Exhibit *1*

5C. 500 mirad of the following locations.

Seattle, WA	47-31-55N	122-18-08W
Edwards AFB, CA	34-54-17N	117-53-01W
Nellis AFB, NV	36-14-32N	115-02-41W
Andrews AFB, MD	38-48-39N	076-52-02W

Exhibit 3

6(a) 11.5° Max at 60° scan; 5.25° Max @ Broadside

6(b) Parallel to Horizontal plane

6(c) Varies dependant on aircraft orientation and electric scanning

EXHIBIT 1 of FCC FORM 422 Question10.

This narrative statement will describe in detail the following:

(a) The complete program of research and experimentation proposed including description of equipment and theory of operation.
(b) The specific objectives to be accomplished
(c) How the program of experimentation has a reasonable promise of contribution to the development extension, expansion or utilization of the radio art, or in along lines not already investigated.

Introduction:
Commercial airlines and military services have expressed a desire for two-way data communications while in transit. As a major supplier of aircraft, Boeing is interested in providing this service to its customers. Once developed, the technology would be useful for any mobile platform in need of two-way data communications. There are two ways to approach this problem.

The first is to construct a network of ground stations that can provide continuous coverage anywhere in the continental United States (CONUS). This approach requires a large investment to construct the necessary infrastructure for desired coverage.

A second approach is to provide the service via satellite. Ku-band FSS Satellites provide worldwide terrestrial and limited maritime coverage with sufficient power to enable high rate data communications. Transponders on these satellites may be leased/purchased at a significantly lower cost than the development of a ground-based network.

Boeing currently manufactures phased array receive antennas for operation with Ku-band FSS and BSS satellites. This system receives information broadcasts anywhere within CONUS at data rates greater than 1.5 Mbps. Customers can receive cable television as well as data transmissions. The low profile array and external mounting hardware virtually eliminate impact to the aerodynamic performance of the platform and all support hardware is installed inside the structure, allowing environmental control and maintenance access.

To satisfy the two-way communication requirement, a data downlink capability is needed from the platform to the ground station. In order to transmit, the antenna's beam must not interfere with satellites on either side of the target satellite. The 2° orbital spacing of FSS satellites makes this rather difficult. A small antenna that does not conform to the requirements of CFR, title 47, part. 25.209 (a) and (b) can be used, provided that it is shown that unacceptable levels of interference will not be caused under conditions of uniform 2° orbital spacing. ITU radio regulations, appendix 29 provides a method of determining a level of acceptable interference not requiring coordination.

Objective:
The objective of this experiment is to develop a high data rate, satellite information transmission system to use on mobile platforms. A small aperture Boeing Ku-band phased array antenna will be used to transmit a direct spread spectrum modulated signal. This transmit system will lower the power spectral density to within acceptable interference levels at adjacent satellites.

The system will be similar to the Qualcomm OmniTRACS system that utilizes Ku-band FSS satellites for mobile communications with truck fleets.

Approach:
A block diagram of the proposed experimental system is shown in Figure 1. The input data is encoded with a concatenated forward error correction (FEC) coding scheme improve the receiver E_b/N_o. The outer code is a Reed-Solomon (RS) (255, 223) code.

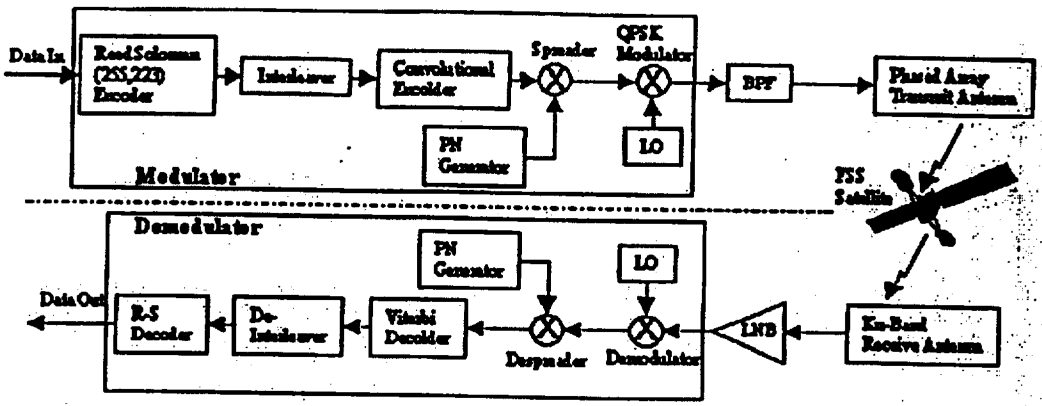

Figure 1 Experimental Transmit System Block Diagram

Given an input data rate of 256 kbps, following the FEC, the coded data rate is 585 kbps and the signal is direct-sequence spread by a factor of 274. The spread signal is QPSK modulated, band-pass filtered at the first spectral null producing a spectral occupancy of about 20 MHz, and transmitted with a phased array antenna.

The transmit antenna is a 254 element phased array. It is approximately 8" x 13.5" x 1.5" and has a broadside 3 dB beamwidth of 6 degrees. When the antenna is scanned to its maximum scan angle the beamwidth is 12 degrees. Figures 2 and 3 are plots of the anticipated beam patterns for the broadside beam and for the maximum angle scanned beam. As can be seen from the beam patterns, there is no appreciable signal interference for signals into the adjacent satellites at a 2° orbital spacing. The spectrum spreading technique is used to reduce the PSD to a level that does not cause unacceptable interference into the adjacent satellite.

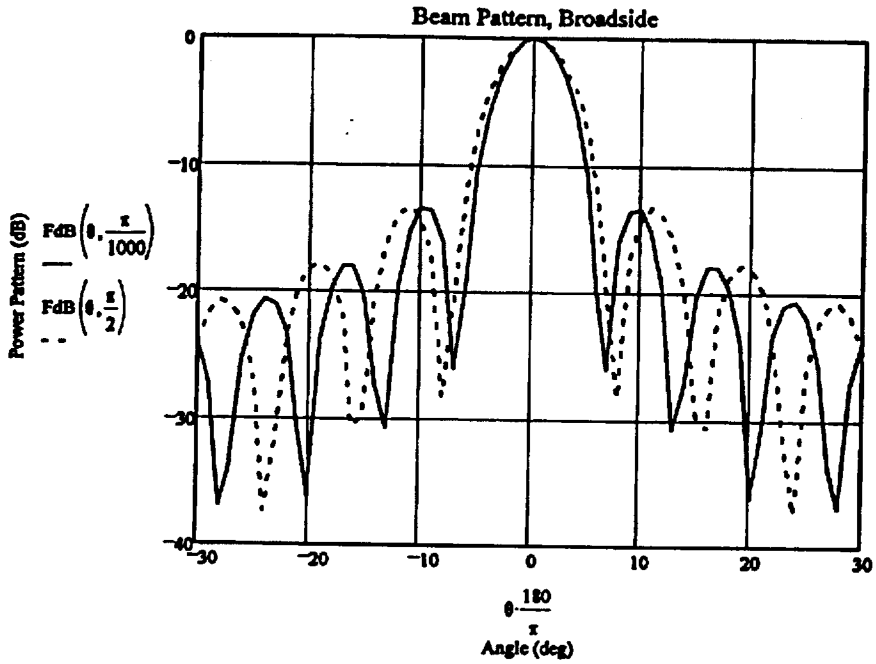

Figure 2 Beam Pattern for Transmit Antenna at Broadside
Solid line shows pattern for ϕ=0° cut. Dashed line shows pattern for ϕ=90° cut.

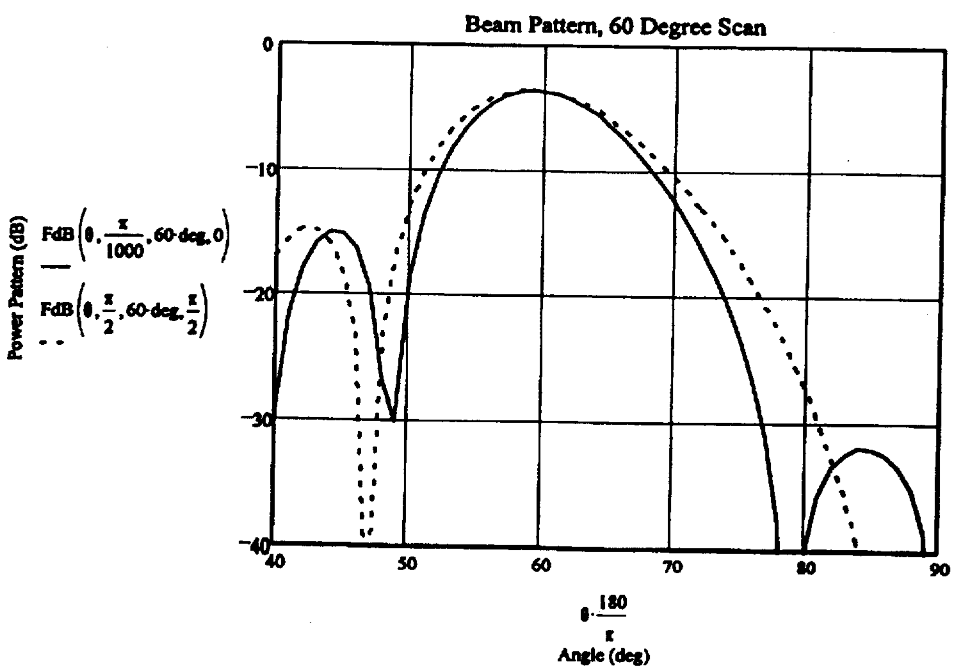

Figure 3 Beam Pattern for Transmit Antenna at Maximum Scan Angle
Solid line shows pattern for ϕ=0° cut and scanned to (θ,ϕ)=(60,0). Dashed line shows pattern for ϕ=90° cut and scanned to (θ,ϕ)=(60,90).

The required output power from the RF Amplifier into the phased array antenna is 1.5 Watts. The final output power from the antenna is 26 W continuous mean power. The antenna will transmit linear polarization matched to the satellite transponder. This is accomplished by adjusting the angle of the transmitted polarization based on position and attitude information, relative to the satellite, supplied by an aircraft's navigational system or a GPS Attitude System. The satellite is tracked by the System Phased Array Controller (SPAC) based on signal strength at the receive antenna. The SPAC in turn keeps the transmit antenna oriented towards the correct satellite. The beam location is updated 100 times every second.

The ground station downlink utilizes a 4.5-meter dish antenna to receive the low-level, spread spectrum signal. The receiver reverses the process of the spread-spectrum modulator by de-spreading, demodulating, and decoding the signal.

It is anticipated that this system will use a transponder on the GE1 satellite (103° West). Figure 4 shows the link budget for the overall system via the satellite. This link budget includes the effects of the uplink, downlink, cross-polarization interference, and adjacent satellite interference from the neighboring satellites. The overall system margin is between .35 and .95 dB depending on system location.

OVERALL SYSTEM LINK BUDGET					
Link Parameter	**Value**				
Transmit Frequency	14.3 GHz				
Boltzmann's Constant	-228.6 dB/Hz-K				
Bandwidth Direct Sequence Spread Spectrum	20 MHz				
Rain Loss	0 dB				
Code Rate ½ convolutional, RS (255,223)	0.437255				
Modulation Type	QPSK				
	GE-1 (103° W)				
	Edwards AFB, CA	Seattle, WA	Nellis AFB, NV	St. Louis, MO	Langley, VA Andrews AFB, MD
Uplink C/N_o (dB)	-9.1	-13.16	-6.41	-7.01	-9.39
C/I (Cross Polarization) (dB)	15	15	15	15	15
C/I (Left Satellite) (dB)	15	15	15	15	15
C/I (Right Satellite) (dB)	15	15	15	15	15
Downlink C/N_o (dB)	12.33	9.98	11.96	12.43	11.22
Total $C/(N_o+I)$ (dB)	-9.16	-13.19	-6.57	-7.14	-9.5
Data Rate (kbps)	550	250	1000	900	550
Achieved E_b/N_o (dB)	6.45	5.85	6.45	6.3	6.13
Required E_b/N_o (dB)	5.5	5.5	5.5	5.5	5.5
System Margin (dB)	0.95	0.35	0.95	0.8	0.63

Figure 4 Overall System Link Budget

Figure 5 shows the link budget for the satellite uplink from an aircraft to the satellite. A C/N of −13.16 dB is acceptable for a spread spectrum signal. The transmit EIRP for this link is about between 37.7 and 39.5 dBW depending on system location.

SATELLITE UPLINK BUDGET					
Link Parameter	**Value**				
Transmit Frequency	14.3 GHz				
Boltzmann's Constant	-228.6 dB/Hz-K				
Bandwidth	20 MHz				
Rain Loss	0 dB				
	GE-1 (103° W)				
	Edwards AFB, CA	Seattle, WA	Nellis AFB, NV	St. Louis, MO	Langley, VA Andrews AFB, MD
Transmit EIRP (dBW) 254 elements, -10dBW / element	39.5	37.7	39.2	39.5	38.4
Scan Angle (degrees)	42	58	45	41	53
Scan Loss (dB)	-1.547	-3.309	-1.81	-1.47	-2.65
Polarization Loss (dB)	-0.1	-0.1	-0.1	-0.1	-0.1
Antenna Losses (dB) Amplitude/phase error, Pattern loss	-0.5	-0.5	-0.5	-0.5	-0.5
Squint Loss (dB)	0	0	0	0	0
Element Efficiency (dB)	-1	-1	-1	-1	-1
Impedance Mismatch (dB)	-0.5	-0.5	-0.5	-0.5	-0.5
Transmit Range (km)	37170	38450	37390	37130	38010
Path Loss (dB)	-206.95	-207.25	-207.00	-206.94	-207.10
Atmospheric Loss(dB)	-0.20	-0.21	-0.20	-0.20	-0.21
Satellite G/T (dB/K)	3	1	6	5	4
Uplink C/N_o (dB)	-9.1	-13.16	-6.41	-7.01	-9.39

Figure 5 Satellite Uplink Budget

Figure 6 shows the link budget for the satellite downlink. A satellite transmit EIRP of approximately 9.27 dBW will produce a C/N of about 9.98 dB. Again, this is acceptable because of the spread-spectrum nature of the signal.

SATELLITE DOWNLINK BUDGET	
Link Parameter	Value
Downlink Frequency	12.2 GHz
Boltzmann's Constant	-228.6 dB/Hz-K
Bandwidth	20 MHz
Rain Loss	0 dB
	GE-1 (103° W)
	Seattle, WA
Transmit EIRP (dBW)	9.27
Antenna Pattern Loss (dB)	-0.5
Polarization Loss (dB)	-0.1
Transmit Range (km)	38450
Path Loss (dB)	-205.87
Atmospheric Loss(dB)	-.21
Ground Station G/T (dB/K)	50
Downlink C/N_o (dB)	9.98

Figure 6 Satellite Downlink Budget

In order to show that the link does not cause unacceptable levels of interference to the adjacent satellites, a ΔT/T analysis was conducted in accordance with the procedure of the ITU Radio Regulations, Appendix 29. That analysis is shown in Figure 7. The ΔT/T of the system is about 4.2%, which is below the 6 % threshold required for coordination.

ΔT/T Interference Analysis				
Operating Satellite	GE-1			
Adjacent Satellite (worse case)	Spacenet IV			
Uplink (Interference)				
Frequency	14.3	GHz		
EIRP (total)			41.009	dBW
# of channels	1	Channel		
Bandwidth	20	MHz	73.01	dBHz
Data Rate	256	Kbps		
Code Rate (1/2 conv, RS(255,223))	.437255			
Spread Ratio	68.32			
Transmit Pattern Loss			0	dB
Angle to Adj. Satellite	2	deg		
Path Loss			-207.26	dB
Range	38,360	km		
Orbit Altitude	35,800	km		
Elevation (from horizon)	33	deg		
Adj. Satellite Receive Gain			31.0	dB
Adj. Satellite Pattern Loss			0	dB
ΔT (up)	108.958	Kelvin	20.373	dBK
Downlink (Interference)				
Frequency	12.2	GHz		
EIRP(S+N)			37	dBW
Transmit Pattern Loss			0	dB
Angle to Adj. Ground Station	0	deg		
Path Loss			-205.77	dB
Range	38,360	km		
Orbit Altitude	35,800	km		
Elevation	33	deg		
Adj. Ground Receive Off-Axis Gain			21.5	dB
ΔT (down)	6.79	Kelvin	8.32	dBK
Link Gain	-11	dB		
Adj. Satellite Noise Temp (Tup)	31.6	dBK	1445.44	Kelvin
Adj. Ground Noise Temp (Tdown)	24	dBK	251.19	Kelvin
ΔT (total)	15.45	Kelvin		
T (total)	366.004	Kelvin		
ΔT/T	0.042		0.06	limit

Figure 7 ΔT/T Analysis for Experimental System

Summary:
Granting of this experimental license will enable the development of low-cost, data-communications systems that can provide communications connectivity to mobile platforms anywhere in CONUS. With extension to other satellites around the world, the system will provide connectivity anywhere there is sufficient coverage.

When additional transmitters are added to the system for operation on the same transponder, the data rate is reduced, in a direct relationship to the number of transmitters added. By utilizing the CDMA architecture a number of simultaneous users may be effectively added to the system, at the expense of the high data rates used during the experimental phase of this endeavor. Even at significantly lower data rates, the transmit capability will be very valuable for the backhaul of data and voice. Specifically, in the commercial arena, in-flight entertainment such as web browsing, does not require high transmit data rates. Unfortunately the military requirement of high data rate backhaul channels, will limit the number of simultaneous transmitters unless a significantly larger antenna is utilized.

The development of this communications system will provide airlines with greater visibility of aircraft operations; resulting in improved servicing and maintenance of the aircraft fleet. It will also provide airline customers with more versatile in-flight services. Military customers will have real-time access to time critical information and the means to participate in multi-party videoconferences between airborne and ground units.

A grant of this experimental license application would be in the public interest.

Exhibit 2 to FCC Form 442, Question 13

Manufacturer	Model	Number
Boeing	Transmit Phased Array Antenna (TxPAA) Prototype	8
Boeing	TxPAA Controller Prototype	8
Boeing	TxPAA Power Supply Prototype	8
SSE Telecom	K-Star 2 watt Transceiver Model OM 042398	8
L3 Communications	Spread Spectrum Modem VME form factor model EB200	8
SBS GreenSpring	IP-Reed Soloman Card, Model 91411921	8

RECEIVE CHARACTERISTICS OF BOEING'S PHASED ARRAY ANTENNA

1 INTRODUCTION

Boeing's unique airborne phased-array antenna system is capable of both transmitting and receiving signals from geostationary ("GSO") satellites operating in the Ku-band. In January 1999, Boeing applied for and was subsequently granted an experimental license to use and operate its phased-array antenna system to transmit radio communications to GSO satellites in 14.0-14.5 GHz frequency band (File No. 0038-EX-PL-1999). Because the technical characteristics of an antenna's receive capabilities are not required for the issuance of an experimental transmitter license, Boeing provided only partial information on this subject at the time of its application. In order to provide a more complete record, however, Boeing hereby provides key technical characteristics of the receive capabilities of its system as a supplement to its present request for amendment of its existing experimental license. Specifically, Boeing provides supplemental information on the sidelobe antenna patterns and link budget of its phased-array system.

2 ANTENNA PATTERNS

The measured antenna patterns for Boeing's phased-array antenna are shown in Figures 2 through 7. Figure 1 shows the coordinate system used to describe the antenna patterns. The planar antenna is assumed to lie in the X-Y plane. The X-axis points down the long axis of the antenna towards the nose of the aircraft. Any point in the far field is described by angles θ_x and θ_y. The angles θ_x and θ_y represent great circle cuts parallel to the y and x axis respectively and denote the angles that each of these planes make with respect to the z axis.

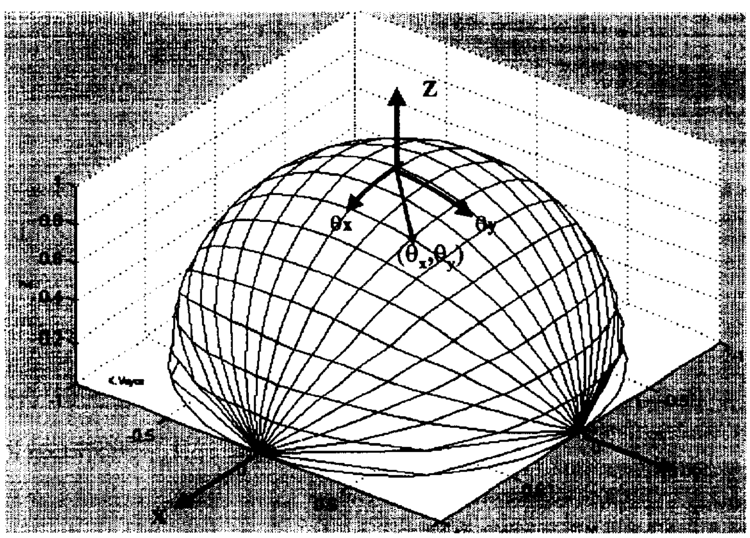

Figure 1. Coordinate System for Antenna Pattern Description

Figure 2 shows a surface plot of the antenna pattern for antenna scan angles of $\theta_x = 0°$ and $\theta_y = 0°$. Only sidelobes greater than –40 dB are shown. The sidelobes are disproportionately high along the principal axes of the antenna due to the rectangular shape of the antenna.

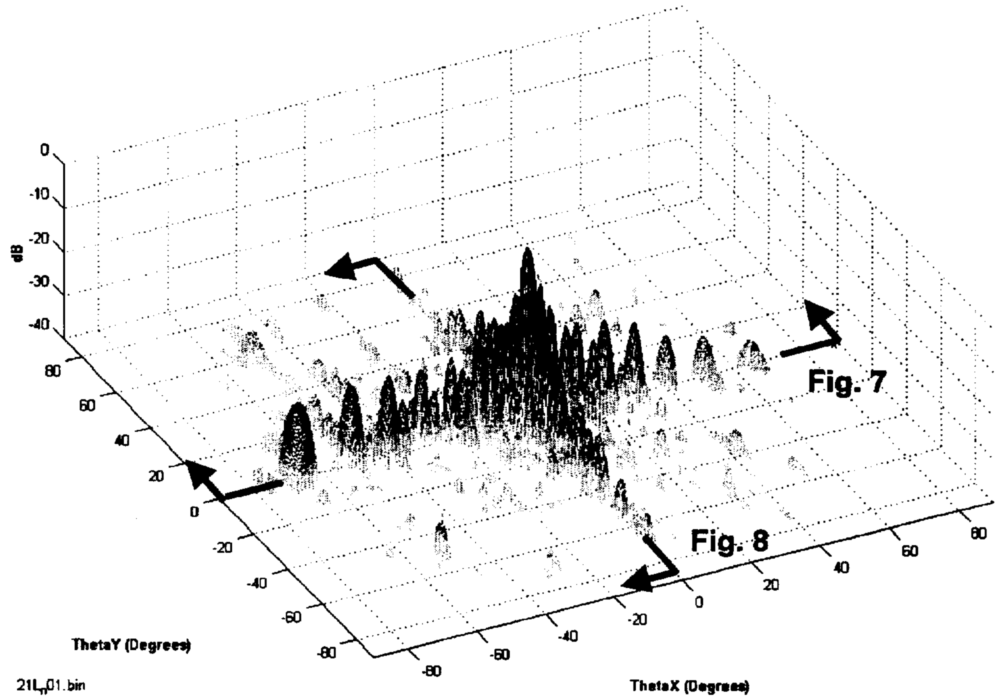

Figure 2. Antenna Pattern For Sidelobes Greater Than –40 dB at Scan Angles of $\theta_x = 0°$, $\theta_y = 0°$

Figures 3 and 4 are cuts through the principal axes of the antenna pattern for antenna scan angles of $\theta_x = 0°$ and $\theta_y = 0$. These cuts show the worst sidelobe levels for this beam position. In each case the peak sidelobe level reaches -20 dB about 10° from beam center.

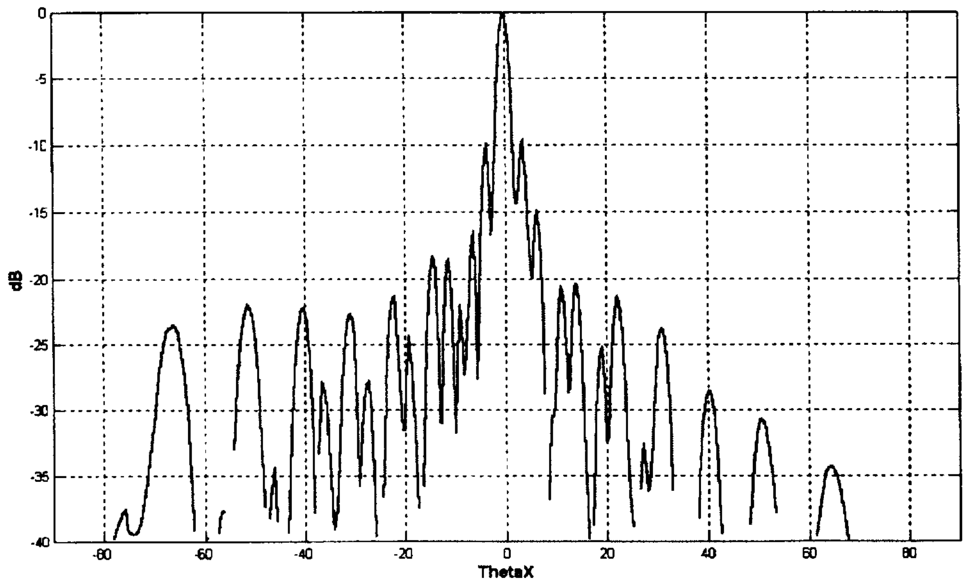

Figure 3. Antenna Pattern Cut Along θ_x
(See Figure 2)

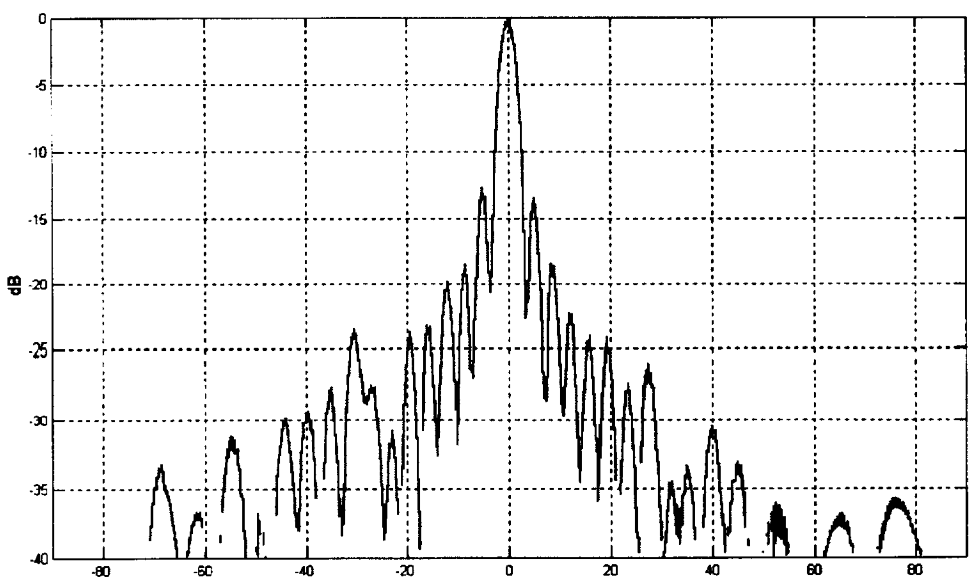

Figure 4. Antenna Pattern Cut Along θ_y
(See Figure 2)

Figure 5 shows a surface plot of the antenna pattern for scan angles of $\theta_x = 58°$ and $\theta_y = 0°$. Only sidelobes greater than –40 dB are shown. Again, the sidelobes are disproportionately high along certain axes.

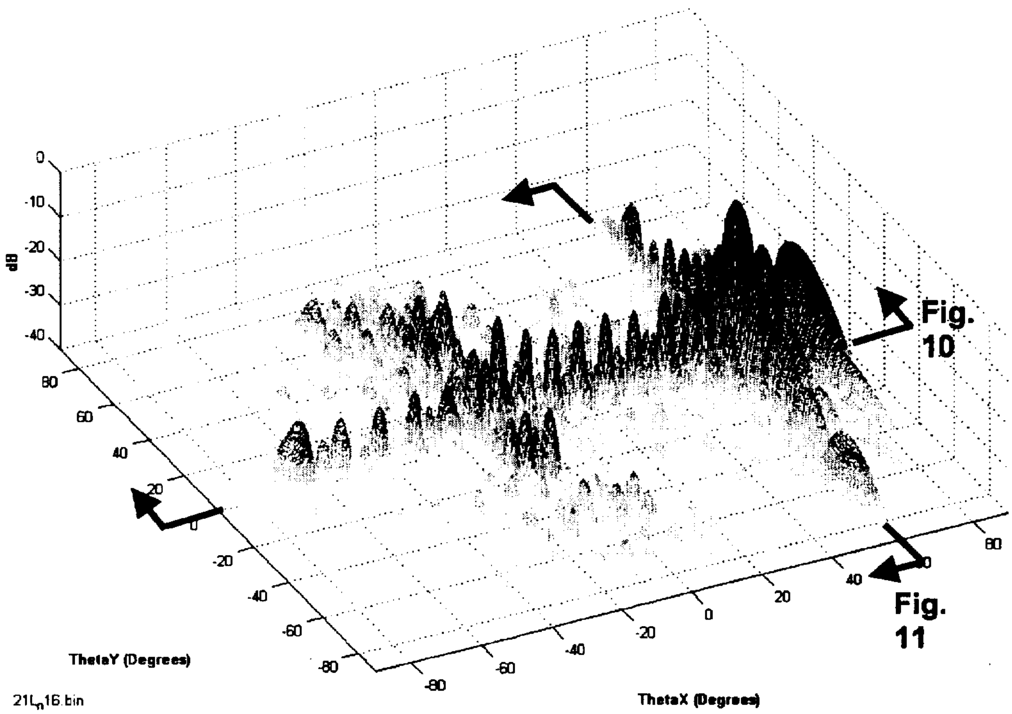

Figure 5. Antenna Pattern For Sidelobes Greater Than –40 dB at Scan Angles of $\theta_x = 58°$, $\theta_y = 0°$

Figures 6 and 7 are cuts through the antenna pattern for scan angles of $\theta_x = 58°$ and $\theta_y = 0°$. Figure 6 is a cut along the X axis of the antenna for $\theta_y = 0°$ and figure 7 is a cut along the Y axis for $\theta_x = 58°$. In Figure 6 the peak sidelobe level remains greater than -20 dB for a considerable distance from the beam center. However, these side lobes would only appear along the GSO arc for an aircraft near the equator and not for one in the continental United States ("CONUS"). Figure 7 is representative of the maximum sidelobe level that would appear along the GSO arc for an aircraft in CONUS. In Figure 7 the peak sidelobe level reaches -20 dB about 10° from beam center.

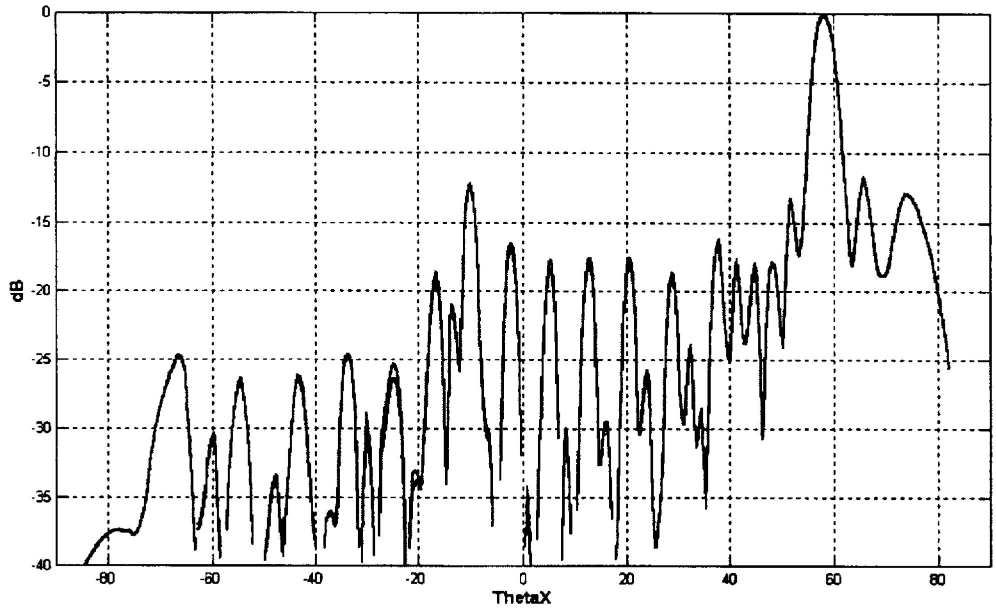

Figure 6. Antenna Pattern Cut Along θ_x
(See Figure 5)

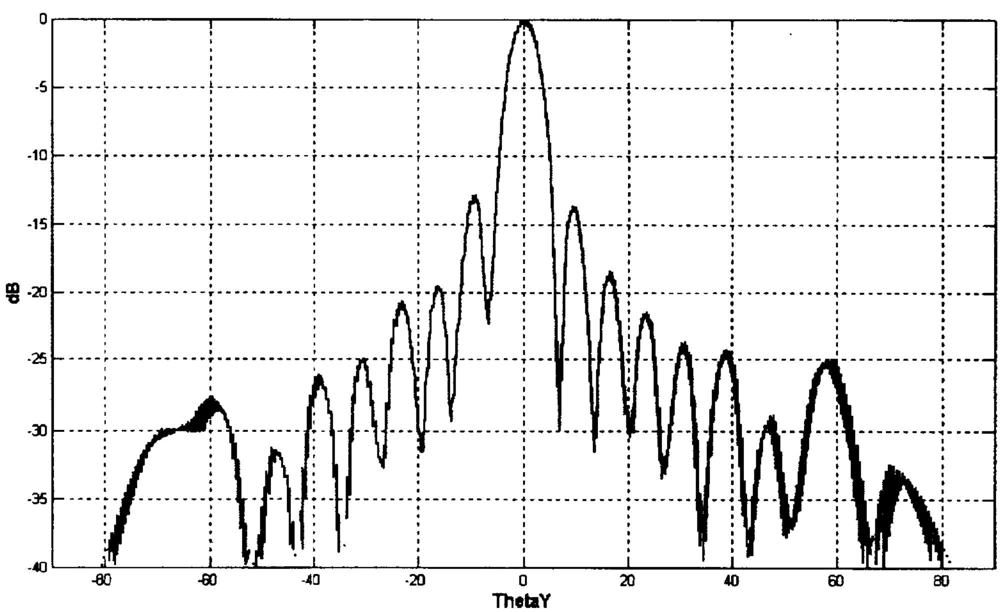

Figure 7. Antenna Pattern Cut Along θ_y for $\theta_x = 58°$
(See Figure 5)

3 LINK BUDGET MODEL

Telstar-6 transponder K21 will be used for transmissions to the Boeing antenna during the experimental use of the system. Telstar-6 is located at 93° W.L. and operated by Loral Skynet. Transponder K21 has a center downlink frequency of 12.084 GHz, a bandwidth of 27 MHz, and a vertical polarization. The transmission signal will operate slightly offset from the transponder K21 center frequency at 12.080 GHz in order to comply with the coordination agreement for this transponder.

Link budgets for the Telstar-6 transponder for Seattle, Bangor, Miami, Brownsville, San Diego, and Salt Lake City are shown in Figure 8. These cities were chosen to represent the geographic extremities of CONUS, the maximum scan angle in CONUS (Seattle), and every rain region in CONUS. Of these, Miami proves to be the worst case but still has sufficient margin to close the link at design availability.

The following information is provided as footnotes to the link budgets provided in Figure 17:

1. Atmospheric attenuation is given by ITU-R Recommendation P.676-3, corrected for altitudes above sea level. A sea level water vapor density of 20 g/m^3 and a water vapor scale height of 2.1 km based on a rain condition are assumed.

2. Rain attenuation is given by the greater of the ITU-R Recommendation P.618-6 rain model or 0.5 dB. Rain attenuation is calculated for 99.9% rain availability at the antenna service altitude of 10,000 feet (3 km). Below 10,000 feet, the availability of the service would be diminished. At northern latitudes in the United States, the 0° isotherm may be near or below 10,000 feet resulting in negligible or zero rain attenuation. In order to maintain a minimum level of rain attenuation at northern latitudes, a 0.5 dB rain attenuation 'floor' is used.

3. The antenna linear polarization converter can track the polarization of a signal in increments of 11.25° resulting in a maximum tracking error of 5.63°. The resulting polarization tracking loss is computed based on a 20 dB axial ratio for the satellite and the receive antenna.

Downlink Budget Summary

Satellite		Telstar-6 (93 W) Transponder K21					
Location		Seattle, WA	Bangor, ME	Miami, FL	Brownsville, TX	San Deigo, CA	Salt Lake City, UT
Rain Region		D	K	N	M	E	B
Elevation Angle	degrees	28.4	33.0	56.6	59.3	43.9	39.0
Transponder Frequency	GHz	12.08	12.080	12.080	12.080	12.080	12.080
Transponder EIRP	dB W	48.0	48.0	48.0	48.0	48.0	48.0
Path Loss	dB	205.8	205.8	205.4	205.3	205.6	205.6
Atmospheric Attenuation[1]	dB	0.09	0.08	0.05	0.05	0.06	0.07
Rain Attenuation[2]	dB	0.50	0.50	2.48	1.74	0.50	0.50
Polarization Tracking Loss[3]	dB	0.04	0.04	0.04	0.04	0.04	0.04
Pointing Loss	dB	0.50	0.50	0.50	0.50	0.50	0.50
Recive Antenna Gain	dB	31.0	31.7	34.0	34.1	33.0	32.5
Receive Power	dB W	-128.0	-127.1	-126.5	-125.6	-125.7	-126.3
Symbol Rate	Msps	4.0	4.0	4.0	4.0	4.0	4.0
Data Rate	Mbps	5.5	5.5	5.5	5.5	5.5	5.5
(QPSK, Rate 3/4, RS 204/188)	dB Hz	67.4	67.4	67.4	67.4	67.4	67.4
Eb	dB W/Hz	-195.4	-194.6	-193.9	-193.0	-193.1	-193.7
Receive System Temperature	K	270	270	357	329	269	269
	dB K	24.3	24.3	25.5	25.2	24.3	24.3
No	dB W/Hz	-204.3	-204.3	-203.1	-203.4	-204.3	-204.3
Adjacent Satellite Co-Polarization Interference	dB W/Hz	-205.6	-203.9	-203.5	-202.5	-203.2	-203.8
Adjacent Satellite Cross-Polarization Interference	dB W/Hz	-214.5	-213.8	-213.5	-212.7	-212.4	-213.1
Io	dB W/Hz	-205.1	-203.5	-203.1	-202.1	-202.7	-203.3
Eb/No	dB	8.9	9.7	9.1	10.4	11.2	10.6
Eb/Io	dB	9.7	9.0	9.2	9.1	9.6	9.6
Eb/(No+Io)	dB	6.3	6.3	6.2	6.7	7.3	7.1

End-to-End Summary

Eb/No Uplink	dB	24.2	24.2	24.2	24.2	24.2	24.2
Eb/(No+Io) End-to-End	dB	6.2	6.2	6.1	6.6	7.2	7.0
Eb/No Required	dB	5.5	5.5	5.5	5.5	5.5	5.5
Margin	dB	0.8	0.8	0.7	1.2	1.8	1.6

Figure. 8 Telstar-6 Transponder K21 Link Budget