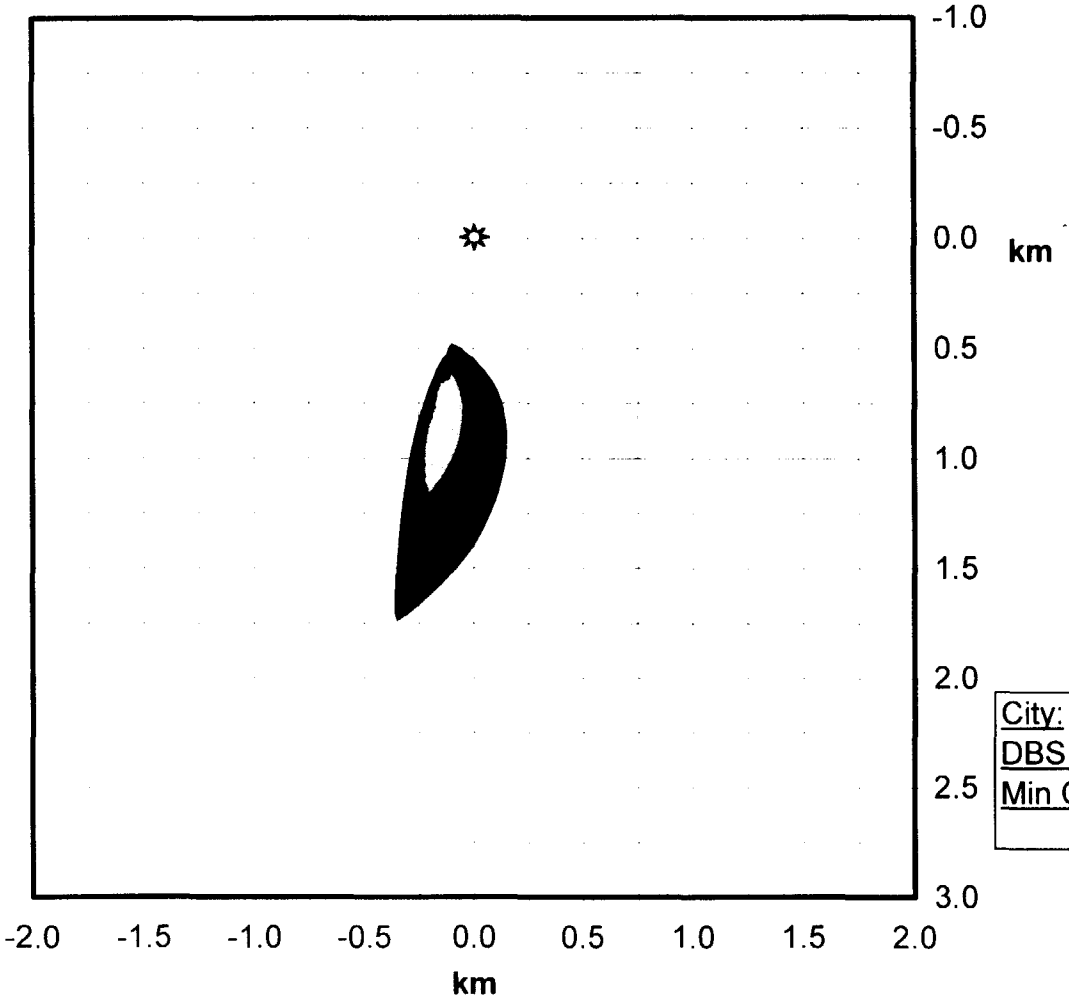
DBS C/I CONTOURS



C/I
22-24
20-22
■ 18-20
16-18

City:	**Bangor**
DBS Sat. Long:	**101 W**
Min C/I Ratio:	**17.4 dB**

DBS C/I CONTOURS



C/I
22-24
20-22
18-20
16-18

City:	**Bangor**
DBS Sat. Long:	**119 W**
Min C/I Ratio:	**17.0 dB**