Tachyon Airborne Satellite Terminal

Exhibit A – Power Spectral Density Analysis Document
For FCC Special Temporary Authorization

Applicant: Tachyon, Inc.
9339 Carroll Park Drive, Suite 150.
San Diego, CA 92121

Table of Contents

TECHNICAL ANALYSIS

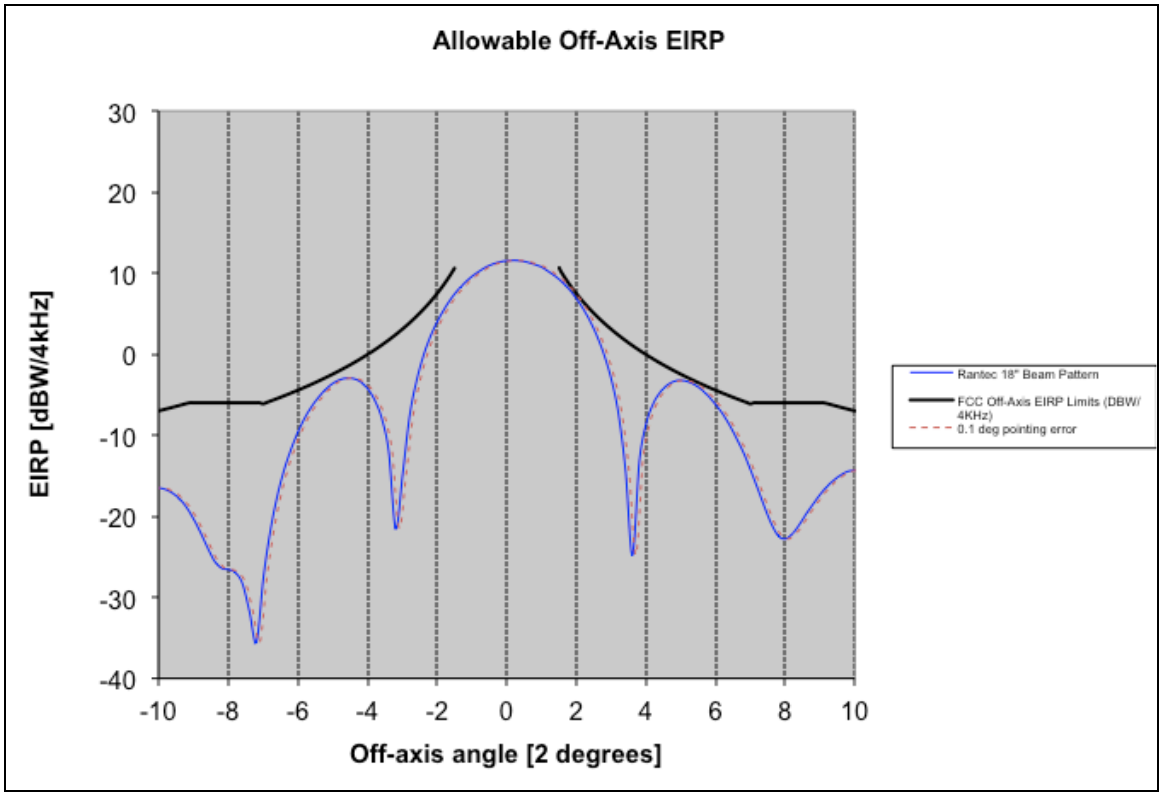
Reference Documents: FCC CFR 47 Part 25
FCC Declaratory Order 3588 4/9/86

1. OVERVIEW OF THE TEST PARAMETERS

Tachyon, Inc. intends to begin conducting tests on a small aperture antenna based Airborne Earth Station ("AES") in a mobile environment. The Tachyon AES system is a point to multipoint star network consisting of a Hub station and multiple AES terminals all under Hub station control. The proposed tests will demonstrate the performance of one (1) AES within a network. The test will be conducted in the 14-14.5 GHz and 11.7-12.2 GHz range. The hub and antenna will be communicating with one (1) of three (3) possible Intelsat satellites depending on commercial availability at the time of the tests. The Intelsat satellite options are: (1) Horizons 2, located at 74.05° W.L., (2) Galaxy 18, located at 123° W.L. and (3) Galaxy 28, located at 89° W.L.

With regard to FCC compliance there are several conditions for the tests intended to ensure compliance with FCC requirements:

1. The Hub stations for each satellite option described above are licensed separately from this application under call signs E030051, E040140 and E040414. The hub stations will be operated in accordance with their licensed parameters.
2. A remote Antenna manufactured by Rantec Microwave Systems will be used for the purpose of testing: their 0.4572 meter airborne antenna model Number 501394. This antenna will be operated in and within 200 nautical miles of a fixed location, with a latitude of 39.521032 North and a longitude of 75.717974 West. This location is the Summit Airport in Middletown, Delaware. Mobile tests will be conducted with the antenna mounted on an aircraft, which will be in motion, either taxiing or in-flight. During testing, the AES will transmit a single 8.4050 MHz digital carrier with an EIRP level of +44 dBW. This corresponds to a transmitted power density level of -23.4 dBW/4 KHz. The maximum resulting E-plane EIRP density radiation pattern for the above antenna is shown in the Figure immediately below. The corresponding maximum power density level used is -21.4 dBW/4KHz, which is 2 dB higher than the levels transmitted during the test. This shows that the proposed transmission will be compliant with the FCC two-degree spacing requirement as specified in Section 25.218(f) of the FCC Rules, in the range of angles relevant for the purpose of determining harmful interference potential into any lawfully operating co-frequency radio-communication systems. Measured antenna data is also provided in Annex A below.
3. Appropriate measures will be taken to address compliance with FCC radiation hazard requirements, as explained in Exhibit B.



The in-flight mobile tests that Tachyon intends to conduct are the following:

1. Inbound Modem performance and BER tests
2. Outbound Modem performance and BER tests
3. Network Management performance
4. Services performance
5. Remote antenna performance

1.1 Test Environment

The 0.4572 meter remote terminal will communicate with one (1) of three (3) Intelsat-owned, U.S. licensed hubs. The hub used for testing will depend upon satellite availability at the time of testing. The three (3) potential hubs are:

Satellite	Hub Location	Hub Size	Call Sign
H-2	Lat 39° 42' 30.600", Lng: -77° 43' 35.400"	11.0m	E030051
G-18	Lat 39° 42' 30.600", Lng: -77° 43' 35.400"	4.8m	E040140
G-28	Lat 39° 42' 30.600", Lng: -77° 43' 35.400"	9.3m	E040414

The hubs are located at a commercial teleport facility owned and operated by Intelsat Corporation, and located in Hagerstown, MD.

The number of components tested consists of a field trial quantity of one (1) AES and one (1) hub station. The physical location of the remote station will be within 200 nautical miles of GPS coordinates 39.521032 degrees N, 75.717974 degrees W, which is within the continental United States.

All testing will be conducted in a mobile environment.

1.2 VSAT Operation

This document contains a detailed analysis and description of the parameters in the Tachyon, Inc. remote satellite communications terminal using already authorized Ku-Band satellites.

This document will analyze FCC compliance when using a 0.4572 meter airborne antenna with a geostationary satellite in the Ku Band. The remote terminal transmitted signal uses a Multiple Channel Per Carrier (MCPC) waveform. The waveform consists of the following:

Description	Modulation	Data Rates (mbps)	Bandwidth (MHz)
Inbound Waveform	BPSK	2.34	8.4050
Outbound Waveform	BPSK	1.264	1.7050

The total system bandwidth for inbound operation is 8.4050 MHz. The total system bandwidth for outbound operation is 1.264 MHz.

The AES transmitter produces up to 15.85 Watts of RF power to overcome rainfall availability. The nominal AES transmitter power (clear sky) is 10 Watts. The network utilizes spread spectrum techniques to manage power in the inbound path.

The total satellite bandwidth used is 9.6690 MHZ.

1. 8.4050 MHZ inbound BPSK/TDMA

2. 1.264 MHZ outbound BPSK

The transit frequency requirement is 14.0 GHz to 14.5 GHz Tx, and 11.7 GHz to 12.2 GHz Rx.

The calculations for maximum EIRP are contained in the following sections.

The AES transmitted signal is BPSK digitally modulated waveform plus overhead occupying an RF bandwidth of 8.4050 MHz within the FCC emissions mask of part 25. The maximum rated RF power into the AES antenna per terminal is +12 dBW. The

maximum controlled power output per AES terminal is +46 dBW. Under closed loop power control the typical clear sky power is +44 dBW.

Accurate pointing of the AES antenna is achieved under direction of the Antenna Control Unit (ACU), which is an established product with over 150 units operating on licensed aircraft with 11.5" antennas. The ACU receives aircraft position, heading, orientation and rate of change information from a dedicated Inertial Reference Unit (IRU), which is also an established product with approximately 150 to 175 units in operation on commercial aircraft. The ACU determines the desired antenna azimuth and elevation by executing an open loop pointing algorithm using:

- ephemeris data stored in the modem to determine the satellite location and polarization;
- stored constants to determine the antenna orientation relative to the airframe; Latitude, Longitude, and altitude data from the dedicated IRU to determine the aircraft location;
- Heading, Yaw, Pitch, and Roll data from the dedicated IRU to determine the aircraft orientation; and
- Speed, Yaw Rate, Pitch Rate, and Roll Rate data from the dedicated IRU to predict changes in aircraft location and orientation.

Once the satellite is acquired, the ACU corrects for aircraft attitude changes based upon the IRU data, without waiting for degradation of the received signal strength. The IRU data is provided every 0.02 seconds, with a data resolution (least significant bit) of 0.05°. The ACU computes the desired antenna azimuth, elevation and polarization 1024 times every second (approximately once every millisecond). The antenna mechanical resolution is 0.09°. The antenna can slew in azimuth and elevation at more than 15° per second, which is sufficient to track aircraft motion within a normal flight envelope. The total root mean square pointing error for the antenna is calculated to be less than 0.1°, which is sufficient to satisfy the requirements for minimizing off-axis emissions, while maintaining the necessary gain for proper system operation.

The link quality measures of E_b/N_o and packet loss rate will be used to determine when the Forward link has degraded to the point where loss of antenna pointing will be declared. The Return link transmission then is terminated within 250 ms typically (820 ms worst case), until the antenna catches up and system lock is restored.

The antenna receive polarization choices are selectable as linear horizontal or linear vertical. Transmit polarization is linear and aligned to be orthogonal to the selected receive polarization. The antenna dish can be rotated 210° for fine control (0.25°) of the polarization. The ACU executes an open loop algorithm using the same inputs that it uses for antenna pointing to control the polarization.

1.3 Test Objectives

This STA is performed under a US Government program for potential use as part of an existing mobile aeronautical service currently provided outside the United States to a U.S. Government customer. Testing of this new antenna will allow Tachyon to determine whether it may be incorporated into the existing U.S. Government service offering.

2.0 FCC Compliance

Tachyon, Inc. is providing analysis in this submittal that verifies the system will operate jointly with other primary fixed services on a non-interference basis.

Tachyon, Inc. complies with the requirements of Part 25 in the following ways.

1. The Power Density Requirements (FCC Declaratory Order (fn 35), which is Based in part 25.209(f) "Antenna Performance Standards," is complied with by using the 0.4572 meter antenna with additional spread spectrum waveform techniques to meet the Power Density Requirements. Adjacent Satellite interference criteria are met by compliance with this FCC order.

2. Susceptibility to interference from FSS and terrestrial sites are complied with by using 0.4572 meter parabolic center bore feed reflector.

3. The minimum elevation angle part 25.205>5°. This requirement is controlled in installation.

4. Emission Limitations, part 25.202(f) are complied with through appropriate filtering and modulation control.

The analysis that follows, indicates that the operation of the proposed airborne antenna guarantees that no unacceptable interference into existing KU-Band operations in a 2-degree spacing environment will result.

For guidance on the non-interference issues, the standard references for the power flux density levels are specified in the referenced FCC Declaratory order (see paragraph 10 & 14). This paragraph indicates that the following levels are acceptable within the routine licensing process:

(1) -14 dBW/4kHz Transmit power into the antenna (Inbound Link) (per Earth Terminal Channel)

(2) 512 Kbps maximum gross bit rate (Inbound) (per Earth Terminal)

(5) Antenna conforming to CFR 47 §25.209 or a demonstration that the antenna (and waveform) will not cause unacceptable interference.

The analysis is summarized below using the following parameters (RF Bandwidth = 8.4050 MHz) with a modulation waveform spread spectrum BPSK.

(1) Inbound PD(Into Antenna)-Modulation waveform BPSK.

a.) Maximum Rated Power Density:
= +12 dBW(RF Maximum Power) / 7000 Ksps = -21.4 dBW/4kHz/channel

b.) Clear sky Power Density level:
= +10 dBW(RF Typical Power) / 7000 Ksps = -23.4 dBW/4kHz/channel

To insure that the Inbound terminals do not exceed power density requirements per FCC Declaratory order 3588, the system uses a spread spectrum waveform.

To provide confirmation that the Inbound terminals collectively will not cause interference in a 2 degree spacing environment, the EIRP of the proposed terminals has been compared against the equation referenced in the FCC Declaratory Order, Footnote 35, i.e.[15-25 Log (Lambda)] dBW/4kHz regarding VSAT Power Density requirements.

EIRP is the sum of the Inbound power density calculated above and the gain of the antenna proposed at a given angle off bore axis, with 0 degrees representing maximum gain.

The conclusion is that the terminal proposed is in compliance with FCC Part 25 rulings as well as FCC Declaratory Order 3588 4/9/86.

Link Budgets. Link budgets for the AES system are shown in Annex B for each possible satellite option. The networks in these examples are operating with 1.1264 Mbps forward link information rate and 2.34 Mbps return link information rate using the Rantec antenna. The AES transmit EIRP for the return link has been backed off to produce at least 0.5 dB target Eb/No margin. As shown in each link budget, the AES terminal is able to close the link in each satellite case with positive link margin.

Protection of Other Users in the 14.0–14.5 GHz Band

Protection of Fixed-Satellite Service. The FCC has not yet established service rules applicable to Ku-band AES terminal operations, but interference considerations are analogous to those that currently apply to Earth Station Vessels ("ESVs") set for in 47 C. F. R. Section 25.222. Tachyon's AES terminal will operate in such a manner that the off-axis EIRP levels are no greater than the levels produced by routinely licensed VSAT earth stations. To the extent that any adjacent satellite operator experiences unacceptable interference from Tachyon's experimental operations, Tachyon will cease terminal transmissions immediately. Additionally, since this testing will be performed under the control of the Tachyon AES network operations center there will be a record of the

AES's location and operating parameters as specified in Section 25.222(a)(4).

Protection of Potential NGSO FSS Systems. Tachyon acknowledges that non-geostationary orbit ("NGSO") systems are also permitted to operate in the Ku-band. However, no such systems are currently authorized or plan to operate within the period contemplated for the proposed experimental operations.

Protection of Terrestrial Radio Services. Tachyon has examined current spectrum use in the 14.0-14.5 GHz band and has determined that there are no active FCC-licensed terrestrial services in this band in North America with which its proposed operations would potentially conflict.

Protection of the Radio Astronomy Service. For purposes of this experimental application, Tachyon terminals will not operate within the 14.47 GHz - 14.5 GHz band.

Protection of Space Research Service. Tachyon recognizes the utilization of the frequency band from 14.0-14.05 GHz and the possible use of the band from 14.05-14.2 GHz allocated to the National Aeronautics and Space Administration ("NASA") Tracking and Data Relay Satellite System ("TDRSS") for space research conducted at White Sands, New Mexico and Blossom Point, Maryland. For purposes of this test demonstration, Tachyon will avoid AES operation within line-of-sight vicinity of these earth stations.

OEM Vendor Equipment:

1. Remote Antenna – Rantec Microwave Systems 0.4572 meter airborne antenna model Number 501394

3.0 EMISSION DESIGNATOR

The remote terminal will transmit in the 14.0-14.5 GHz (Earth to Space) and receive in the 11.7 to 12.2 GHz (Space to Earth) Fixed Satellite Service (FSS) band. The emission type is standard BPSK. The emission designator is expected to be 2M00G7D. This bandwidth per the FCC definition of occupied 50dB bandwidth, Section 25.202(f1) is presently 8.4050 MHz.

Annex A

Measured Antenna Data

Rantec 18” Ku-band Antenna

Model Number 501394

MI-3000 Analysis Results

Value being computed	*Min*	*Result*	*Max*	*Units*

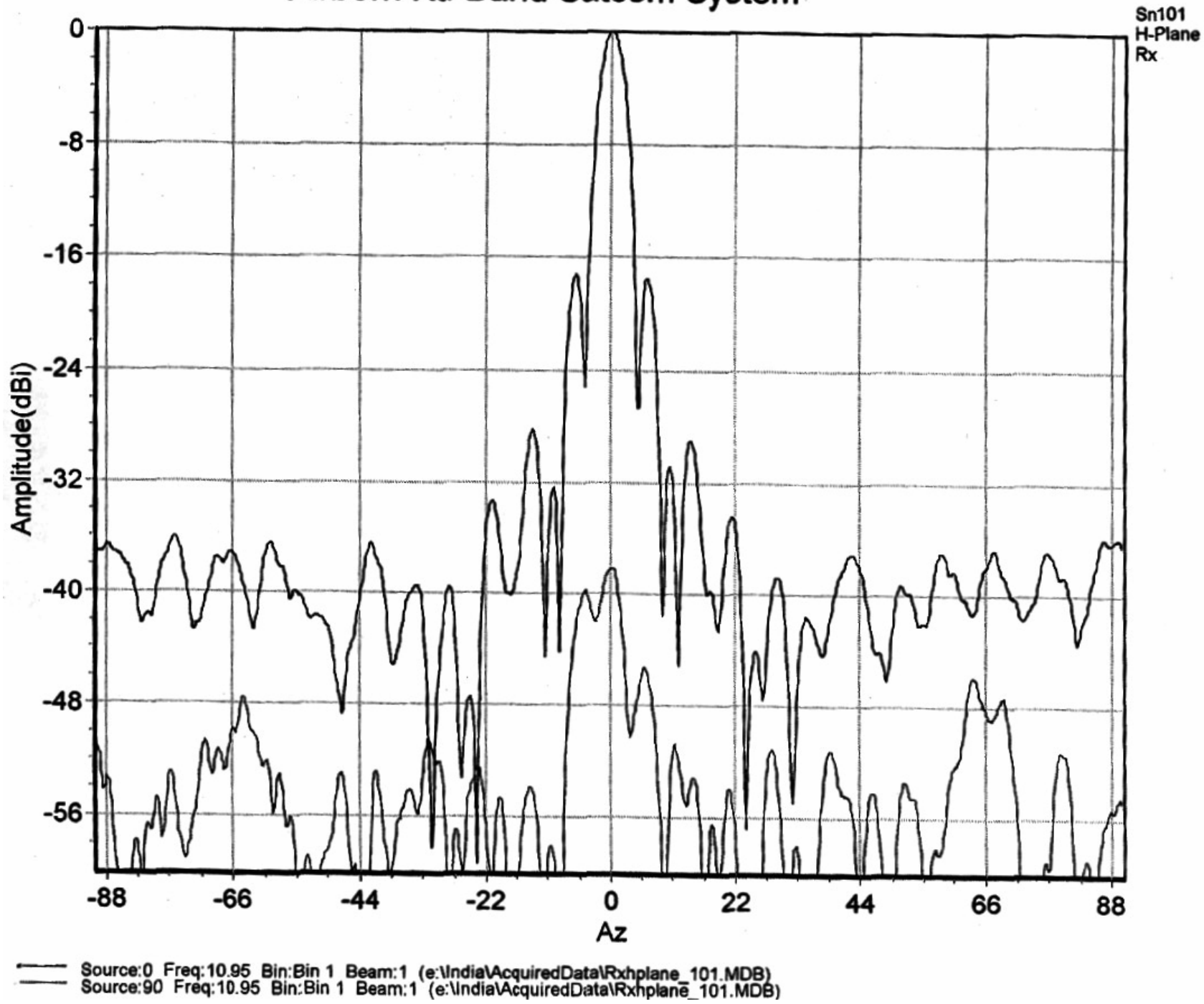
Gain Measurement Analysis

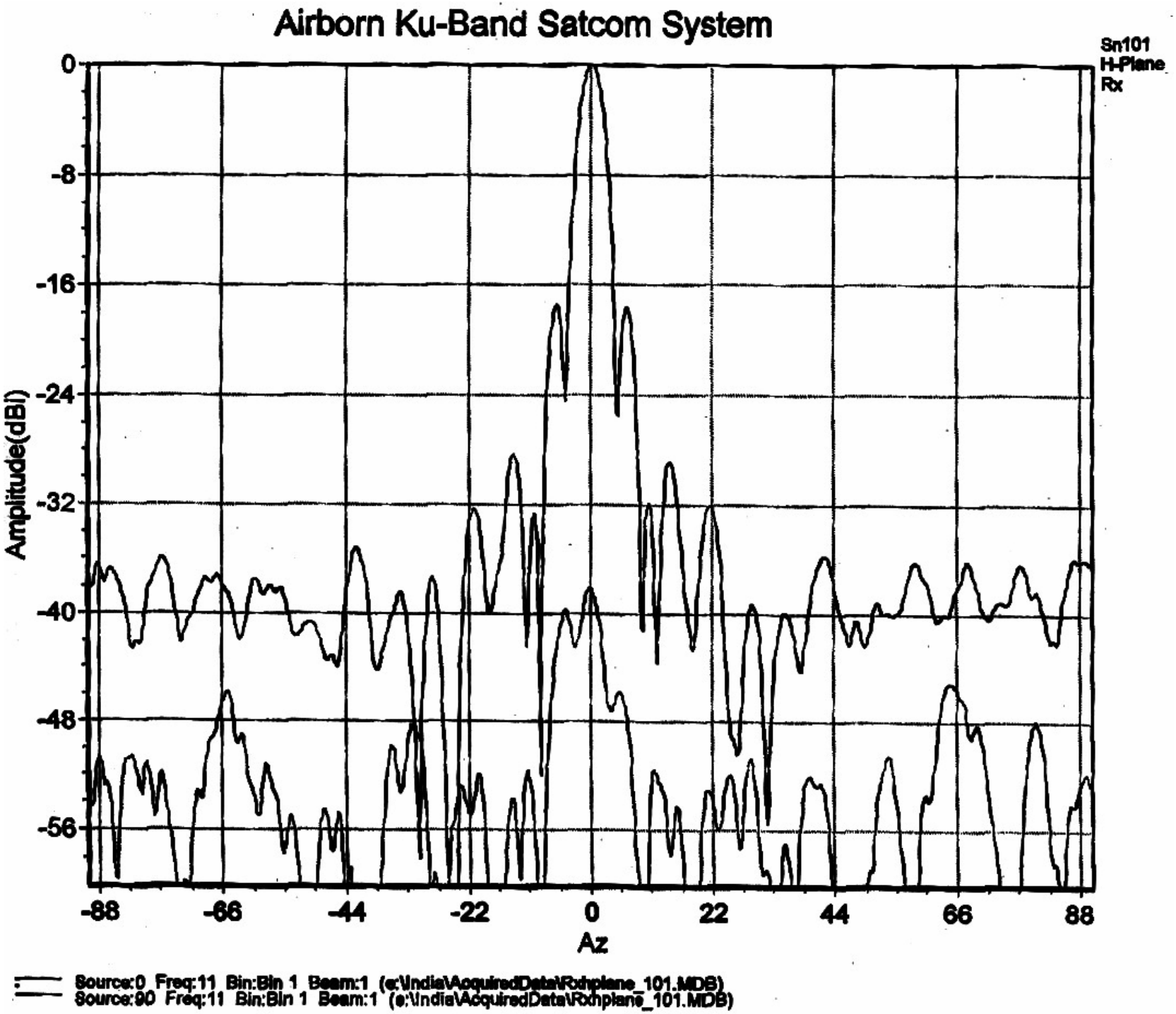
Antenna Gain (dBi) at f =	10.950	**32.08**
Antenna Gain (dBi) at f =	11.000	**32.44**
Antenna Gain (dBi) at f =	11.300	**32.24**
Antenna Gain (dBi) at f =	11.700	**32.77**

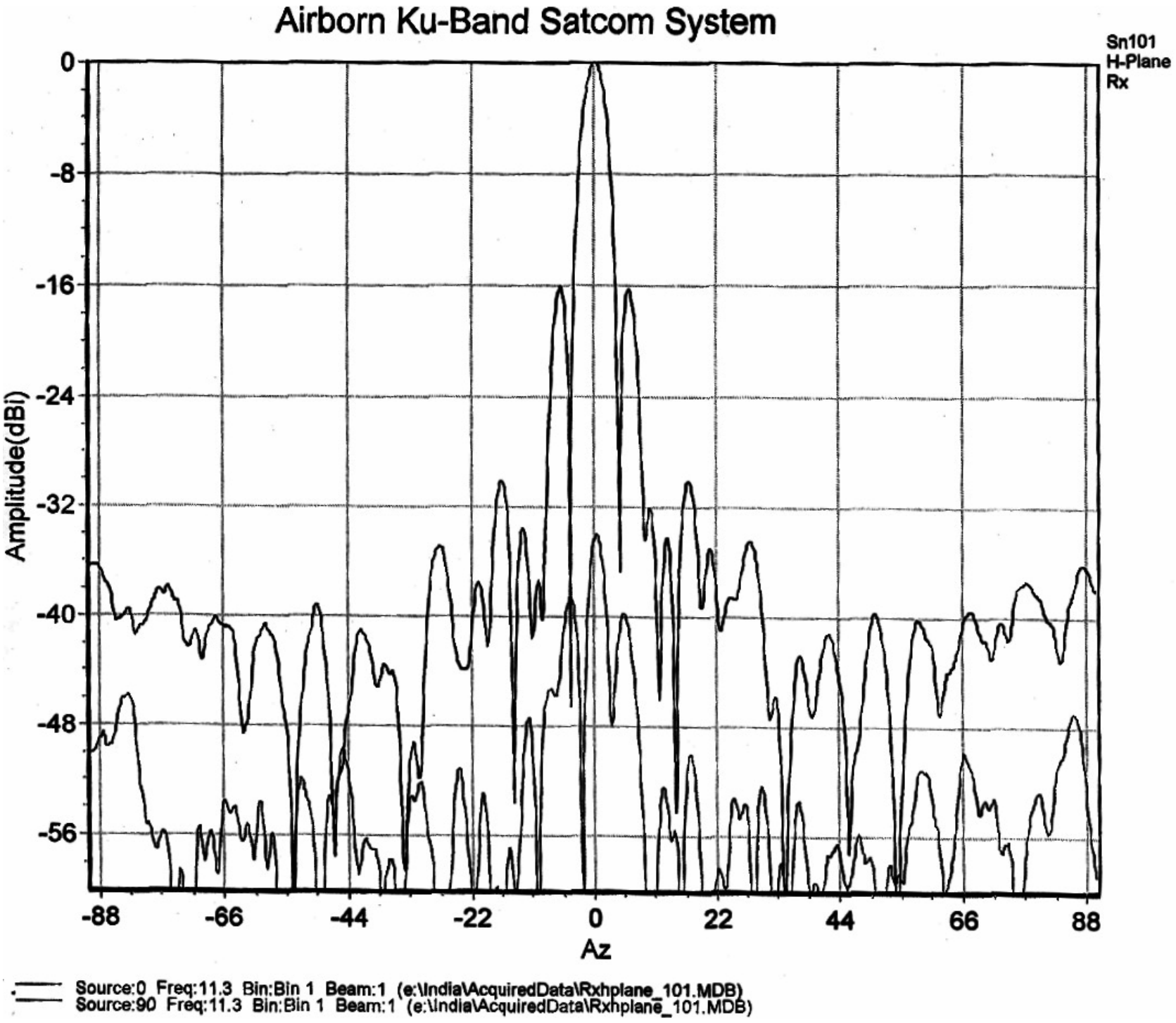
Gain Analysis of file
e:\India\AcquiredData\Rxhplane_101.MDB

Analysis performed on AUT measurements of:
all frequencies
a linearly polarized range and AUT
all channels
and Gain Standard measurements:
from file e:\India\AcquiredData\Rxgst_101.MDB
assuming gain standard '8.2 - 12.4'
on the Bin 1 channel

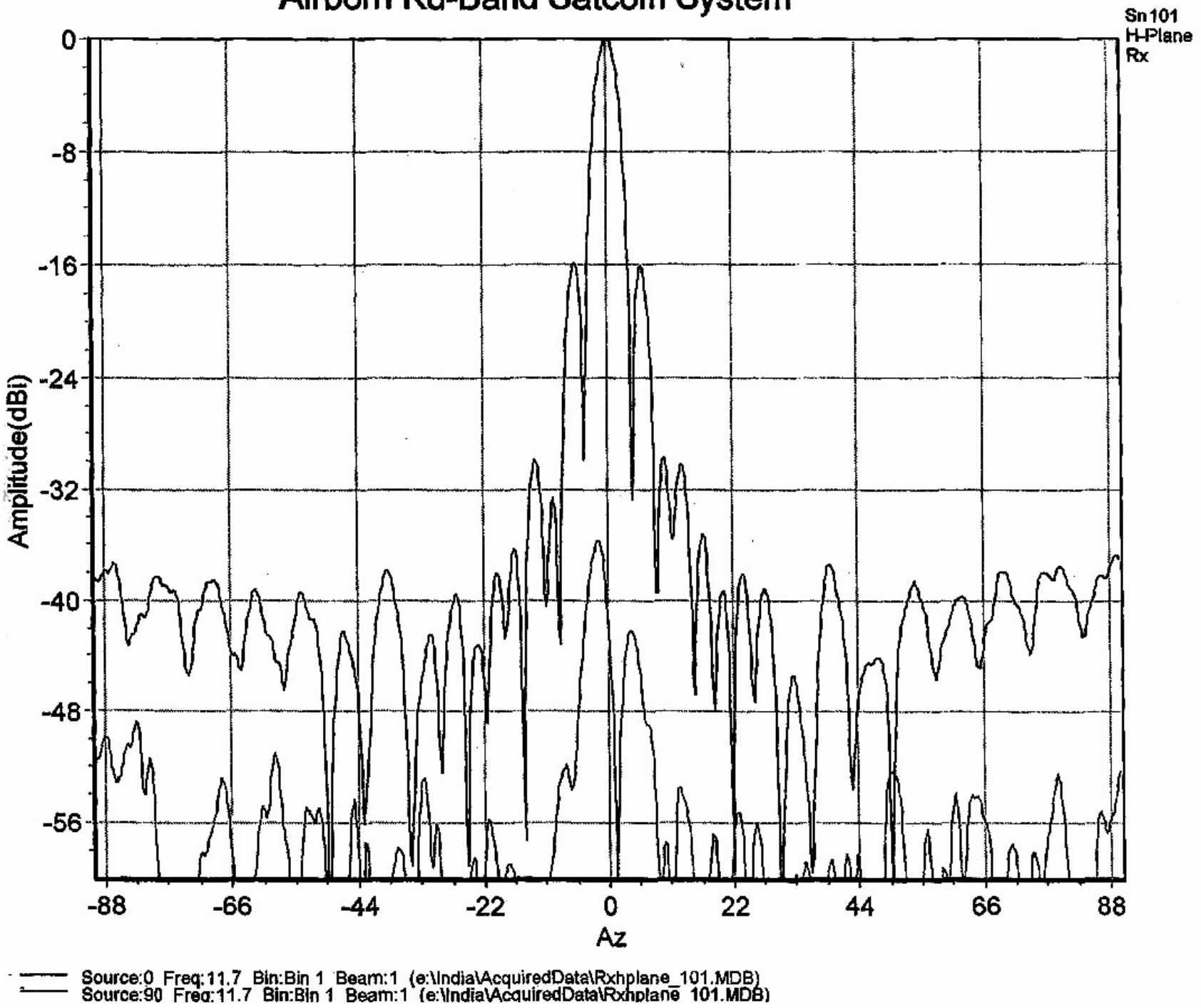
Airborn Ku-Band Satcom System

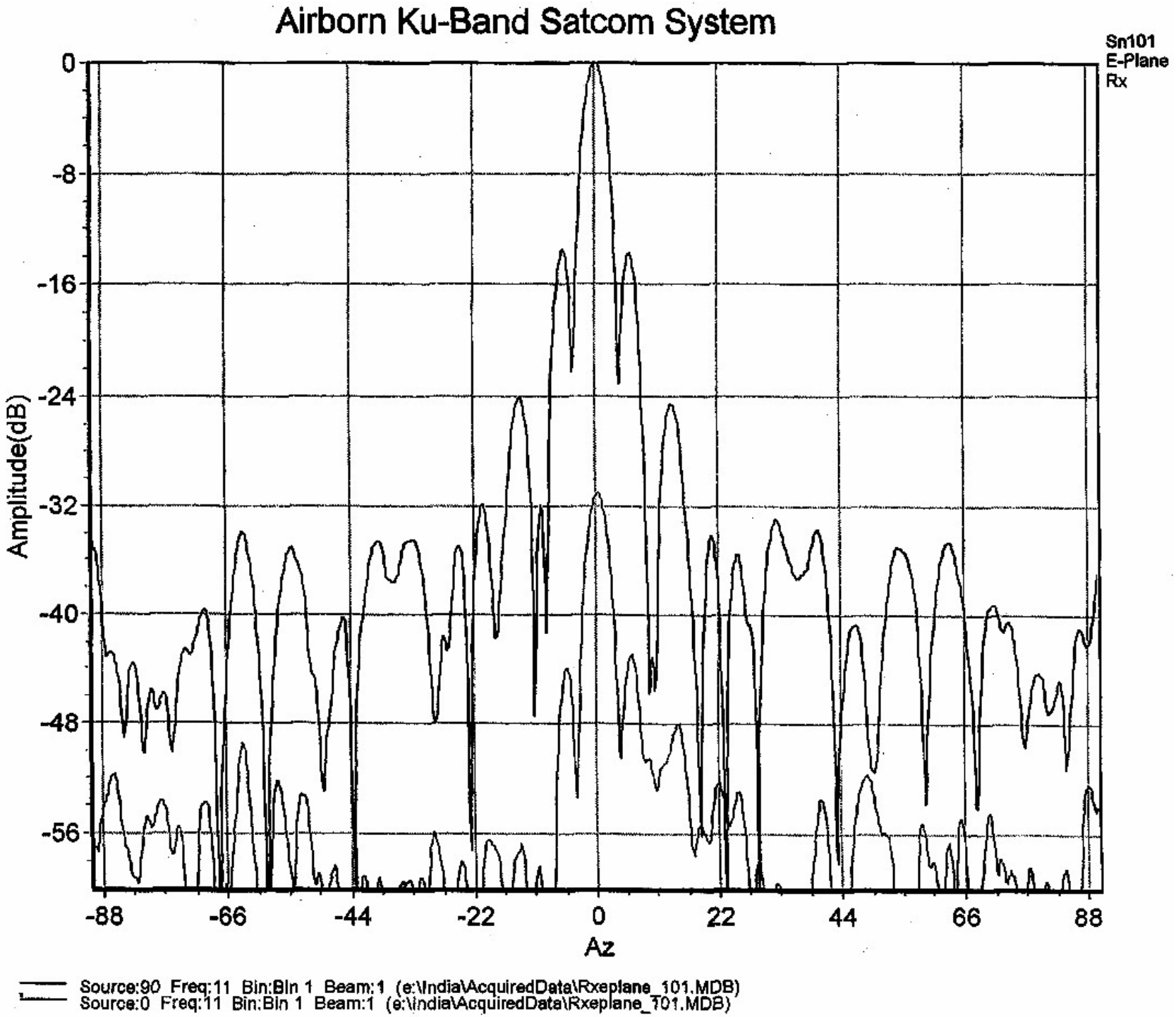


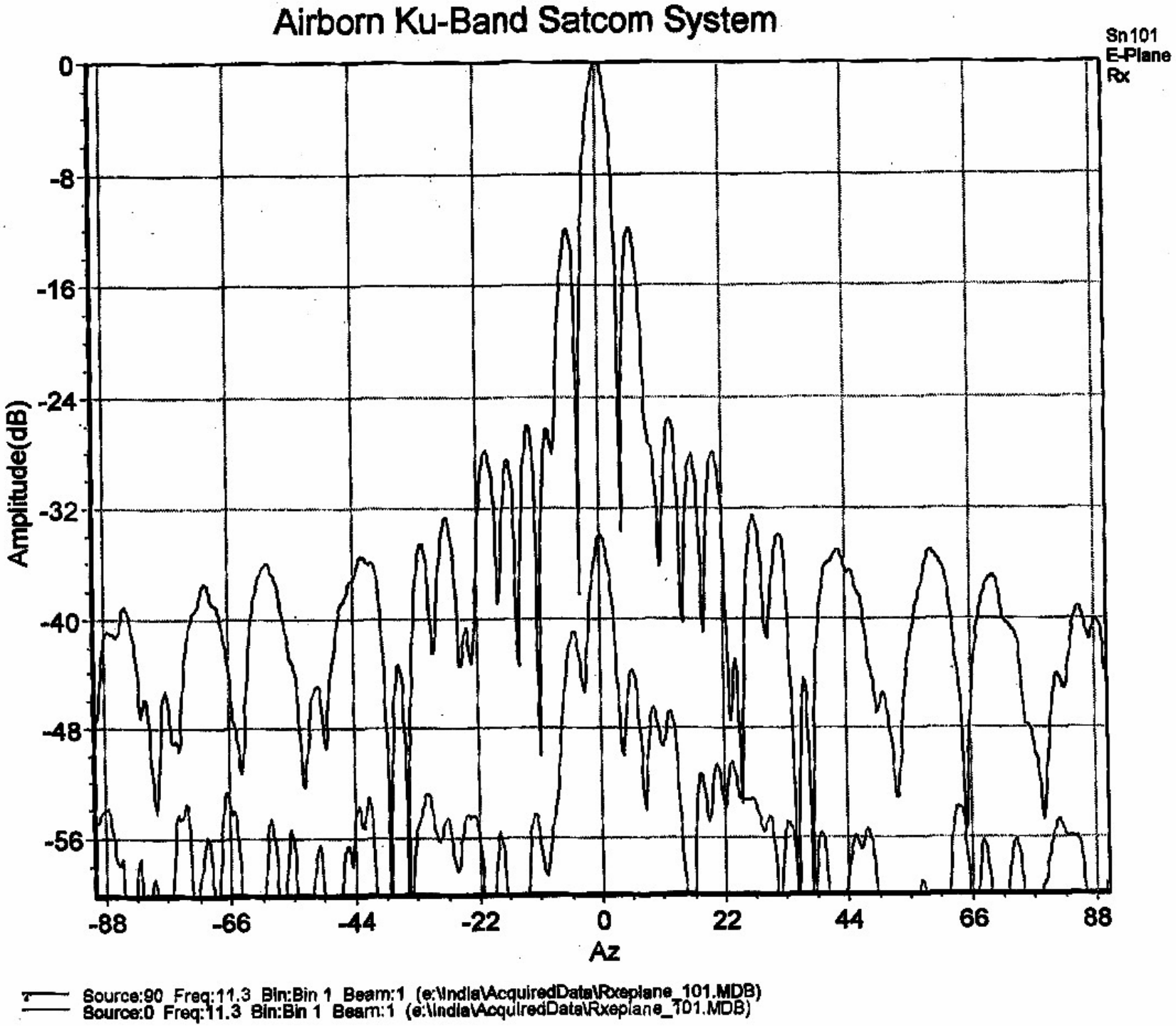

Airborn Ku-Band Satcom System
Sn101
H-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dBi)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rohplane_101.MDB)
Source:90 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rohplane_101.MDB)

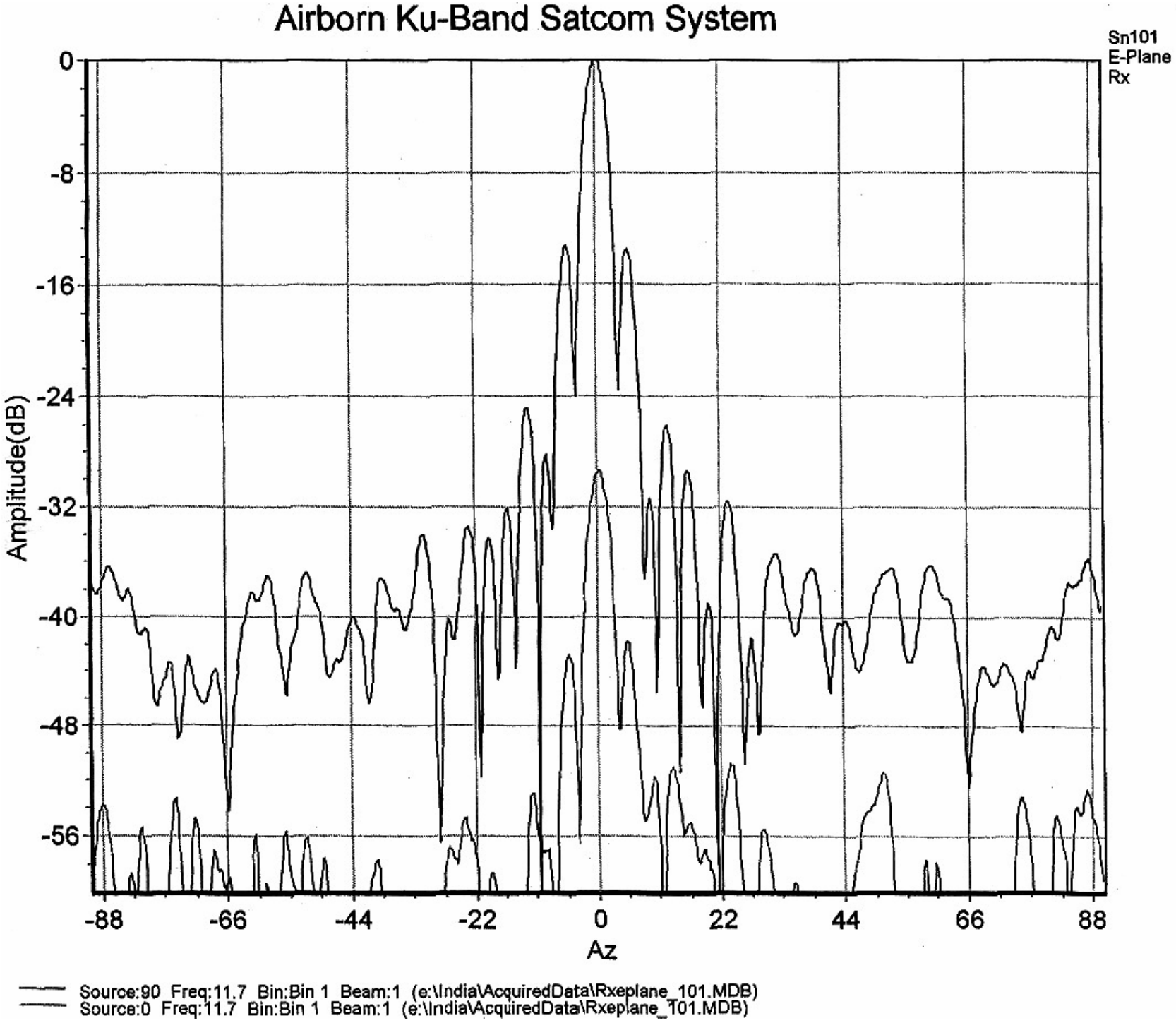

Airborn Ku-Band Satcom System
Sn101
H-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dBi)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxhplane_101.MDB)
Source:90 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxhplane_101.MDB)

Airborn Ku-Band Satcom System




Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11.3 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Rx
Amplitude(dB)
0
-8
-16
-24
-32
-40
-48
-56
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:11.7 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)
Source:0 Freq:11.7 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Rxeplane_101.MDB)

MI Technologies

MI-3000 Analysis Results

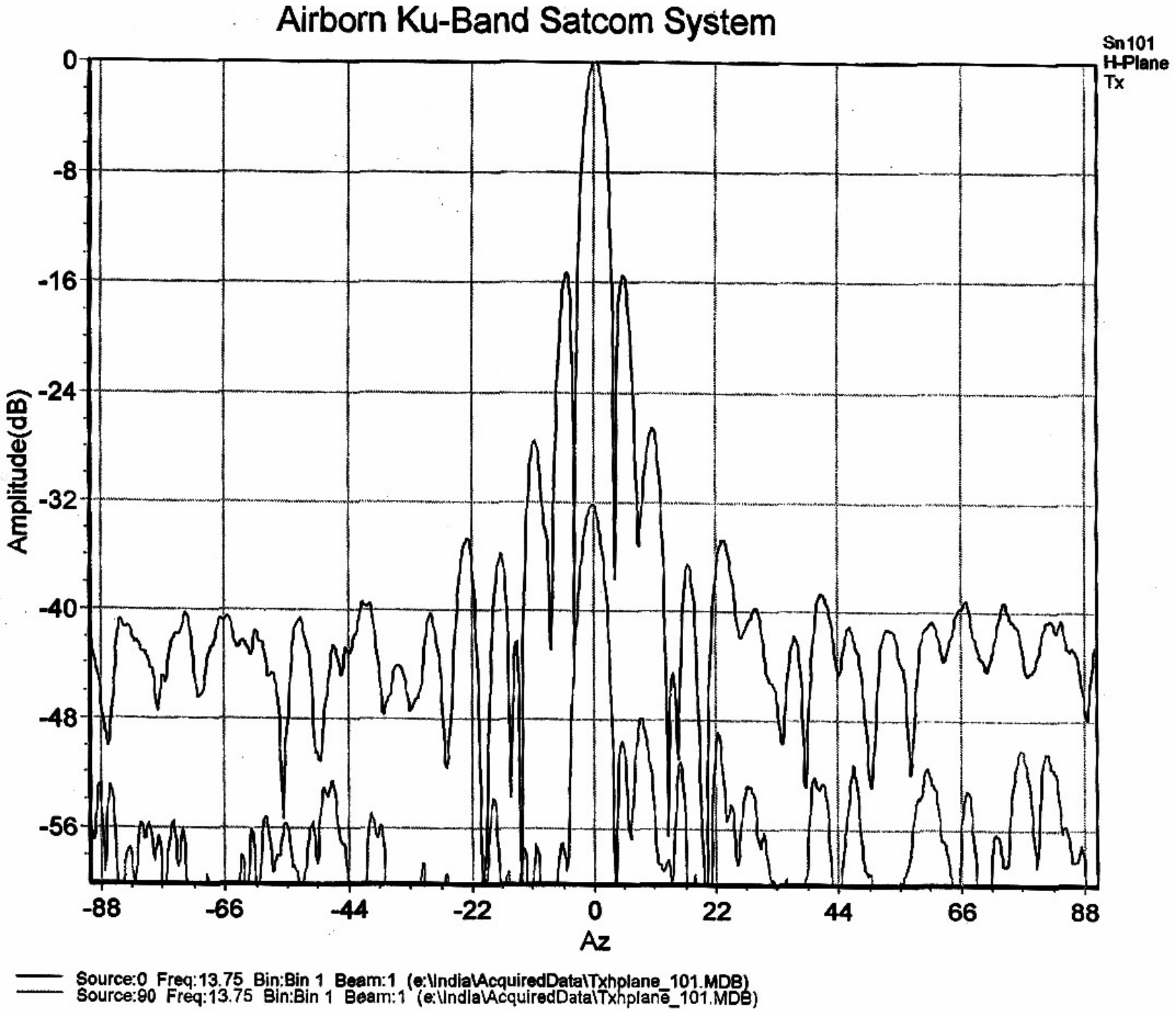
Value being computed	*Min*	*Result*	*Max*	*Units*

Gain Measurement Analysis

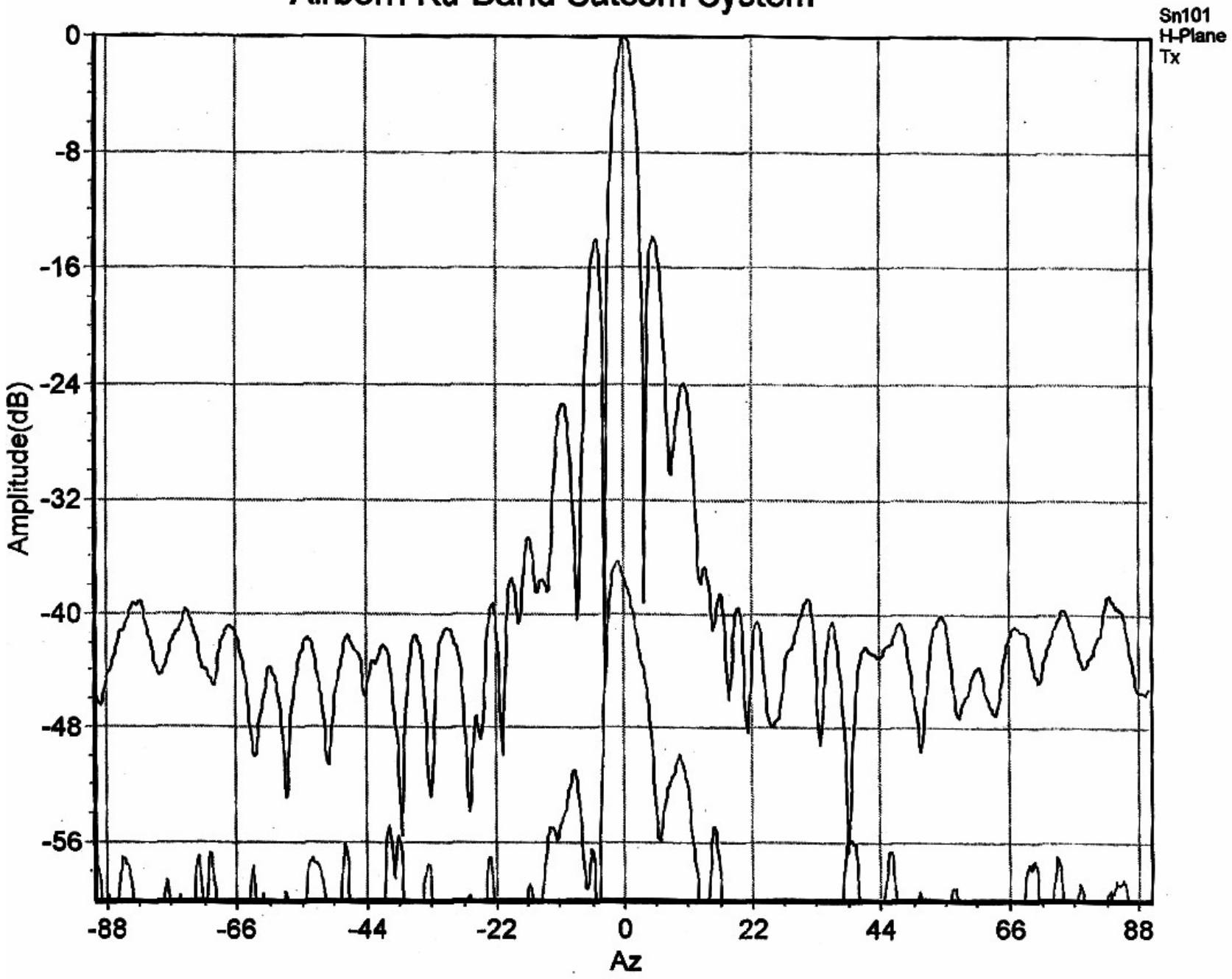
Antenna Gain (dBi) at f =	13.750	**33.69**
Antenna Gain (dBi) at f =	14.000	**34.37**
Antenna Gain (dBi) at f =	14.500	**34.47**

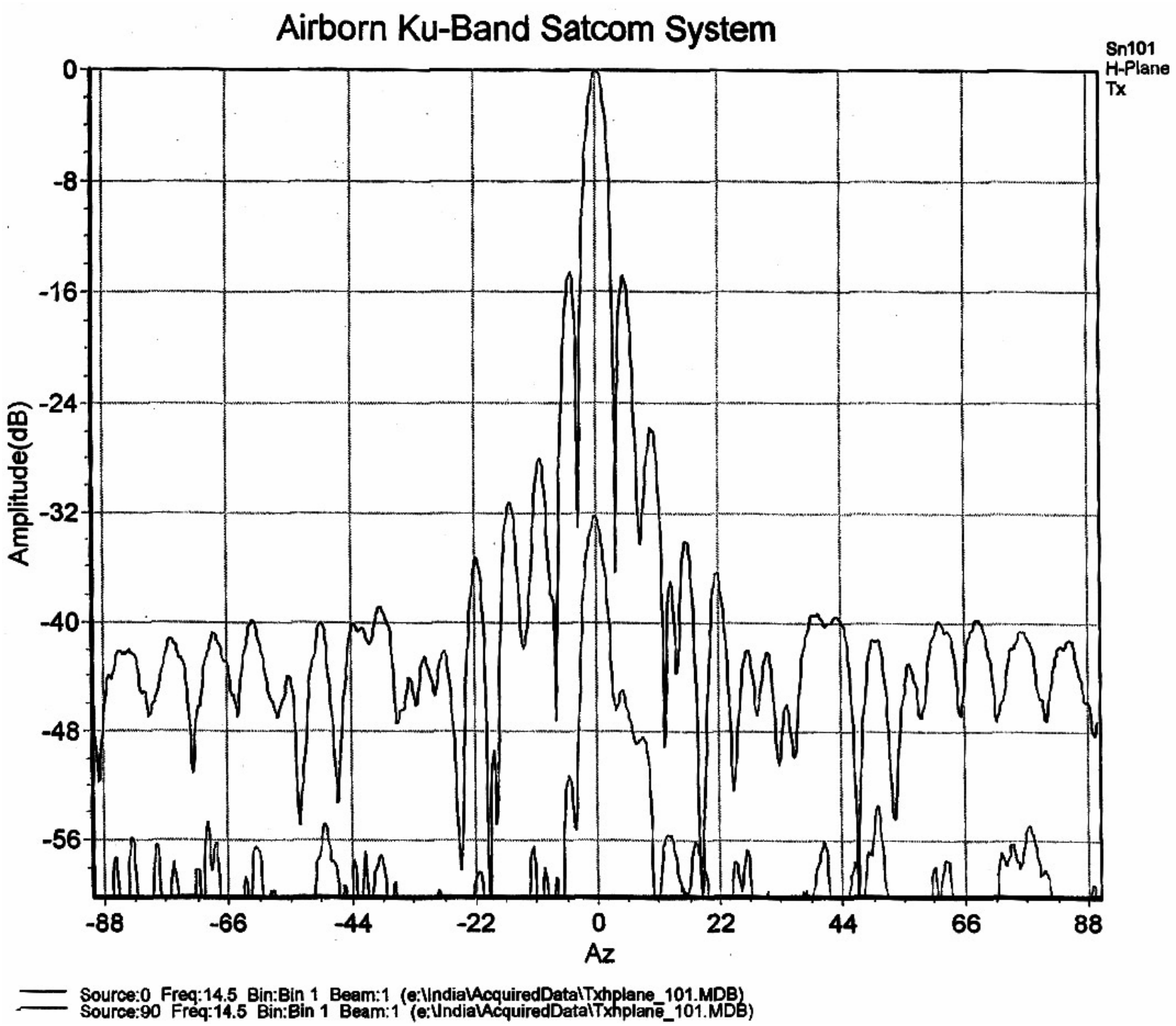
Gain Analysis of file
e:\India\AcquiredData\Txhplane_101.MDB

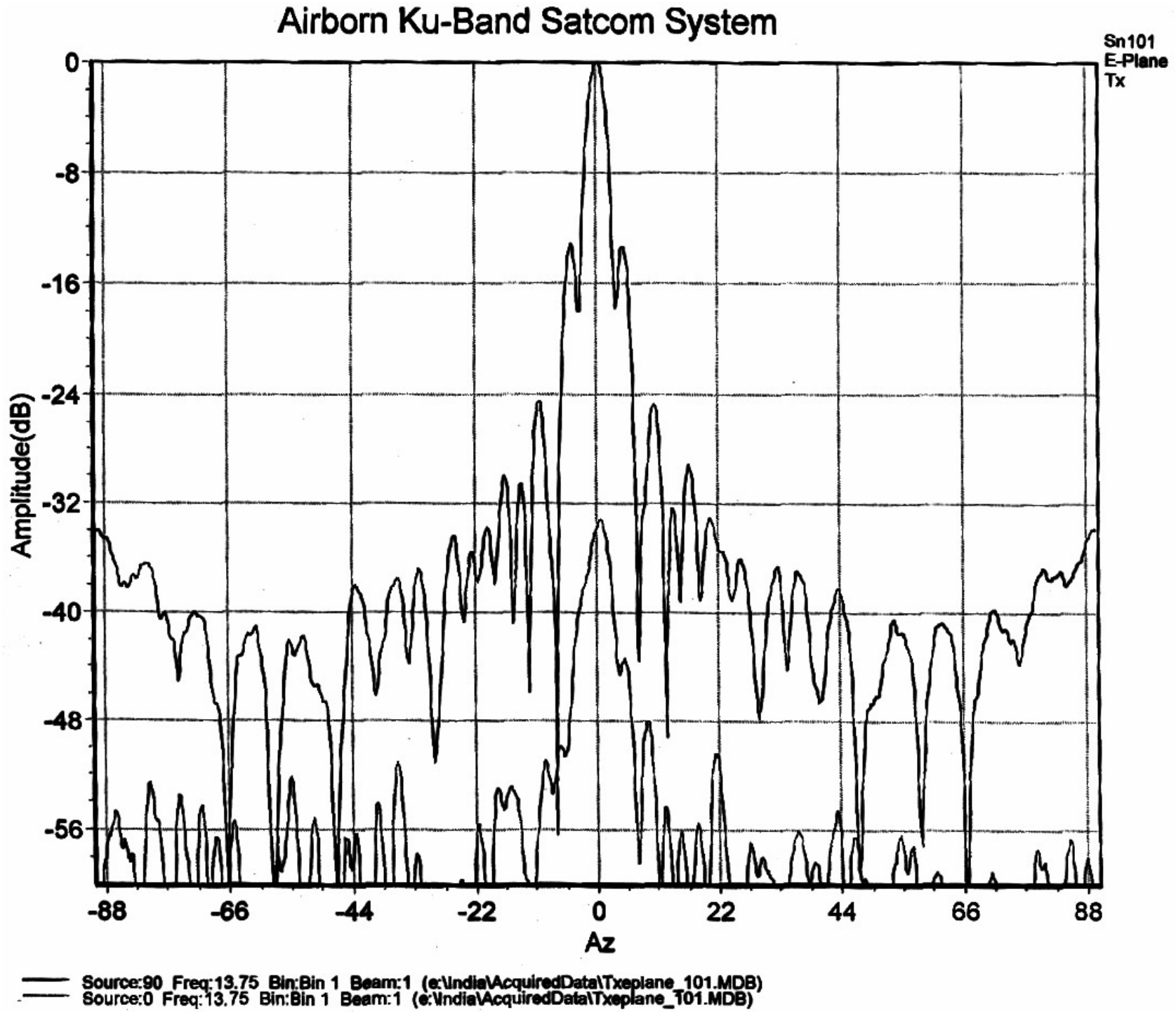
Analysis performed on AUT measurements of:
all frequencies
a linearly polarized range and AUT
all channels
and Gain Standard measurements:
from file e:\India\AcquiredData\Txgst_101.MDB
assuming gain standard '12.4 - 18.0'
on the Bin 1 channel

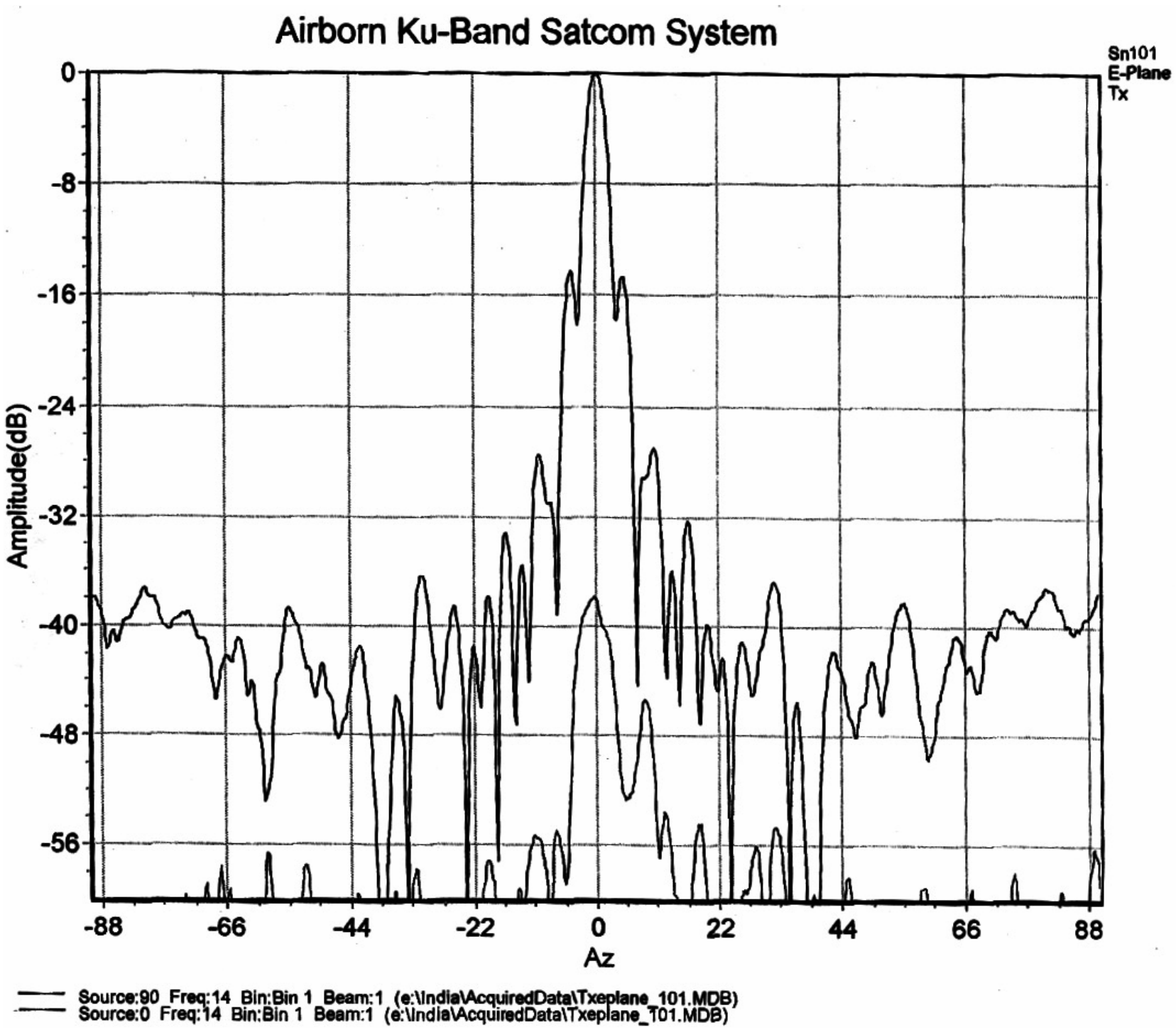

Airborn Ku-Band Satcom System
Sn101
H-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)
Source:90 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)

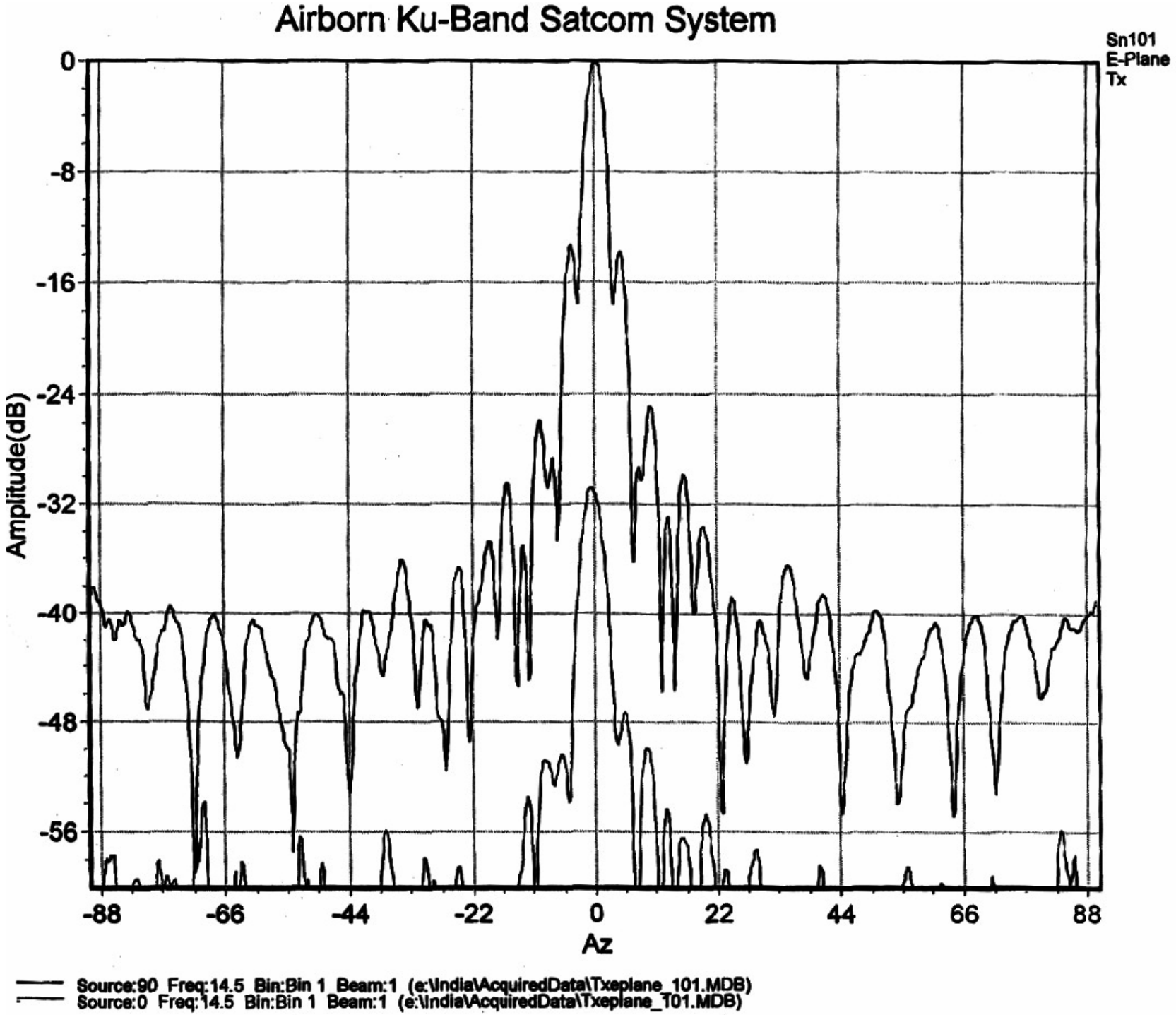
Airborn Ku-Band Satcom System




Airborn Ku-Band Satcom System
Sn101
H-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:0 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)
Source:90 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txhplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:13.75 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_T01.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:14 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:14 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)


Airborn Ku-Band Satcom System
Sn101
E-Plane
Tx
0
-8
-16
-24
-32
-40
-48
-56
Amplitude(dB)
-88
-66
-44
-22
0
22
44
66
88
Az
Source:90 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_101.MDB)
Source:0 Freq:14.5 Bin:Bin 1 Beam:1 (e:\India\AcquiredData\Txeplane_T01.MDB)

Annex B

Link Budgets

Link Budget

Produced using Satmaster+

Wednesday 5 October 2011

Service Name	Tachyon Airborne
Coverage	Delaware G18
Uplink earth station	Hagerstown, USA-MD
Downlink earth station	Middletown, USA-DE
Satellite name	GALAXY 18

Link Input Parameters	Up	Down	Units
Site latitude	39.65N	39.45N	degrees
Site longitude	77.72W	75.72W	degrees
Site altitude	0	4	km
Frequency	14.031	11.48125	GHz
Polarization	Horizontal	Vertical	
Rain model	ITU (43.3)	ITU (47.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	4.8	0.457	metres
Antenna efficiency or gain (+ or - prefix)	66.5	58	% or dBi
Coupling loss	0.3	0.2	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	0.5		dB
Number of carriers / HPA	2		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	MIN		W

Satellite Input Parameters	Value	Units
Satellite longitude	123.00W	degrees
Transponder type	TWTA	
G/T Reference	8.4	dB/K
SFD Reference	-98	dBW/m2
Receive G/T	8.4	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-98.00**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	52.3	dBW
Transponder bandwidth	36	MHz
Input back off total	6.0	dB
Output back off total	3.5	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4.3	dB
Information rate	1.024	Mbps
Overhead	10	%
FEC code rate	0.793	
Spreading gain	0	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.40	dB/m2
Uplink C/No	94.60	dB.Hz
Downlink C/No	86.11	dB.Hz
Total C/No	85.54	dB.Hz
Uplink EIRP for saturation	65.81	dBW

General Calculations	Up	Down	Units
Elevation	24.94	23.65	degrees
True azimuth	237.71	239.60	degrees
Compass bearing	248.21	251.21	degrees
Path distance to satellite	39076.13	39199.23	km
Propagation time delay	0.130344	0.130754	seconds
Antenna efficiency	66.50	58.00	%
Antenna gain	55.20	32.44	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-70.50	-26.30	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	46.23	46.23	46.23	dBW
Transponder input back-off (total)	6.00	6.00	6.00	dB
Input back-off per carrier	19.58	22.34	19.58	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	207.23	207.23	207.23	dB
Atmospheric absorption	0.16	0.16	0.16	dB
Tropospheric scintillation fading	0.31	0.31	0.31	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	2.77	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	2.77	0.00	dB
C/No (thermal)	75.02	72.26	75.02	dB.Hz
C/N (thermal)	12.71	9.94	12.71	dB
C/ACI	26.11	23.34	26.11	dB
C/ASI	24.11	21.34	24.11	dB
C/XPI	22.11	19.34	22.11	dB
C/IM	33.11	30.34	33.11	dB
C/(N+I) [= Es/(No+Io)]	11.77	9.00	11.77	dB
Eb/(No+Io)	13.57	10.80	13.57	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	52.30	52.30	52.30	dBW
Transponder output back-off (total)	3.50	3.50	3.50	dB
Output back-off per carrier	17.08	19.84	17.08	dB
Satellite EIRP per carrier	35.22	32.46	35.22	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.51	205.51	205.51	dB
Atmospheric absorption	0.14	0.14	0.14	dB
Tropospheric scintillation fading	0.40	0.40	0.40	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Noise increase due to precipitation	0.00	0.00	0.00	dB
Downlink degradation (DND)	0.00	0.00	0.00	dB
Total system noise	111.35	111.35	111.35	K
Figure of merit (G/T)	11.27	11.27	11.27	dB/K
C/No (thermal)	69.04	66.27	69.04	dB.Hz
C/N (thermal)	6.72	3.95	6.72	dB
C/ACI	28.61	25.84	28.61	dB
C/ASI	26.61	23.84	26.61	dB
C/XPI	24.61	21.84	24.61	dB

C/IM	19.61	16.84	19.61	dB
C/(N+I) [= Es/(No+Io)]	6.37	3.60	6.37	dB
Eb/(No+Io)	8.17	5.40	8.17	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	68.06	65.29	68.06	dB.Hz
C/N (thermal)	5.74	2.98	5.74	dB
C/ACI	24.17	21.40	24.17	dB
C/ASI	22.17	19.40	22.17	dB
C/XPI	20.17	17.40	20.17	dB
C/IM	19.42	16.65	19.42	dB
C/(No+Io)	67.58	64.82	67.58	dB.Hz
C/(N+I) [= Es/(No+Io)]	5.27	2.50	5.27	dB
Eb/(No+Io)	7.07	4.30	7.07	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	7.07	4.30	7.07	dB
Required Eb/(No+Io)	4.30	4.30	4.30	dB
Excess margin	**2.77**	**0.00**	**2.77**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	46.23	dBW
Antenna gain	55.20	dBi
Antenna feed flange power per carrier	-8.97	dBW
Uplink power control	0.00	dB
HPA output back off	0.50	dB
Waveguide loss	0.3	dB
Filter truncation loss	0	dB
Number of HPA carriers	2	
Total HPA power required	-5.1626	dBW
Required HPA power capability	0.3046	W
Spectral power density (feed flange)	-70.50	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	1.1264	Mbps
Transmit rate	1.4204	Mbps
Symbol rate	1.4204	Mbaud
Noise Bandwidth	62.32	dB.Hz
Occupied bandwidth	**1.7045**	**MHz**
Minimum allocated bandwidth required	1.7045	MHz
Allocated transponder bandwidth	**1.7050**	**MHz**
Percentage transponder bandwidth used	**4.74**	**%**
Used transponder power	**35.22**	**dBW**
Percentage transponder power used	**4.39**	**%**
Max carriers by transponder bandwidth	21.11	
Max carriers by transponder power	22.79	
Max transponder carriers limited by:-	Bandwidth	[21.11]
Power equivalent bandwidth usage	1.5796	MHz

Link Budget

Produced using Satmaster+

Tuesday 4 October 2011

Service Name	Tachyon Airborne
Coverage	Delaware G18
Uplink earth station	Middletown, USA-DE
Downlink earth station	Hagerstown, USA-MD
Satellite name	GALAXY 18

Link Input Parameters	Up	Down	Units
Site latitude	39.45N	39.65N	degrees
Site longitude	75.72W	77.72W	degrees
Site altitude	4	2	km
Frequency	14.031	11.48125	GHz
Polarization	Vertical	Horizontal	
Rain model	ITU (47.3)	ITU (43.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	0.457	4.8	metres
Antenna efficiency or gain (+ or - prefix)	58	66.5	% or dBi
Coupling loss	0.2	0.3	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	0.5		dB
Number of carriers / HPA	2		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	16		W

Satellite Input Parameters	Value	Units
Satellite longitude	123.00W	degrees
Transponder type	TWTA	
G/T Reference	8.4	dB/K
SFD Reference	-98	dBW/m2
Receive G/T	8.4	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-98.00**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	52.4	dBW
Transponder bandwidth	36	MHz
Input back off total	6.0	dB
Output back off total	3.5	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4	dB
Information rate	1.8	Mbps
Overhead	30	%
FEC code rate	2/3	
Spreading gain	3	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.40	dB/m2
Uplink C/No	94.60	dB.Hz
Downlink C/No	107.39	dB.Hz
Total C/No	94.38	dB.Hz
Uplink EIRP for saturation	65.99	dBW

General Calculations	Up	Down	Units
Elevation	23.65	24.94	degrees
True azimuth	239.60	237.71	degrees
Compass bearing	251.21	248.21	degrees
Path distance to satellite	39199.23	39076.13	km
Propagation time delay	0.130754	0.130344	seconds
Antenna efficiency	58.00	66.50	%
Antenna gain	34.18	53.46	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-60.12	-37.03	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	42.51	42.51	42.51	dBW
Transponder input back-off (total)	6.00	6.00	6.00	dB
Input back-off per carrier	23.48	23.48	23.48	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	207.26	207.26	207.26	dB
Atmospheric absorption	0.18	0.18	0.18	dB
Tropospheric scintillation fading	0.45	0.45	0.45	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	0.00	0.00	dB
C/No (thermal)	71.13	71.13	71.13	dB.Hz
C/N (thermal)	1.88	1.88	1.88	dB
C/ACI	15.28	15.28	15.28	dB
C/ASI	13.28	13.28	13.28	dB
C/XPI	11.28	11.28	11.28	dB
C/IM	22.28	22.28	22.28	dB
C/(N+I) [= Es/(No+Io)]	0.94	0.94	0.94	dB
Eb/(No+Io)	6.49	6.49	6.49	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	52.40	52.40	52.40	dBW
Transponder output back-off (total)	3.50	3.50	3.50	dB
Output back-off per carrier	20.98	20.98	20.98	dB
Satellite EIRP per carrier	31.42	31.42	31.42	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.49	205.49	205.49	dB
Atmospheric absorption	0.13	0.13	0.13	dB
Tropospheric scintillation fading	0.29	0.29	0.29	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	1.05	dB
Noise increase due to precipitation	0.00	0.00	1.75	dB
Downlink degradation (DND)	0.00	0.00	2.80	dB
Total system noise	108.79	108.79	162.60	K
Figure of merit (G/T)	32.29	32.29	30.55	dB/K
C/No (thermal)	86.41	86.41	83.61	dB.Hz
C/N (thermal)	17.17	17.17	14.37	dB
C/ACI	17.78	17.78	17.78	dB
C/ASI	15.78	15.78	15.78	dB
C/XPI	13.78	13.78	13.78	dB

C/IM	8.78	8.78	8.78	dB
C/(N+I) [= Es/(No+Io)]	6.26	6.26	5.95	dB
Eb/(No+Io)	11.81	11.81	11.50	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	71.00	71.00	70.89	dB.Hz
C/N (thermal)	1.75	1.75	1.64	dB
C/ACI	13.34	13.34	13.34	dB
C/ASI	11.34	11.34	11.34	dB
C/XPI	9.34	9.34	9.34	dB
C/IM	8.59	8.59	8.59	dB
C/(No+Io)	69.07	69.07	68.99	dB.Hz
C/(N+I) [= Es/(No+Io)]	-0.18	-0.18	-0.25	dB
Eb/(No+Io)	5.37	5.37	5.30	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	5.37	5.37	5.30	dB
Required Eb/(No+Io)	4.00	4.00	4.00	dB
Excess margin	**1.37**	**1.37**	**1.30**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	42.51	dBW
Antenna gain	34.18	dBi
Antenna feed flange power per carrier	8.33	dBW
Uplink power control	0.00	dB
HPA output back off	0.50	dB
Waveguide loss	0.2	dB
Filter truncation loss	0	dB
Number of HPA carriers	2	
Total HPA power required	12.0412	dBW
Required HPA power capability	16.0000	W
Spectral power density (feed flange)	-60.12	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	2.3400	Mbps
Transmit rate	3.5100	Mbps
Symbol rate	7.0034	Mbaud
Noise Bandwidth	69.24	dB.Hz
Occupied bandwidth	**8.4040**	**MHz**
Minimum allocated bandwidth required	8.4040	MHz
Allocated transponder bandwidth	**8.4050**	**MHz**
Percentage transponder bandwidth used	**23.35**	**%**
Used transponder power	**31.42**	**dBW**
Percentage transponder power used	**1.79**	**%**
Max carriers by transponder bandwidth	4.28	
Max carriers by transponder power	55.93	
Max transponder carriers limited by:-	Bandwidth	[4.28]
Power equivalent bandwidth usage	0.6437	MHz

Link Budget

Produced using Satmaster+

Wednesday 5 October 2011

Service Name	Tachyon Airborne
Coverage	Delaware G28
Uplink earth station	Hagerstown, USA-MD
Downlink earth station	Middletown, USA-DE
Satellite name	GALAXY 28

Link Input Parameters	Up	Down	Units
Site latitude	39.65N	39.45N	degrees
Site longitude	77.72W	75.72W	degrees
Site altitude	0	4	km
Frequency	14.031	11.48125	GHz
Polarization	Horizontal	Vertical	
Rain model	ITU (43.3)	ITU (47.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	9.3	0.457	metres
Antenna efficiency or gain (+ or - prefix)	66.5	58	% or dBi
Coupling loss	0.3	0.2	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	1		dB
Number of carriers / HPA	1		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	MIN		W

Satellite Input Parameters	Value	Units
Satellite longitude	89.0W	degrees
Transponder type	TWTA	
G/T Reference	4.1	dB/K
SFD Reference	-97.4	dBW/m2
Receive G/T	4.1	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-97.40**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	49.6	dBW
Transponder bandwidth	36	MHz
Input back off total	5.9	dB
Output back off total	3.8	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4.3	dB
Information rate	1.024	Mbps
Overhead	10	%
FEC code rate	0.793	
Spreading gain	0	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.40	dB/m2
Uplink C/No	90.90	dB.Hz
Downlink C/No	84.16	dB.Hz
Total C/No	83.33	dB.Hz
Uplink EIRP for saturation	65.80	dBW

General Calculations	Up	Down	Units
Elevation	42.65	42.31	degrees
True azimuth	197.36	200.38	degrees
Compass bearing	207.86	211.99	degrees
Path distance to satellite	37579.50	37604.92	km
Propagation time delay	0.125352	0.125436	seconds
Antenna efficiency	66.50	58.00	%
Antenna gain	60.95	32.44	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-74.54	-27.69	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	47.93	47.93	47.93	dBW
Transponder input back-off (total)	5.90	5.90	5.90	dB
Input back-off per carrier	17.87	19.88	17.87	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	206.89	206.89	206.89	dB
Atmospheric absorption	0.10	0.10	0.10	dB
Tropospheric scintillation fading	0.10	0.10	0.10	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	2.02	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	2.02	0.00	dB
C/No (thermal)	73.04	71.02	73.04	dB.Hz
C/N (thermal)	10.72	8.70	10.72	dB
C/ACI	27.82	25.80	27.82	dB
C/ASI	25.82	23.80	25.82	dB
C/XPI	23.82	21.80	23.82	dB
C/IM	34.82	32.80	34.82	dB
C/(N+I) [= Es/(No+Io)]	10.29	8.28	10.29	dB
Eb/(No+Io)	12.09	10.08	12.09	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	49.60	49.60	49.60	dBW
Transponder output back-off (total)	3.80	3.80	3.80	dB
Output back-off per carrier	15.77	17.78	15.77	dB
Satellite EIRP per carrier	33.83	31.82	33.83	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.15	205.15	205.15	dB
Atmospheric absorption	0.09	0.09	0.09	dB
Tropospheric scintillation fading	0.22	0.22	0.22	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Noise increase due to precipitation	0.00	0.00	0.00	dB
Downlink degradation (DND)	0.00	0.00	0.00	dB
Total system noise	107.79	107.79	107.79	K
Figure of merit (G/T)	11.41	11.41	11.41	dB/K
C/No (thermal)	68.39	66.38	68.39	dB.Hz
C/N (thermal)	6.08	4.06	6.08	dB
C/ACI	29.92	27.90	29.92	dB
C/ASI	27.92	25.90	27.92	dB
C/XPI	25.92	23.90	25.92	dB

C/IM	20.92	18.90	20.92	dB
C/(N+I) [= Es/(No+Io)]	5.85	3.83	5.85	dB
Eb/(No+Io)	7.65	5.63	7.65	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	67.11	65.10	67.11	dB.Hz
C/N (thermal)	4.80	2.78	4.80	dB
C/ACI	25.73	23.72	25.73	dB
C/ASI	23.73	21.72	23.73	dB
C/XPI	21.73	19.72	21.73	dB
C/IM	20.75	18.73	20.75	dB
C/(No+Io)	66.83	64.82	66.83	dB.Hz
C/(N+I) [= Es/(No+Io)]	4.52	2.50	4.52	dB
Eb/(No+Io)	6.32	4.30	6.32	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	6.32	4.30	6.32	dB
Required Eb/(No+Io)	4.30	4.30	4.30	dB
Excess margin	**2.02**	**0.00**	**2.02**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	47.93	dBW
Antenna gain	60.95	dBi
Antenna feed flange power per carrier	-13.01	dBW
Uplink power control	0.00	dB
HPA output back off	1.00	dB
Waveguide loss	0.3	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	-11.7144	dBW
Required HPA power capability	0.0674	W
Spectral power density (feed flange)	-74.54	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	1.1264	Mbps
Transmit rate	1.4204	Mbps
Symbol rate	1.4204	Mbaud
Noise Bandwidth	62.32	dB.Hz
Occupied bandwidth	**1.7045**	**MHz**
Minimum allocated bandwidth required	1.7045	MHz
Allocated transponder bandwidth	**1.7050**	**MHz**
Percentage transponder bandwidth used	**4.74**	**%**
Used transponder power	**33.83**	**dBW**
Percentage transponder power used	**6.36**	**%**
Max carriers by transponder bandwidth	21.11	
Max carriers by transponder power	15.72	
Max transponder carriers limited by:-	Power	[15.72]
Power equivalent bandwidth usage	2.2898	MHz

Link Budget

Produced using Satmaster+

Tuesday 4 October 2011

Service Name	Tachyon Airborne
Coverage	Delaware G28
Uplink earth station	Middletown, USA-DE
Downlink earth station	Hagerstown, USA-MD
Satellite name	GALAXY 28

Link Input Parameters	Up	Down	Units
Site latitude	39.45N	39.65N	degrees
Site longitude	75.72W	77.72W	degrees
Site altitude	4	0	km
Frequency	14.031	11.48125	GHz
Polarization	Vertical	Horizontal	
Rain model	ITU (47.3)	ITU (43.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	0.457	9.3	metres
Antenna efficiency or gain (+ or - prefix)	58	66.5	% or dBi
Coupling loss	0.2	0.3	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	1		dB
Number of carriers / HPA	1		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	16		W

Satellite Input Parameters	Value	Units
Satellite longitude	89.0W	degrees
Transponder type	TWTA	
G/T Reference	4.3	dB/K
SFD Reference	-97.6	dBW/m2
Receive G/T	4.3	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-97.60**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	49.3	dBW
Transponder bandwidth	36	MHz
Input back off total	5.9	dB
Output back off total	3.8	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4	dB
Information rate	1.8	Mbps
Overhead	30	%
FEC code rate	2/3	
Spreading gain	3	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0			dB

Calculations at Saturation	**Value**	**Units**
Gain 1m^2	44.40	dB/m2
Uplink C/No	90.90	dB.Hz
Downlink C/No	110.73	dB.Hz
Total C/No	90.86	dB.Hz
Uplink EIRP for saturation	65.75	dBW

General Calculations	**Up**	**Down**	**Units**
Elevation	42.31	42.65	degrees
True azimuth	200.38	197.36	degrees
Compass bearing	211.99	207.86	degrees
Path distance to satellite	37604.92	37579.50	km
Propagation time delay	0.125436	0.125352	seconds
Antenna efficiency	58.00	66.50	%
Antenna gain	34.18	59.20	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-57.61	-37.78	dBW/Hz

Uplink Calculation	**Clear**	**Rain Up**	**Rain Dn**	**Units**
Uplink transmit EIRP	45.02	45.02	45.02	dBW
Transponder input back-off (total)	5.90	5.90	5.90	dB
Input back-off per carrier	20.72	20.72	20.72	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	206.89	206.89	206.89	dB
Atmospheric absorption	0.11	0.11	0.11	dB
Tropospheric scintillation fading	0.24	0.24	0.24	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	0.00	0.00	dB
C/No (thermal)	70.18	70.18	70.18	dB.Hz
C/N (thermal)	0.93	0.93	0.93	dB
C/ACI	18.03	18.03	18.03	dB
C/ASI	16.03	16.03	16.03	dB
C/XPI	14.03	14.03	14.03	dB
C/IM	25.03	25.03	25.03	dB
C/(N+I) [= Es/(No+Io)]	0.51	0.51	0.51	dB
Eb/(No+Io)	6.06	6.06	6.06	dB

Downlink Calculation	**Clear**	**Rain Up**	**Rain Dn**	**Units**
Satellite EIRP total	49.30	49.30	49.30	dBW
Transponder output back-off (total)	3.80	3.80	3.80	dB
Output back-off per carrier	18.62	18.62	18.62	dB
Satellite EIRP per carrier	30.68	30.68	30.68	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.15	205.15	205.15	dB
Atmospheric absorption	0.08	0.08	0.08	dB
Tropospheric scintillation fading	0.10	0.10	0.10	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	1.21	dB
Noise increase due to precipitation	0.00	0.00	1.97	dB
Downlink degradation (DND)	0.00	0.00	3.17	dB
Total system noise	105.78	105.78	166.39	K
Figure of merit (G/T)	38.16	38.16	36.19	dB/K
C/No (thermal)	92.11	92.11	88.93	dB.Hz
C/N (thermal)	22.86	22.86	19.69	dB
C/ACI	20.13	20.13	20.13	dB
C/ASI	18.13	18.13	18.13	dB
C/XPI	16.13	16.13	16.13	dB

C/IM	11.13	11.13	11.13	dB
C/(N+I) [= Es/(No+Io)]	8.80	8.80	8.62	dB
Eb/(No+Io)	14.36	14.36	14.18	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	70.15	70.15	70.12	dB.Hz
C/N (thermal)	0.91	0.91	0.88	dB
C/ACI	15.95	15.95	15.95	dB
C/ASI	13.95	13.95	13.95	dB
C/XPI	11.95	11.95	11.95	dB
C/IM	10.96	10.96	10.96	dB
C/(No+Io)	69.15	69.15	69.13	dB.Hz
C/(N+I) [= Es/(No+Io)]	-0.09	-0.09	-0.12	dB
Eb/(No+Io)	5.46	5.46	5.44	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	5.46	5.46	5.44	dB
Required Eb/(No+Io)	4.00	4.00	4.00	dB
Excess margin	**1.46**	**1.46**	**1.44**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	45.02	dBW
Antenna gain	34.18	dBi
Antenna feed flange power per carrier	10.84	dBW
Uplink power control	0.00	dB
HPA output back off	1.00	dB
Waveguide loss	0.2	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	12.0412	dBW
Required HPA power capability	16.0000	W
Spectral power density (feed flange)	-57.61	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	2.3400	Mbps
Transmit rate	3.5100	Mbps
Symbol rate	7.0034	Mbaud
Noise Bandwidth	69.24	dB.Hz
Occupied bandwidth	**8.4040**	**MHz**
Minimum allocated bandwidth required	8.4040	MHz
Allocated transponder bandwidth	**8.4050**	**MHz**
Percentage transponder bandwidth used	**23.35**	**%**
Used transponder power	**30.68**	**dBW**
Percentage transponder power used	**3.29**	**%**
Max carriers by transponder bandwidth	4.28	
Max carriers by transponder power	30.36	
Max transponder carriers limited by:-	Bandwidth	[4.28]
Power equivalent bandwidth usage	1.1857	MHz

Link Budget

Produced using Satmaster+

Wednesday 5 October 2011

Service Name	FWD Tachyon Airborne H2
Coverage	Delaware
Uplink earth station	Hagerstown, USA-MD
Downlink earth station	Middletown, USA-DE
Satellite name	H2

Link Input Parameters	Up	Down	Units
Site latitude	39.65N	39.45N	degrees
Site longitude	77.72W	75.72W	degrees
Site altitude	0	4	km
Frequency	14.031	11.48125	GHz
Polarization	Horizontal	Vertical	
Rain model	ITU (43.3)	ITU (47.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	11	0.457	metres
Antenna efficiency or gain (+ or - prefix)	66.5	58	% or dBi
Coupling loss	0.3	0.2	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	0.5		dB
Number of carriers / HPA	1		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	MIN		W

Satellite Input Parameters	Value	Units
Satellite longitude	74.05W	degrees
Transponder type	TWTA	
G/T Reference	6.1	dB/K
SFD Reference	-92	dBW/m2
Receive G/T	6.1	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-92.00**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	52.5	dBW
Transponder bandwidth	72	MHz
Input back off total	6.1	dB
Output back off total	4.0	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4.3	dB
Information rate	1.024	Mbps
Overhead	10	%
FEC code rate	0.793	
Spreading gain	0	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.40	dB/m2
Uplink C/No	98.30	dB.Hz
Downlink C/No	87.11	dB.Hz
Total C/No	86.80	dB.Hz
Uplink EIRP for saturation	71.15	dBW

General Calculations	Up	Down	Units
Elevation	43.97	44.32	degrees
True azimuth	174.26	177.37	degrees
Compass bearing	184.76	188.98	degrees
Path distance to satellite	37484.25	37459.32	km
Propagation time delay	0.125034	0.124951	seconds
Antenna efficiency	66.50	58.00	%
Antenna gain	62.40	32.44	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-74.08	-28.23	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	49.85	49.85	49.85	dBW
Transponder input back-off (total)	6.10	6.10	6.10	dB
Input back-off per carrier	21.31	23.26	21.31	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	206.87	206.87	206.87	dB
Atmospheric absorption	0.10	0.10	0.10	dB
Tropospheric scintillation fading	0.09	0.09	0.09	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	1.95	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	1.95	0.00	dB
C/No (thermal)	76.99	75.04	76.99	dB.Hz
C/N (thermal)	14.68	12.73	14.68	dB
C/ACI	24.38	22.43	24.38	dB
C/ASI	22.38	20.43	22.38	dB
C/XPI	20.38	18.43	20.38	dB
C/IM	31.38	29.43	31.38	dB
C/(N+I) [= Es/(No+Io)]	12.73	10.77	12.73	dB
Eb/(No+Io)	14.52	12.57	14.52	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	52.50	52.50	52.50	dBW
Transponder output back-off (total)	4.00	4.00	4.00	dB
Output back-off per carrier	19.21	21.16	19.21	dB
Satellite EIRP per carrier	33.29	31.34	33.29	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.12	205.12	205.12	dB
Atmospheric absorption	0.08	0.08	0.08	dB
Tropospheric scintillation fading	0.21	0.21	0.21	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Noise increase due to precipitation	0.00	0.00	0.00	dB
Downlink degradation (DND)	0.00	0.00	0.00	dB
Total system noise	107.59	107.59	107.59	K
Figure of merit (G/T)	11.42	11.42	11.42	dB/K
C/No (thermal)	67.91	65.96	67.91	dB.Hz
C/N (thermal)	5.59	3.64	5.59	dB
C/ACI	26.48	24.53	26.48	dB
C/ASI	24.48	22.53	24.48	dB
C/XPI	22.48	20.53	22.48	dB

C/IM	17.48	15.53	17.48	dB
C/(N+I) [= Es/(No+Io)]	5.15	3.20	5.15	dB
Eb/(No+Io)	6.95	5.00	6.95	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	67.40	65.45	67.40	dB.Hz
C/N (thermal)	5.08	3.13	5.08	dB
C/ACI	22.29	20.34	22.29	dB
C/ASI	20.29	18.34	20.29	dB
C/XPI	18.29	16.34	18.29	dB
C/IM	17.30	15.35	17.30	dB
C/(No+Io)	66.77	64.82	66.77	dB.Hz
C/(N+I) [= Es/(No+Io)]	4.45	2.50	4.45	dB
Eb/(No+Io)	6.25	4.30	6.25	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	6.25	4.30	6.25	dB
Required Eb/(No+Io)	4.30	4.30	4.30	dB
Excess margin	**1.95**	**0.00**	**1.95**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	49.85	dBW
Antenna gain	62.40	dBi
Antenna feed flange power per carrier	-12.56	dBW
Uplink power control	0.00	dB
HPA output back off	0.50	dB
Waveguide loss	0.3	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	-11.7587	dBW
Required HPA power capability	0.0667	W
Spectral power density (feed flange)	-74.08	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	1.1264	Mbps
Transmit rate	1.4204	Mbps
Symbol rate	1.4204	Mbaud
Noise Bandwidth	62.32	dB.Hz
Occupied bandwidth	**1.7045**	**MHz**
Minimum allocated bandwidth required	1.7045	MHz
Allocated transponder bandwidth	**1.7050**	**MHz**
Percentage transponder bandwidth used	**2.37**	**%**
Used transponder power	**33.29**	**dBW**
Percentage transponder power used	**3.01**	**%**
Max carriers by transponder bandwidth	42.23	
Max carriers by transponder power	33.17	
Max transponder carriers limited by:-	Power	[33.17]
Power equivalent bandwidth usage	2.1706	MHz

Link Budget

Produced using Satmaster+

Tuesday 4 October 2011

Service Name	Tachyon Airborne
Coverage	Delaware
Uplink earth station	Middletown, USA-DE
Downlink earth station	Hagerstown, USA-MD
Satellite name	H2

Link Input Parameters	Up	Down	Units
Site latitude	39.45N	39.65N	degrees
Site longitude	75.72W	77.72W	degrees
Site altitude	4	2	km
Frequency	14.031	11.48125	GHz
Polarization	Vertical	Horizontal	
Rain model	ITU (47.3)	ITU (43.3)	(mm/h or zone)
Availability (average year)	99.75	99.75	%
Antenna aperture	0.457	11	metres
Antenna efficiency or gain (+ or - prefix)	58	66.5	% or dBi
Coupling loss	0.2	0.3	dB
Antenna mispoint loss	0.5	0.5	dB
Ionospheric losses	0	0	dB
LNB noise figure or temp (+ prefix)		0.7	dB or K
Antenna noise		AUTO	K
Csat/ACIo	108	108	dB.Hz
Csat/ASIo	106.00	106.00	dBW.Hz
Csat/XPIo	104	104	dB.Hz
Uplink station HPA output back-off	0.5		dB
Number of carriers / HPA	1		
HPA Csat/IMo	115		dB.Hz
Uplink power control	0		dB
Uplink filter truncation loss	0		dB
Required HPA power capability	16		W

Satellite Input Parameters	Value	Units
Satellite longitude	74.05W	degrees
Transponder type	TWTA	
G/T Reference	5.6	dB/K
SFD Reference	-91.5	dBW/m2
Receive G/T	5.6	dB/K
Attenuator pad (gain step)	0	dB
Effective SFD	**-91.50**	**dBW/m2**
Satellite ALC	0	dB
EIRP (saturation)	53.1	dBW
Transponder bandwidth	72	MHz
Input back off total	6.1	dB
Output back off total	4.0	dB
Number of transponder carriers	AUTO	

Carrier/Link Input Parameters	Value	Units
Modulation	BPSK	
Required bit error rate performance	10^-7	
Required Eb/No without FEC coding	11.31	dB
Required Eb/No with FEC coding	4	dB
Information rate	1.8	Mbps
Overhead	30	%
FEC code rate	2/3	
Spreading gain	3	dB
Reed Solomon code	1	
(1 + Roll off factor)	1.2	
Carrier spacing factor	1.2	
Bandwidth allocation step size	0.001	MHz

System margin	0	dB

Calculations at Saturation	Value	Units
Gain 1m^2	44.40	dB/m2
Uplink C/No	98.30	dB.Hz
Downlink C/No	116.03	dB.Hz
Total C/No	98.23	dB.Hz
Uplink EIRP for saturation	71.80	dBW

General Calculations	Up	Down	Units
Elevation	44.32	43.97	degrees
True azimuth	177.37	174.26	degrees
Compass bearing	188.98	184.76	degrees
Path distance to satellite	37459.32	37484.25	km
Propagation time delay	0.124951	0.125034	seconds
Antenna efficiency	58.00	66.50	%
Antenna gain	34.18	60.66	dBi
Availability (average year)	99.75	99.75	%
Link downtime (average year)	21.915	21.915	hours
Availability (worst month)	99.147	99.147	%
Link downtime (worst month)	6.234	6.234	hours
Spectral power density	-57.11	-39.53	dBW/Hz

Uplink Calculation	Clear	Rain Up	Rain Dn	Units
Uplink transmit EIRP	45.52	45.52	45.52	dBW
Transponder input back-off (total)	6.10	6.10	6.10	dB
Input back-off per carrier	26.28	26.28	26.28	dB
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	206.86	206.86	206.86	dB
Atmospheric absorption	0.10	0.10	0.10	dB
Tropospheric scintillation fading	0.23	0.23	0.23	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.00	dB
Uplink power control	0.00	0.00	0.00	dB
Uncompensated rain fade	0.00	0.00	0.00	dB
C/No (thermal)	72.03	72.03	72.03	dB.Hz
C/N (thermal)	2.78	2.78	2.78	dB
C/ACI	12.48	12.48	12.48	dB
C/ASI	10.48	10.48	10.48	dB
C/XPI	8.48	8.48	8.48	dB
C/IM	19.48	19.48	19.48	dB
C/(N+I) [= Es/(No+Io)]	0.83	0.83	0.83	dB
Eb/(No+Io)	6.38	6.38	6.38	dB

Downlink Calculation	Clear	Rain Up	Rain Dn	Units
Satellite EIRP total	53.10	53.10	53.10	dBW
Transponder output back-off (total)	4.00	4.00	4.00	dB
Output back-off per carrier	24.18	24.18	24.18	dB
Satellite EIRP per carrier	28.92	28.92	28.92	dBW
Antenna mispoint	0.50	0.50	0.50	dB
Free space loss	205.12	205.12	205.12	dB
Atmospheric absorption	0.08	0.08	0.08	dB
Tropospheric scintillation fading	0.08	0.08	0.08	dB
Ionospheric losses	0.00	0.00	0.00	dB
Rain attenuation	0.00	0.00	0.71	dB
Noise increase due to precipitation	0.00	0.00	1.33	dB
Downlink degradation (DND)	0.00	0.00	2.04	dB
Total system noise	105.66	105.66	143.50	K
Figure of merit (G/T)	39.62	39.62	38.29	dB/K
C/No (thermal)	91.86	91.86	89.82	dB.Hz
C/N (thermal)	22.61	22.61	20.57	dB
C/ACI	14.58	14.58	14.58	dB
C/ASI	12.58	12.58	12.58	dB
C/XPI	10.58	10.58	10.58	dB

C/IM	5.58	5.58	5.58	dB
C/(N+I) [= Es/(No+Io)]	3.38	3.38	3.34	dB
Eb/(No+Io)	8.93	8.93	8.90	dB

Totals per Carrier (End-to-End)	**Clear**	**Rain Up**	**Rain Dn**	**Units**
C/No (thermal)	71.98	71.98	71.96	dB.Hz
C/N (thermal)	2.74	2.74	2.71	dB
C/ACI	10.39	10.39	10.39	dB
C/ASI	8.39	8.39	8.39	dB
C/XPI	6.39	6.39	6.39	dB
C/IM	5.41	5.41	5.41	dB
C/(No+Io)	68.15	68.15	68.14	dB.Hz
C/(N+I) [= Es/(No+Io)]	-1.09	-1.09	-1.10	dB
Eb/(No+Io)	4.46	4.46	4.45	dB
System margin	0.00	0.00	0.00	dB
Net Eb/(No+Io)	4.46	4.46	4.45	dB
Required Eb/(No+Io)	4.00	4.00	4.00	dB
Excess margin	**0.46**	**0.46**	**0.45**	**dB**

Earth Station Power Requirements	**Value**	**Units**
EIRP per carrier	45.52	dBW
Antenna gain	34.18	dBi
Antenna feed flange power per carrier	11.34	dBW
Uplink power control	0.00	dB
HPA output back off	0.50	dB
Waveguide loss	0.2	dB
Filter truncation loss	0	dB
Number of HPA carriers	1	
Total HPA power required	12.0412	dBW
Required HPA power capability	16.0000	W
Spectral power density (feed flange)	-57.11	dBW/Hz

Space Segment Utilization	**Value**	**Units**
Overall link availability	99.501	%
Information rate (inc overhead)	2.3400	Mbps
Transmit rate	3.5100	Mbps
Symbol rate	7.0034	Mbaud
Noise Bandwidth	69.24	dB.Hz
Occupied bandwidth	**8.4040**	**MHz**
Minimum allocated bandwidth required	8.4040	MHz
Allocated transponder bandwidth	**8.4050**	**MHz**
Percentage transponder bandwidth used	**11.67**	**%**
Used transponder power	**28.92**	**dBW**
Percentage transponder power used	**0.96**	**%**
Max carriers by transponder bandwidth	8.57	
Max carriers by transponder power	104.12	
Max transponder carriers limited by:-	Bandwidth	[8.57]
Power equivalent bandwidth usage	0.6915	MHz