PART VII GENERAL TECHNICAL INFORMATION

VII.A <u>SYSTEM OPERATIONAL CHARACTERISTICS</u>

KaSTARCOM. is a communication network service that combines configuration and control management on ground stations with traffic switching networks supplied in space. The space portion is accomplished by links through one of four satellites located at 73° West Longitude, 109.2° West Longitude, 52° East Longitude and 175° West Longitude, at geosynchronous orbit. The satellites will be launched by one of the currently available commercial launch vehicles able to meet its weight requirements. Once in orbit, each spacecraft will be stationary within a tolerance of ±0.05° and at a zero orbital inclination with a tolerance of ±0.05°. Figure VII.A-1 summarizes the key system characteristics.

On the ground, several types of stations will be required to use, control, and reconfigure the space segment:

1. Earth stations to provide the necessary telemetry, tracking, and command ("TT&C") functions for the spacecraft.
2. An operations control center that will integrate the terrestrial and space segments of **KaSTARCOM.**
3. Transmit/receive earth-based platforms that will provide communications services.

VII.A.1 <u>Satellite Control Facilities</u>

Initially, transfer orbit operations and in-orbit testing will be controlled from an appropriate facility that has experience in supporting complex missions. Such facilities include the Lockheed Martin Spacecraft Operations Center in Sunnyvale, CA, and other commercially available support services. After the satellite is fully operational, control and operations will be transferred to the **KaSTARCOM.** Satellite Operations Control Center (SOCC) located at Douglas County, Colorado.

Technical Summary Satellite	Orbital Location	Launch Vehicle	Min. Design Life
LADYBUG-1	73° West	Ariane, Proton, Sea Launch	10 years
LADYBUG-2	109.2° West	Ariane, Proton, Sea Launch	10 years
LADYBUG-3	52° East	Ariane, Proton, Sea Launch	10 years
LADYBUG-4	175° West	Ariane, Proton, Sea Launch	10 years

	Transmit	Receive
Transponder configuration		
Frequency band (GHz) (Both Satellites)	18.3 - 18.8 and 19.7 - 20.2	28.35 - 28.6 and 29.25 - 30.0
Number of transponders:	60 per satellite	
Inter-satellite link frequency band:	500 MHz channel in the 54.25 to 58.25 Ghz or 65 to 71 GHz range	
HPA power:	50W	ISL: 60W per 120MHz channel
HPA redundancy:	80 for 70	ISL: 5 for 3
Receiver redundancy:	80 for 70	ISL: 5 for 3
Satellite overview		
Satellite manufacturer:	Lockheed Martin Telecommunications/TRW	
Launch service provider:	TBD	
Design life:	10 years	
Structure height:	11.7 ft. (3.6m)	
Structure (DXW):	6.7 ft. X 6.7 ft. (2.0m X 2.0m)	
Overall length (solar arrays deployed).	92.03 ft. (28.06m)	
Total weight at launch (Proton):	4242 kg	
Dry weight:	2385 kg	
Liquid propellant weight:	1857 kg	
Power available (end of life):	10 kw	
Batteries:	Nickel Hydrogen	
Eclipse capability:	100% (79% DoD)	
Stationkeeping:	±0.050 degrees box	
Attitude control:	Three axis stabilization	
Command and telemetry frequency:	C- and Ka-band	
Ka-band reflector antennas:	4 spotbeam transmit, 4 spotbeam receive, 1 CONUS transmit and receive	
ISL antenna:	2 transmit and receive	
Omni antennas:	1 dual deployed	

Figure VII.A-1 KaSTARCOM. Key System Characteristics

The SOCC maintains full operational access to the spacecraft during its entire mission life by monitoring satellite status, performance, and equipment settings, and by commanding the satellite to new configurations when necessary.

VII.A.2 Frequency Plan

Due to the wide availability of bandwidth and satellite slots at Ka-band, **KaSTARCOM.** has selected the uplink for ground-to-space transmissions to operate in the bands of 28.35 GHz to 28.60 GHz and 29.25 GHz to 30.0 GHz, and the downlink for space-to-ground transmission to operate in the bands of 18.3 GHz to 18.8 GHz and 19.7 GHz to 20.2 GHz. Figure VII.A.2-1 shows the Ka-band frequency assignments for each service channel and its associated polarization, for Orderwire functions used for user coordination, and for on-station TT&C. The same frequency plan may apply to all satellites.

The frequency plan is broken down into four beam families, A through D. Each family will include from 14 to 16 active beams, from 7 to 8 in each of two polarizations. A family is a group of beams connected to one antenna. Each is allocated two 120-MHz bands of frequency allocation, one per polarization. Each beam covers a one degree circular spot on the service area and is widely separated from the other beams in its family. Each satellite will employ a total of 60 active 120 MHz spot beams for uplink and downlink communications (30 in each polarization). Because of the isolation achieved between non-adjacent beams, the same frequencies can be reused on average of 15 times for the 500-MHz spectrum of each satellite.

In the uplink band 29.25 to 29.5 (bands BE, CE and DE) sharing with the MSS feeder links is required. **KaSTARCOM.** will operate in this band only from major Gateway Stations servicing major metropolitan centers. Location of these stations will be coordinated with any MSS Earth Stations at these centers.

Two 10-MHz wide channels on opposite polarizations are allocated to the Orderwire. The Orderwire provides the coordination and assignment of service to users.

Beam Family	Polarization	Uplink Frequency Band (GHz)	Downlink Frequency Band
A A AE AE	RHCP LHCP RHCP LHCP	29.50-29.62 29.74-29.86 29.26-29.38 28.36-28.48	19.70-19.82 19.94-20.06 18.32-18.44 18.56-18.68
B B BE BE	RHCP LHCP RHCP LHCP	29.62-29.74 29.86-29.98 29.38-29.50 28.48-28.60	19.82-19.94 20.06-20.18 18.44-18.56 18.68-18.80
C C CE CE	RHCP LHCP RHCP LHCP	29.74-29.86 29.50-29.62 28.36-28.48 29.26-29.38	19.94-20.06 19.70-19.82 18.56-18.68 18.32-18.44
D D DE DE	RHCP LHCP RHCP LHCP	29.86-29.98 29.62-29.74 28.48-28.60 29.38-29.50	20.06-20.18 19.82-19.94 18.68-18.80 18.44-18.56
Orderwire 1 Orderwire 2	RHCP LHCP	29.98-29.99 29.99-29.30	20.18-20.19 20.19-20.20
Command Carrier Telemetry Beacon	LHCP RHCP	29.9815 ----	---- 20.1995
Intersatellite Link (Typical)	Polarization	L1-L2 Frequency Band (GHz)	L2-L1 Frequency Band (GHz
L1-L2 1 L1-L2 2 L1-L2 3 L2-L1 1 L2-L1 2 L2-L1 3	RHCP RHCP RHCP LHCP LHCP LHCP	54.300-54.425 54.425-55.550 54.550-55.675 ---- ---- ----	---- ---- ---- 55.700-55.825 55.825-55.950 55.950-56.075

Notes:
(1) Beams AE, BE, CE, and DE are the additional channels provided in high traffic areas.
(2) Polarizations: RHCP = Right hand circular polarization
LHCP = Left hand circular polarization
(3) Intersatellite links: L1-L2 = LADYBUG-1 to LADYBUG-2
L2-L1 = LADYBUG-2 to LADYBUG-1

Figure VII.A.2-1 Frequency and polarization plan

Ka-band frequencies are allotted to the command carrier on the uplink and the telemetry beacon on the downlink as shown in Figure VII.A.2-1. In addition, TT&C access for use during transfer orbit and on orbit, as required, will be available at the following C-band frequencies:

Transfer Orbit Command Uplink Frequency	Transfer Orbit Telemetry Downlink Frequency
6425-6525 MHz Band	3600-3700 MHz Band

The selection of the specific transfer orbit C-Band operational frequencies will be determined upon FCC approval for operating in these bands.

Lastly, intersatellite links provide up to 500-MHz bandwidth for transmitting and receiving data between satellites. These links will be allocated frequencies in the W-band as shown in Figure VII.A.2-1. The selected frequencies will be decided when the appropriate bands are determined by the FCC.

The satellite communications subsystem will include appropriate filtering at the inputs and outputs of the satellite to minimize noise effects outside the satellite frequency band and out-of-band spurious transmissions.

VII.A.3 <u>Emission Designations</u>

All data links, including commands from the TT&C ground station, telemetry to the ground station, communications to and from terminals, ISL crosslinks and Orderwire transmissions, will be phase modulated with a large deviation on their carriers in order to minimize the flux density radiating on the Earth. Each satellite will be equipped with government-approved encryption equipment in order to secure command transmissions. The emission designations for **KaSTARCOM.** are shown in Figure VII-A.3-1.

Signal	Emission designator
Command, transfer orbit	1M50X9D
Command, on-station	1M50X9D
Telemetry, transfer orbit	300KG9D
Telemetry, on-station	300KG9D
Communications uplink 384 kbps 768 kbps 1.544 Mbps 155.52 Mbps	 300KG7F 800KG7F 1MZOG7F 120MOOG1F
Orderwire access channel, uplink	10KOG1D
Communications downlink	120MOOG1F
Orderwire access channel, downlink	10KOG1D
ISL crosslink KSTAR-T7003	120MOOG1F

Figure VII.A.3-1 Emission designators

VII.A.4 Communications Coverage

Each spot beam is circular with a one-degree diameter. A typical coverage arrangement is shown in Figure VII.A.4-5; **KaSTARCOM** will cover an extensive territory. The grouping of beams into families is demonstrated for the downlink in Figures VII.A.4-1 through VII.A.4-4 for families A, B, C, and D, respectively. Figure VII.A.4-5 shows the combined transmit spot beam. Groupings for the uplink are shown in Figures VII.A.4-6 through VII.A.4-9 for families A, B, C, and D, respectively. The beam patterns for uplink and downlink are very similar. The figures are applicable for the 73°W orbital location. Beam spots shown over CONUS and Europe represent both polarities. All other beams in the 73°W orbital slot represent a single polarity, thus 59 total polarizations/beams are shown with one of the single polarization beams available for a second polarization if so desired due to traffic density.

Following the figures for the 73°W, are the uplink and downlink plots for the 109.2°W orbital position, shown in Figures VII.A.4-10 through 17. The antennas are designed so that there is at least 18 dB of isolation between beams of the same beam family so that different signals can be transmitted at the same frequencies without mutual interference. The isolations between beams are demonstrated in Figures VII.A.4-1 through VII.A.4-4 for the downlink (EIRP plots) and in Figures VII.A.4-6 through VII.A.4-9 for the uplink (G/T plots). In the figures, the first contour circling a beam's boresight is the 4-dB beamwidth; the second contour is the 22-dB isolation point. The beams for 52°EL and 175°WL will have similar characteristics.

The Orderwire will be a single horn with an elliptical beam overlapping the communications service area. Sufficient G/T will be provided in order to receive requests for channels. The Orderwire transponders are independent from the rest of the payload.

VII.A.5 Power Flux Densities

The maximum EIRP (center of beam) of each **KaSTARCOM.** Ka-band satellite is 60 dBW. The maximum power flux density on the ground for an unmodulated saturated carrier therefore is 60-162.4 = -102.4 dBW/m^2. Thus, an unmodulated carrier technically would exceed by 2.6 dB the power flux density limit of -105 dBW/m^2 specified in Section 25.208 of the Commission's rules. See 47 CFR Section 25.208(c) (1992). However, the downlinks proposed are restricted to digital traffic. For this digitally modulated traffic, the flux density in any 2-MHz band is -120.2 dBW/m^2. Thus, the Ka-band downlinks always will have sufficient spectral content such that the above referenced limits will not be exceeded. The transfer orbit C-band telemetry signal will produce a power flux density at the Earth's surface less than or equal to -152 dBW/m^2 for all arrival angles and therefore will comply with the requirements of Section 25.208.

VII.B.1 Spacecraft Overview

The **KaSTARCOM.** spacecraft in its launch and on-orbit configuration is shown in Figures VII.B.1-1 and VII.B.1-2, respectively. The solar arrays and antennas remain stowed for the 3-

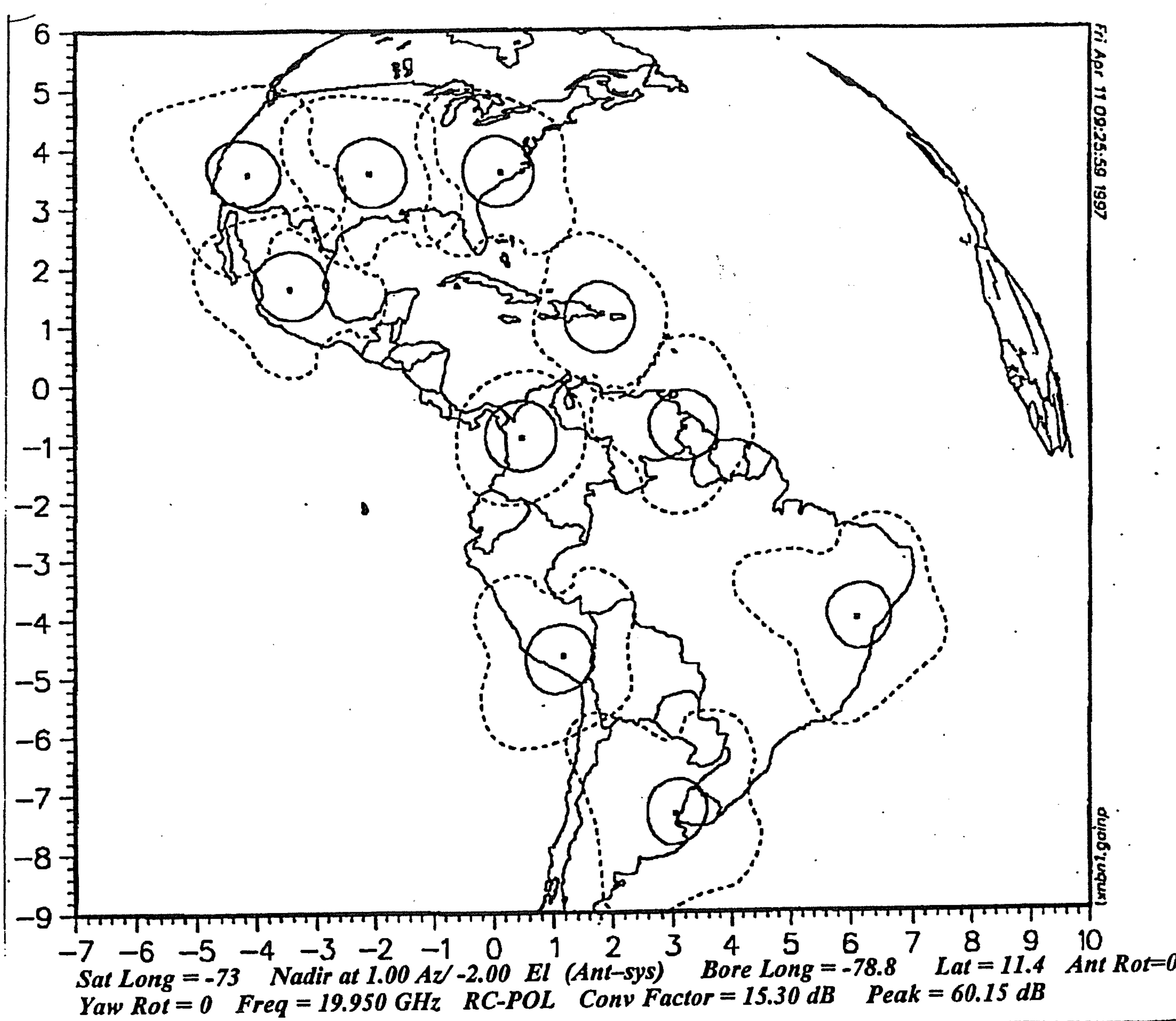

Figure VII.A.4-1: 73°W Ka-Band Antenna:

EIRP Beam Family "A"Contour Levels: 56.3,38.3 dBW

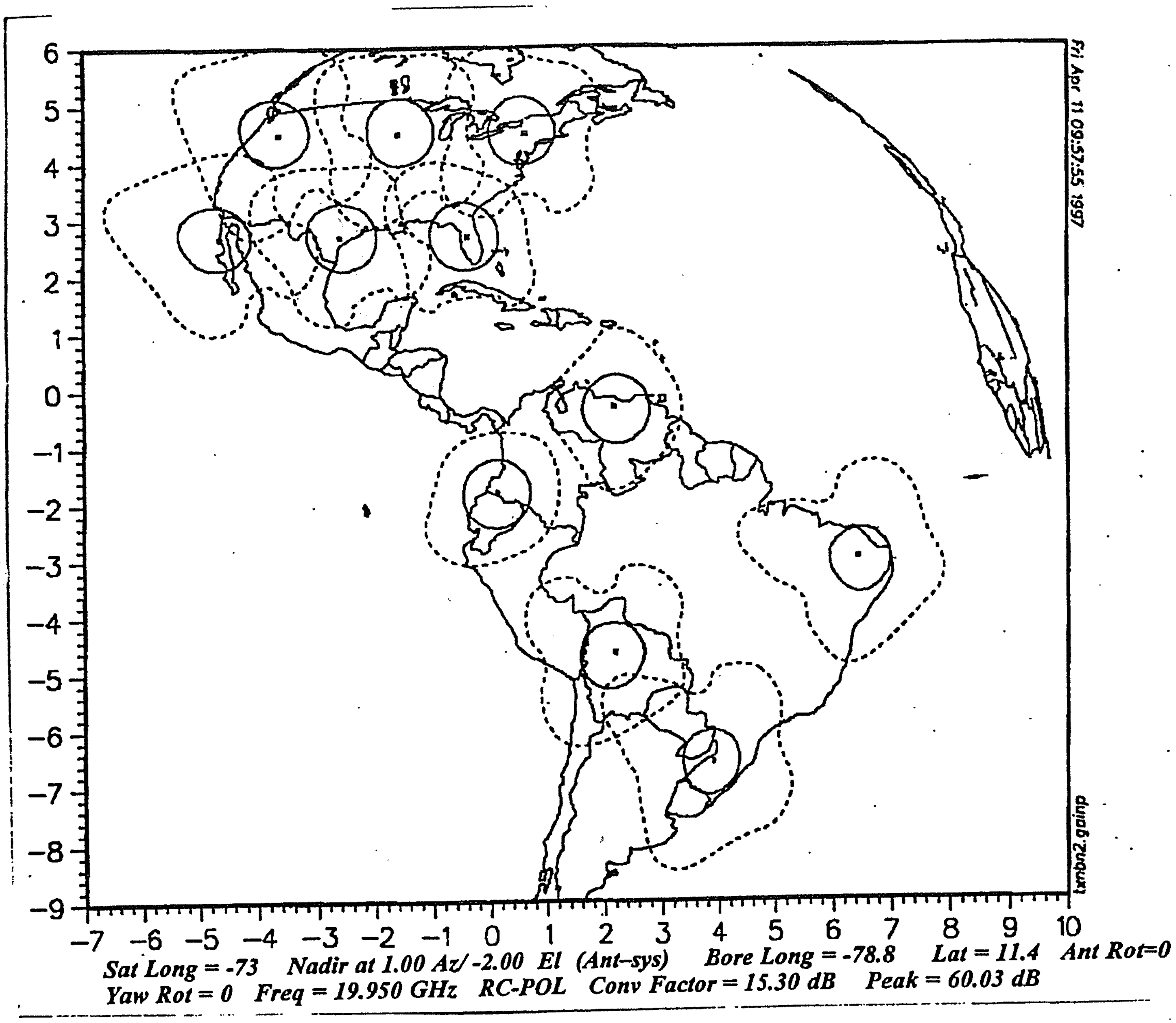

Figure VII.A.4-2 73°W Ka-Band Antenna:

EIRP Beam Family "B" Contour Levels: 56.3, 38.3 dBW

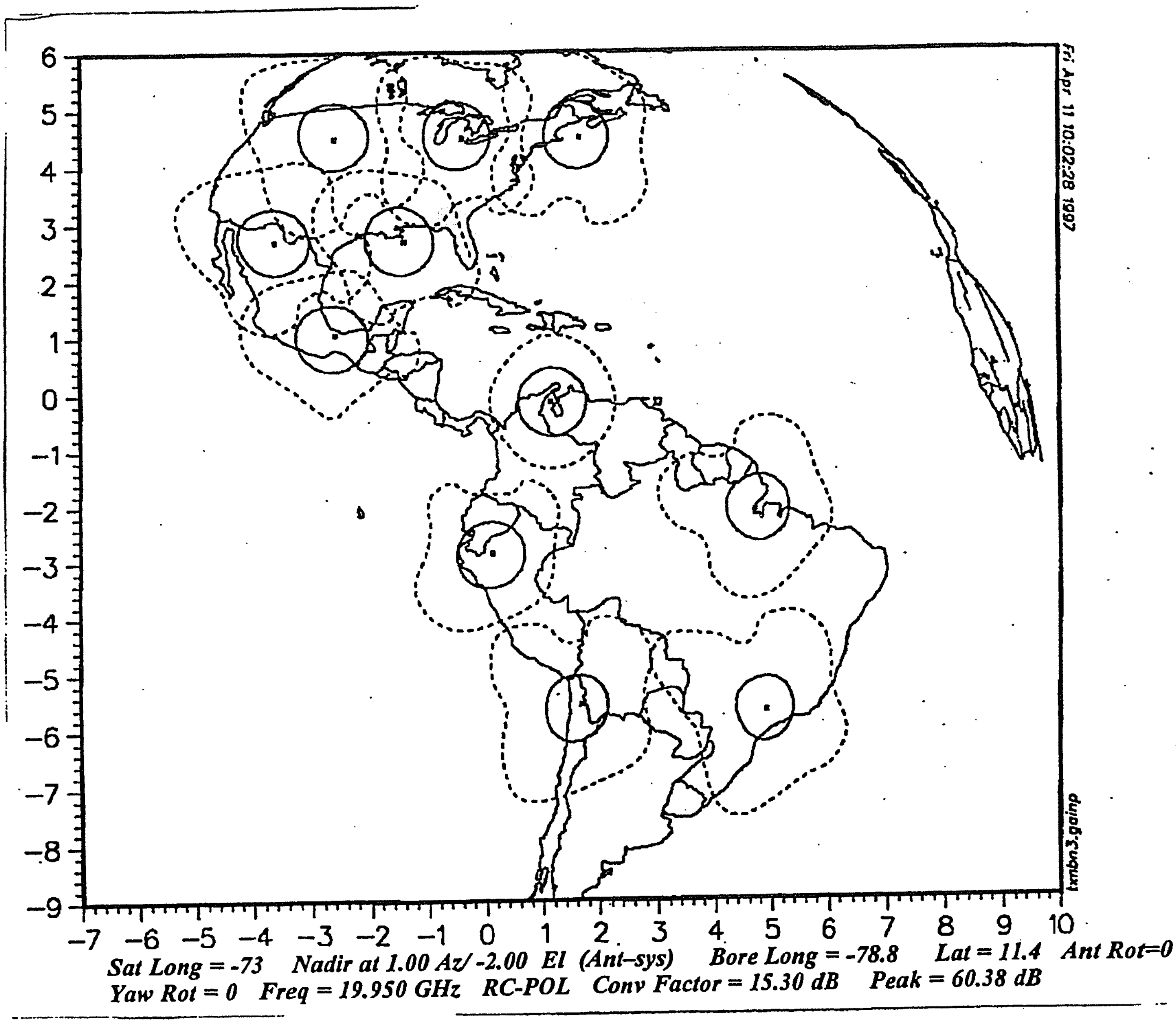

Figure VII.A.4-3 73°W Ka-Band Antenna:

EIRP Beam Family "C" Contour Levels 56.3, 38.3 dBW

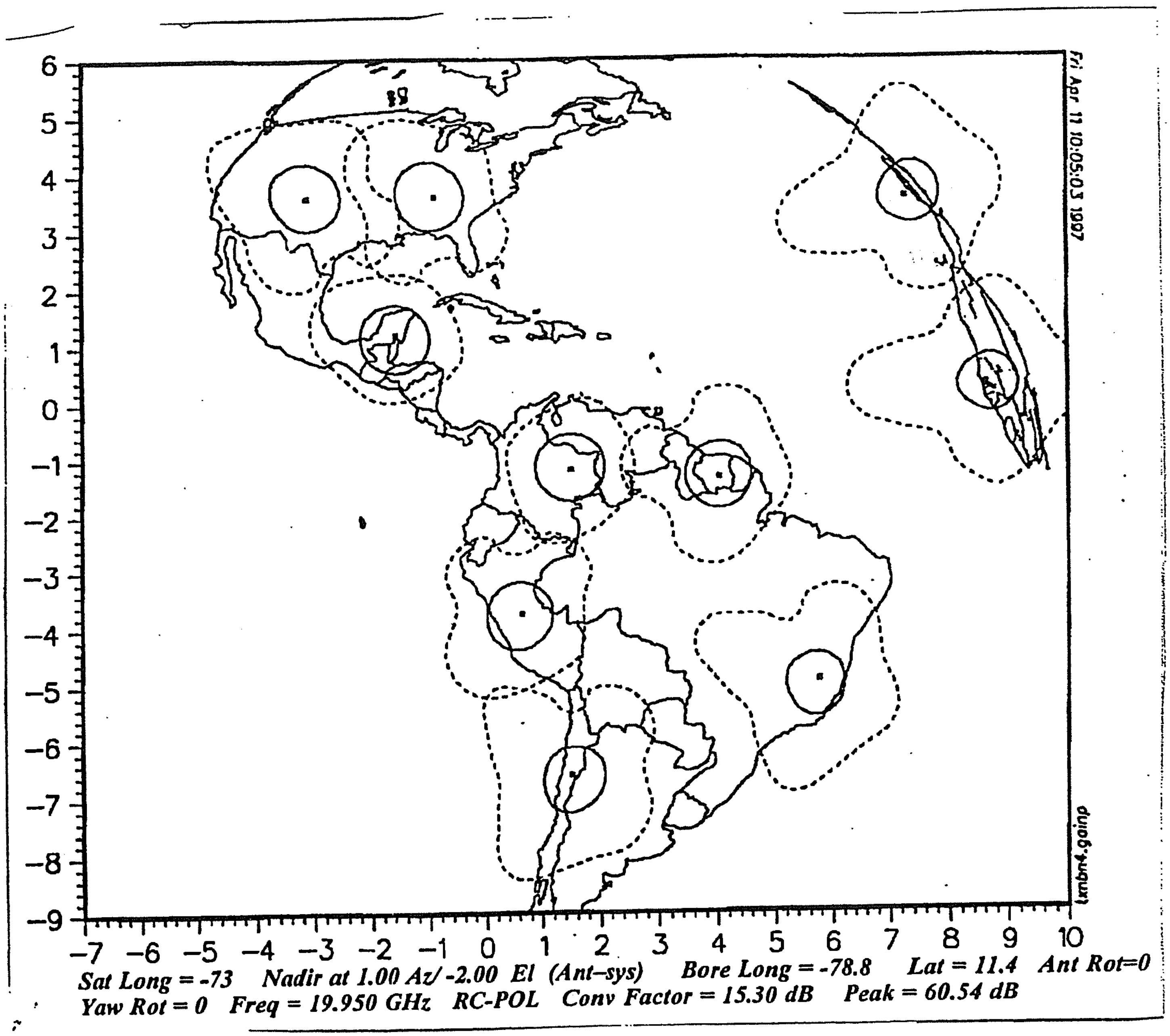

Figure VII.A.4-4 73°W Ka-Band Antenna:

EIRP Beam Family "C" Contour Levels: 56.3, 38.3 dBW

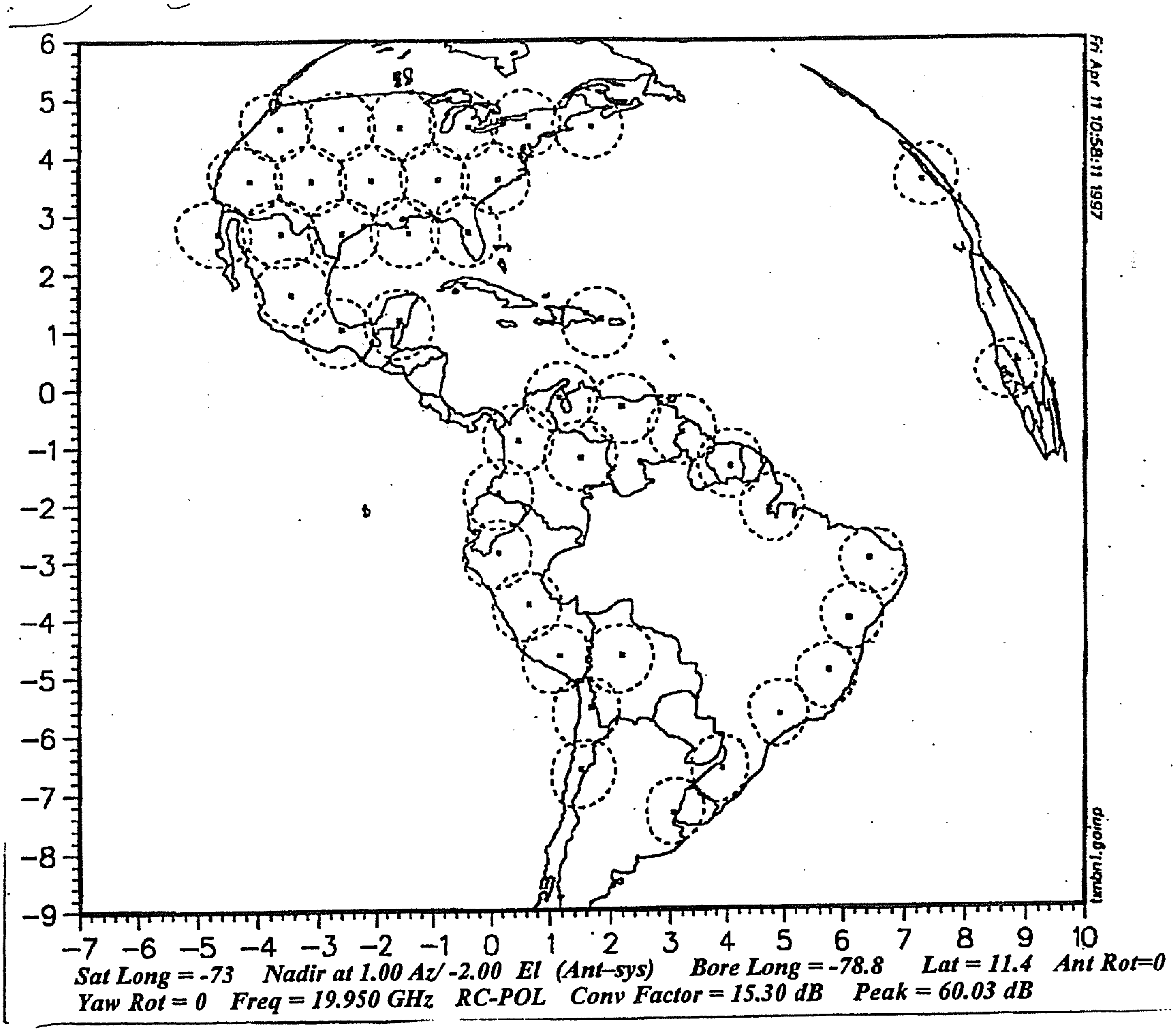

Figure VII.A.4-5 73°W Ka-Band Antenna:

Combined Transmit Spot Beam

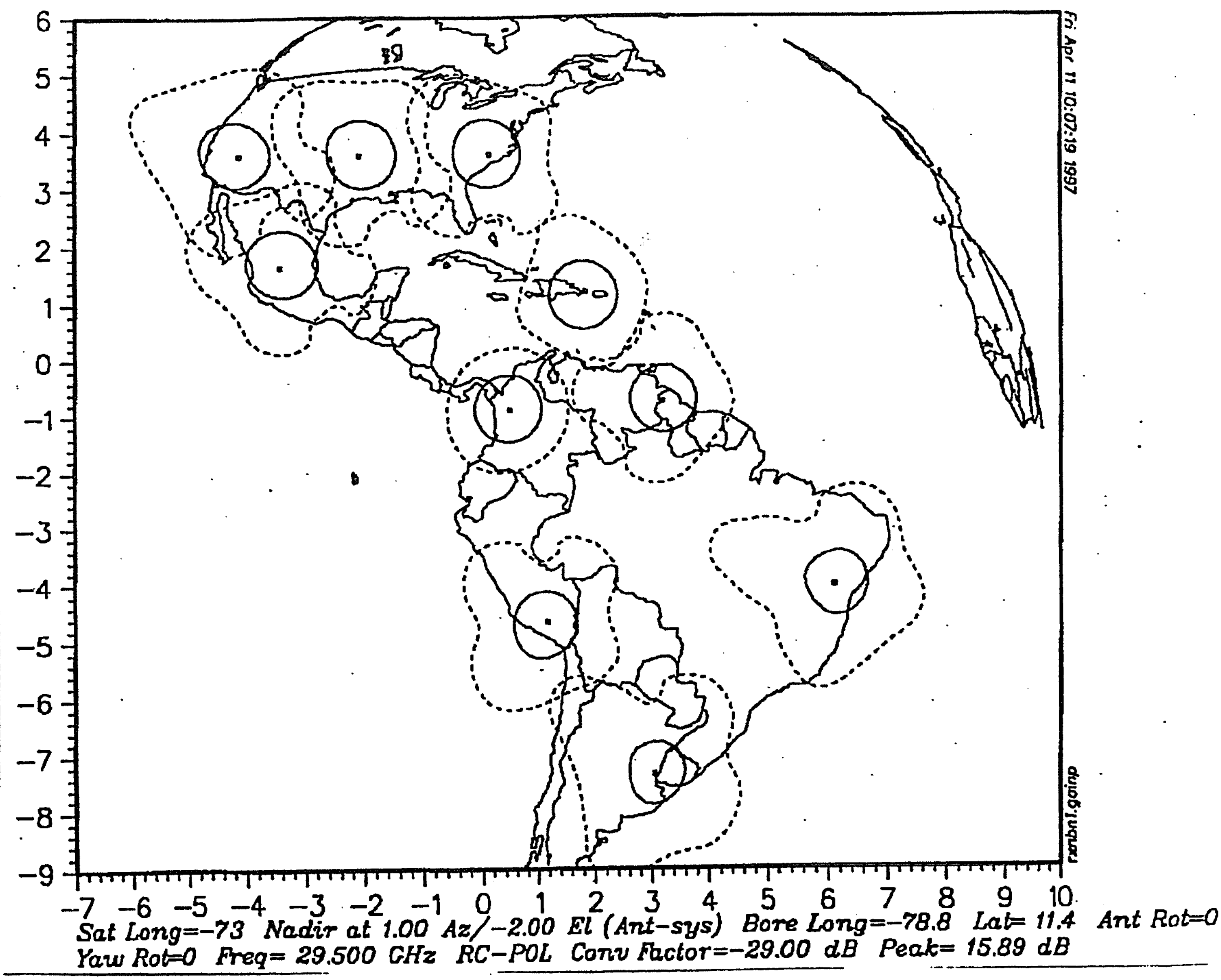

Figure VII.A.4-6 73°W Ka-Band Antenna:

G/T Beam Family "Contour Levels: 12.0, -6.0 dB/K

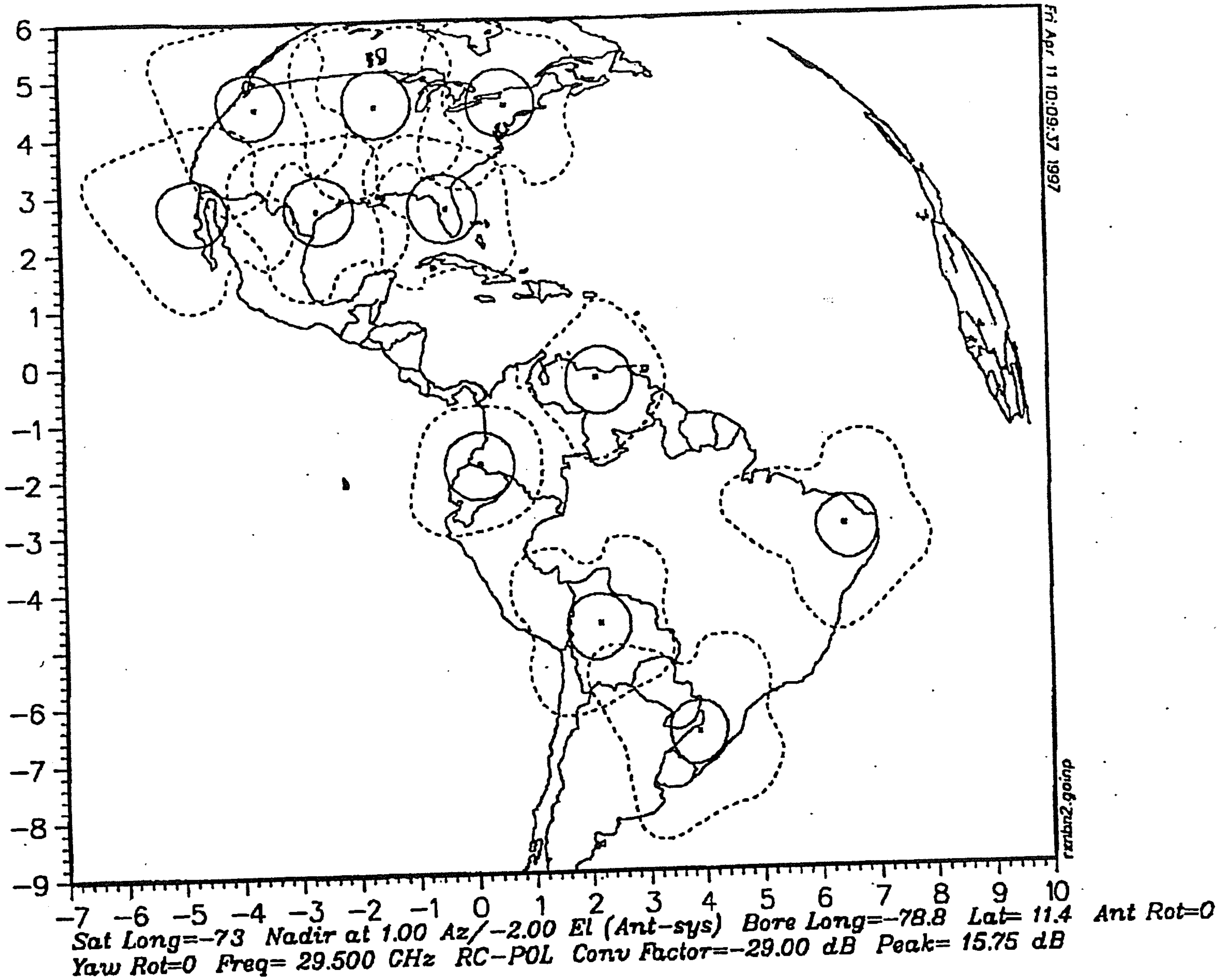

Figure VII.S.4-7 73° W Ka-Band Antenna:

G/T Beam Family "B" Contour Levels: 12.0, -6.0 dB/K

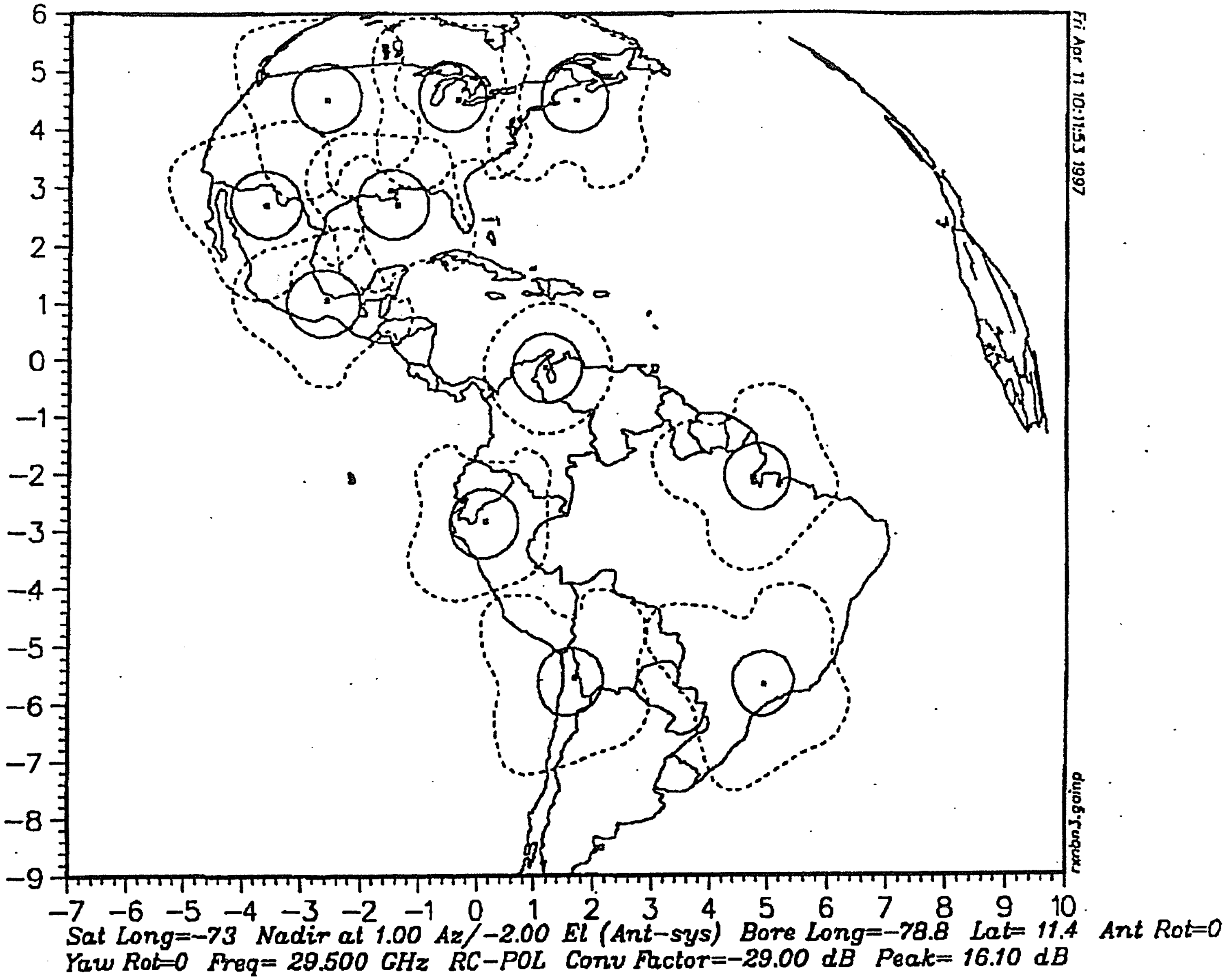

Figure VII.A.4-8 73°W Ka-Band Antenna:

G/T Beam Family "C" Contour Levels: 12, -6.0 dB/K

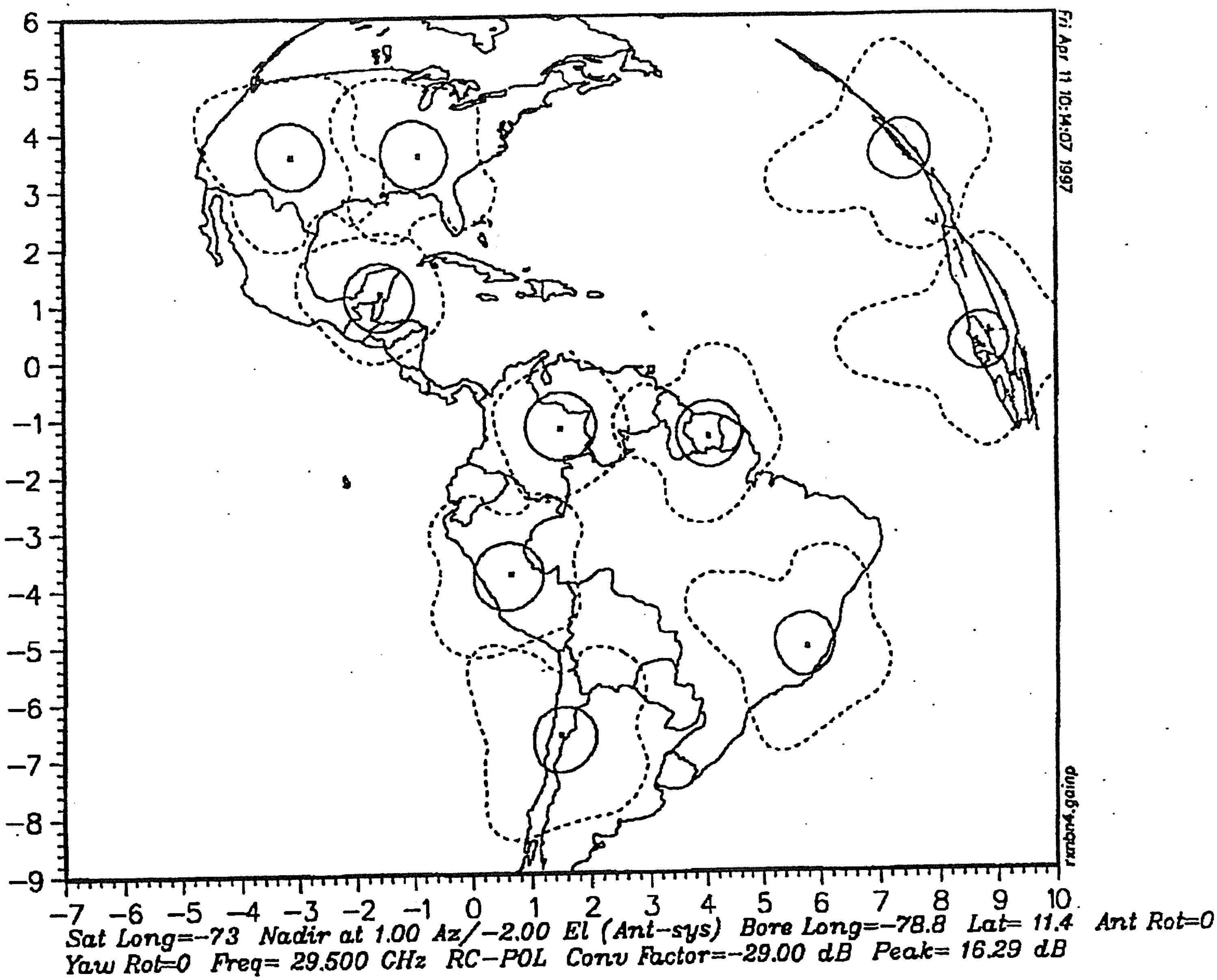

Figure VII.A.4-9 73°W Ka-Band Antenna:

G/T Beam Family "D" Contour Levels: 12.0, -6.00 dB/K

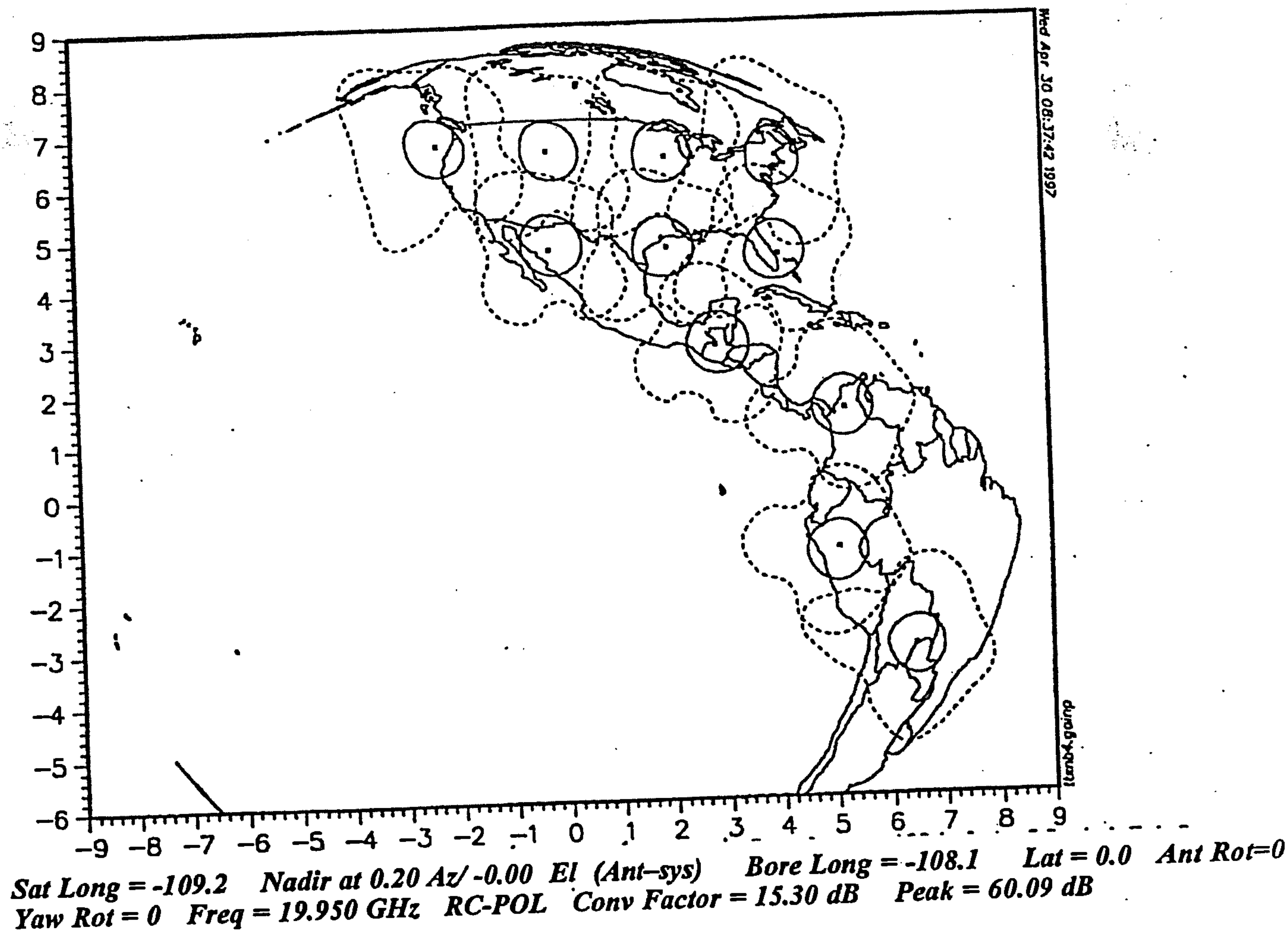

Figure VII.A.4-10 109.2°W Ka-Band Antenna:

EIRP Beam Family "A" Contour Levels: 56.3, 38.3 dBW

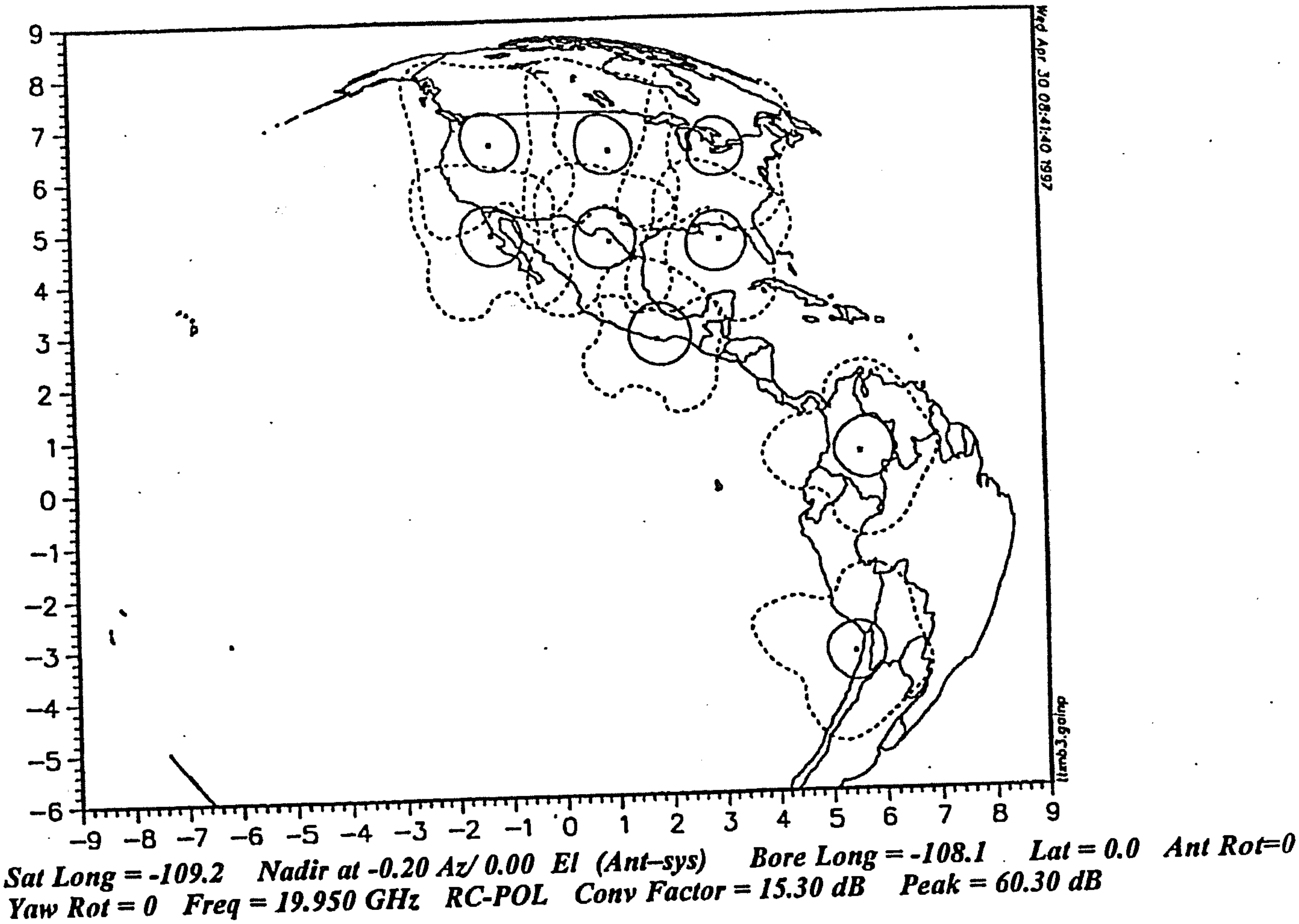

Figure VII.A.4-11 109.2°W Ka-Band Antenna:

EIRP Beam Family "B" Contour Levels: 56.3, 38.3 dBW

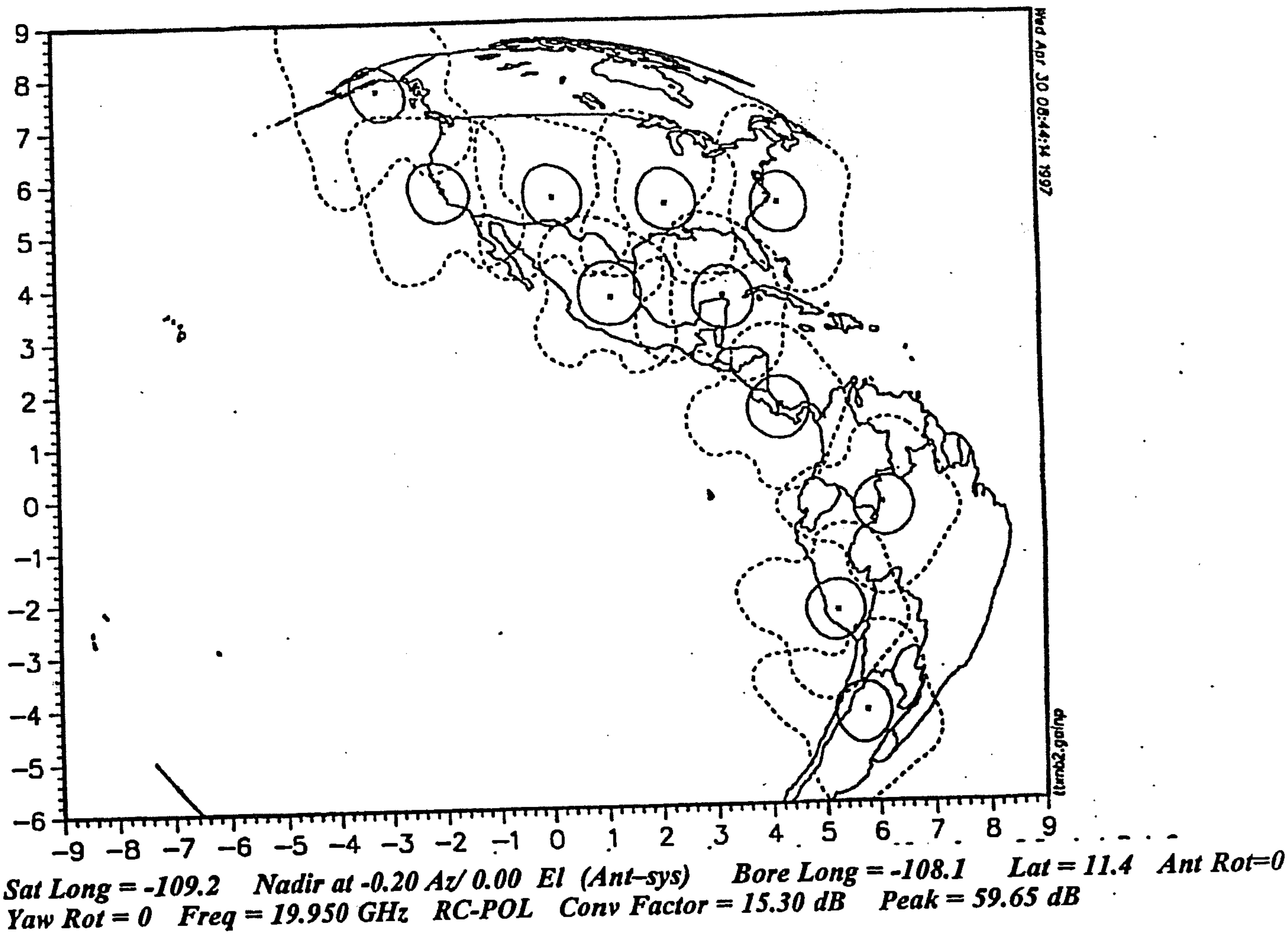

Figure VII.A.4-12 109.2°W Ka-Band Antenna:

EIRP Beam Family "C" Contour 56.3, 38.3 dBW

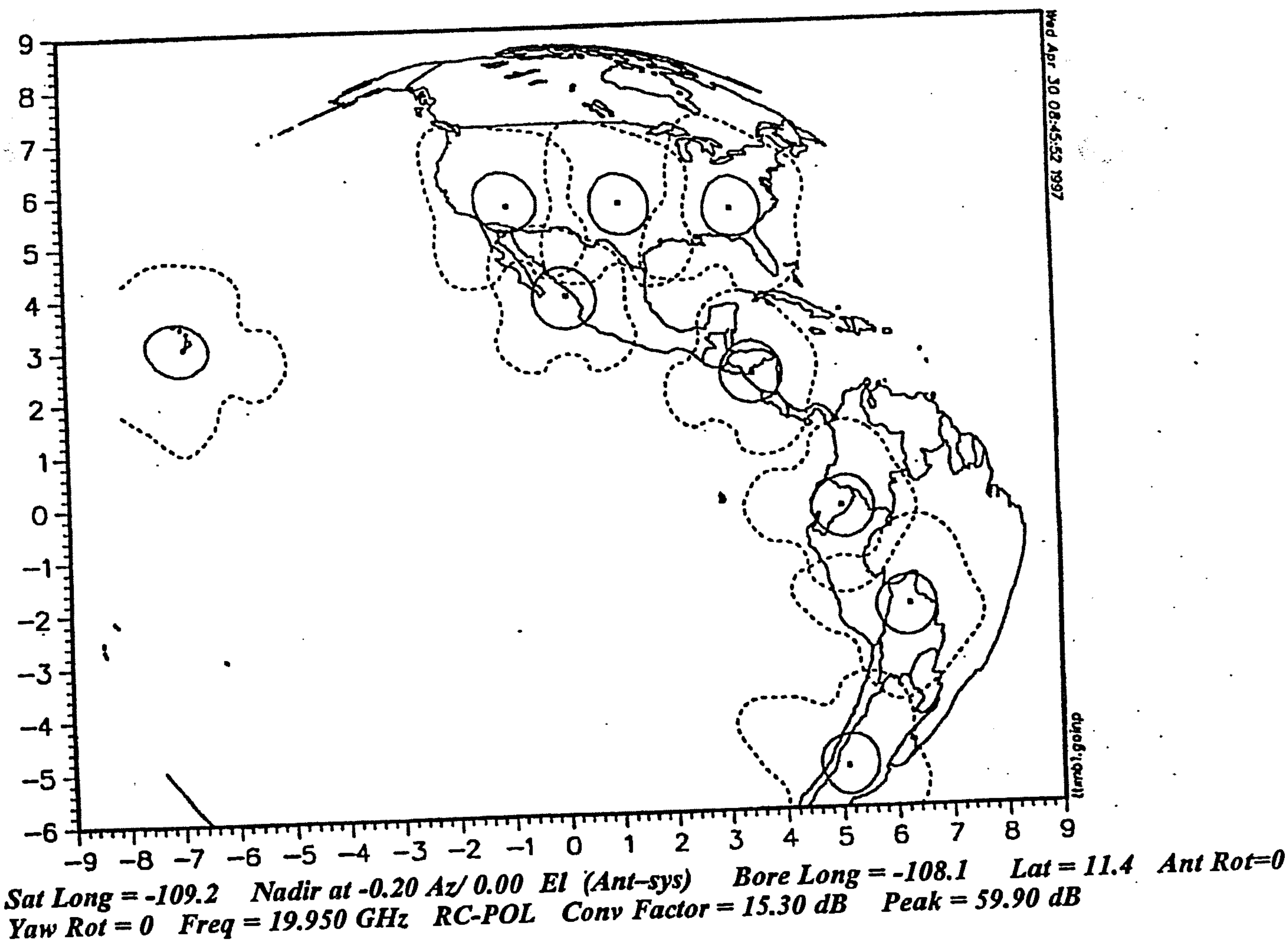

Figure VII.A.4-13 109.2°W Ka-Band Antenna:

EIRP Beam Family "D" Contour Levels: 56.3, 38.3 dBW

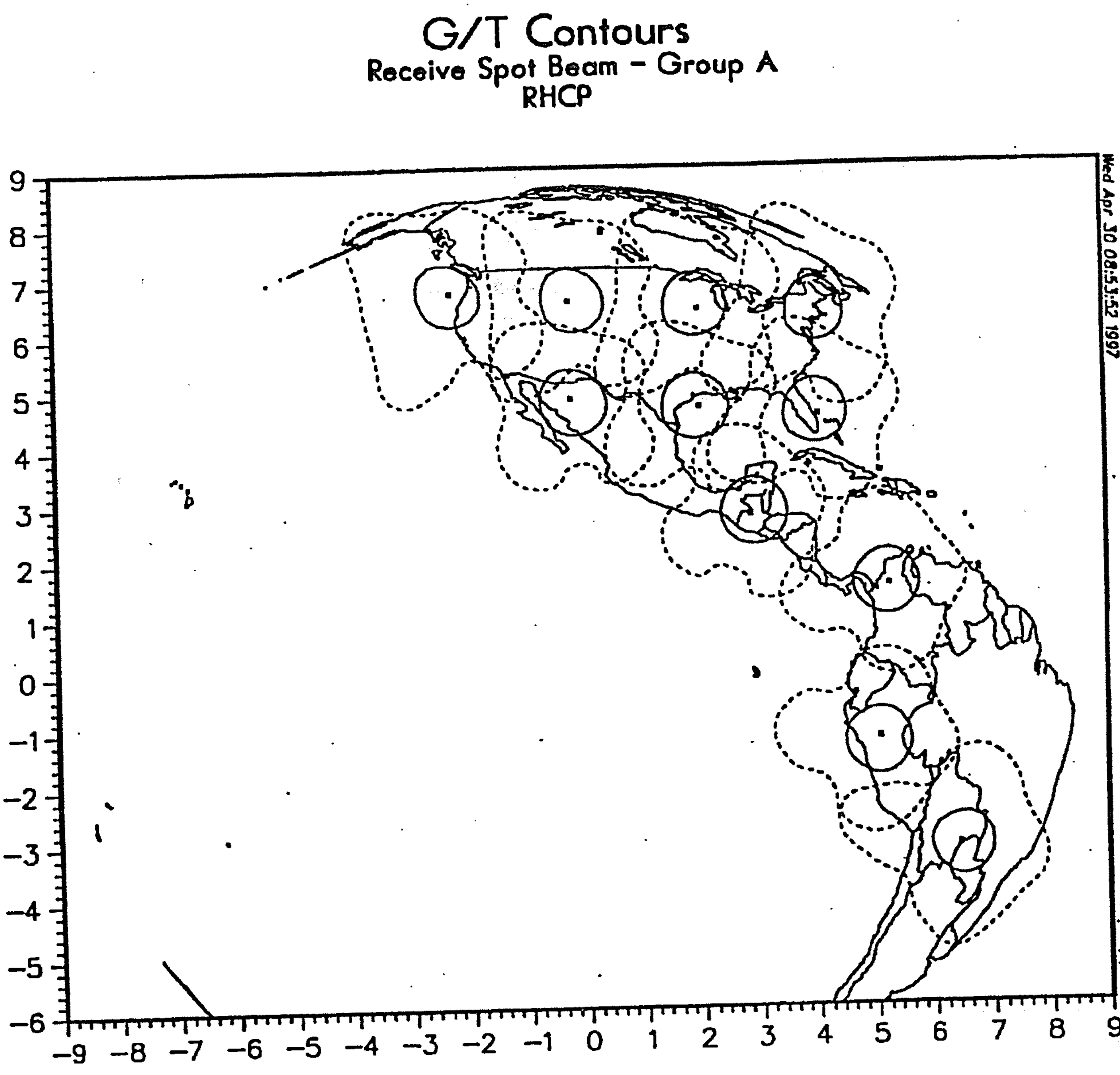

Figure VII.A.4-14 109.2°W Ka-Band Antenna:

G/T Beam Family "A" Contour Levels: 12.0, -6.0 dB/K

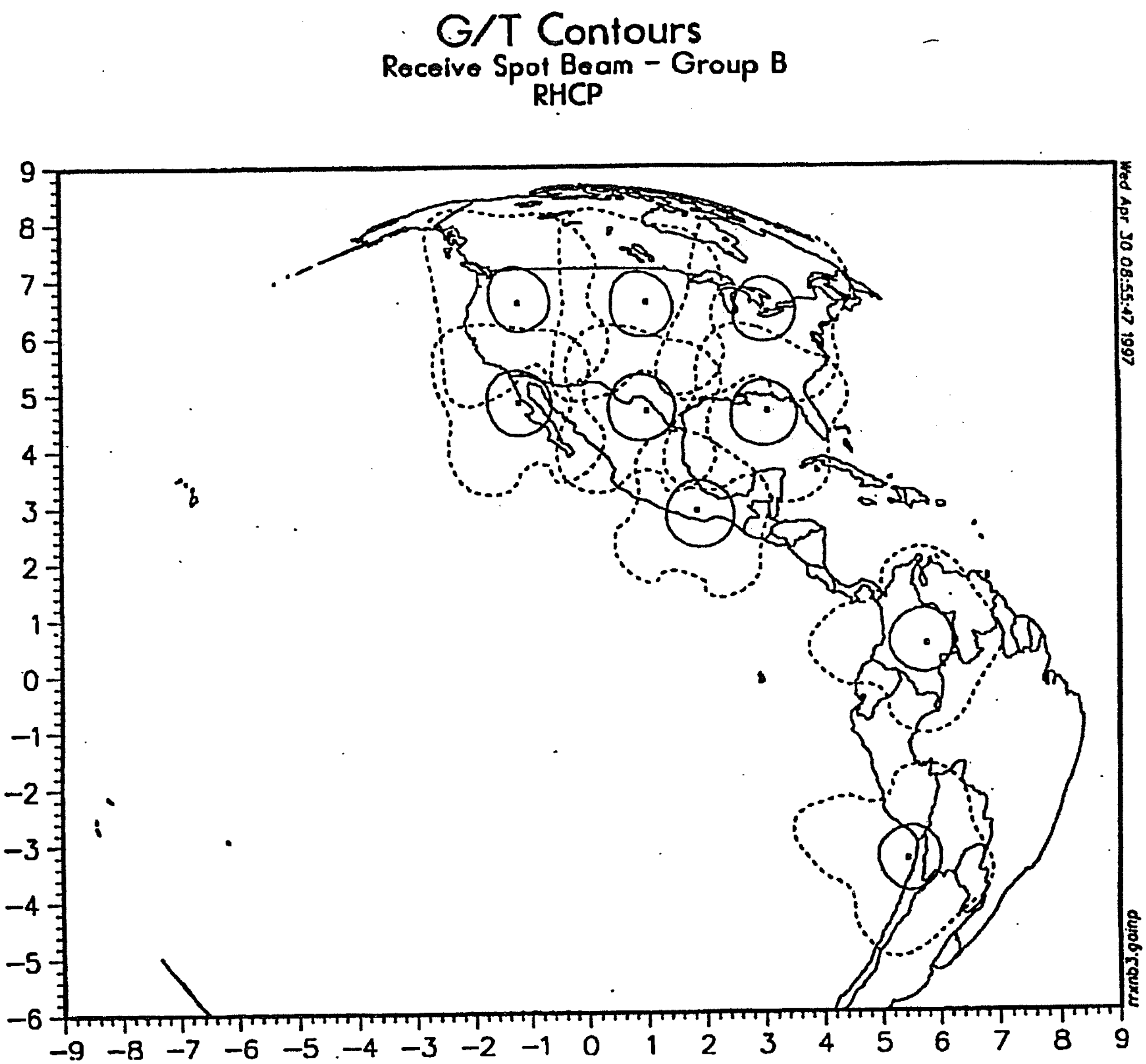

Figure VII.A.4-15 109.2°W Ka-band antenna: G/T beam family "B" contour levels: 12.0, -6.0 dB/K

Figure VII.A.4-15 109.2° Ka-Band Antenna:

G/T Beam Family "B" Contour Levels: 12.0, -6.0 dB/K

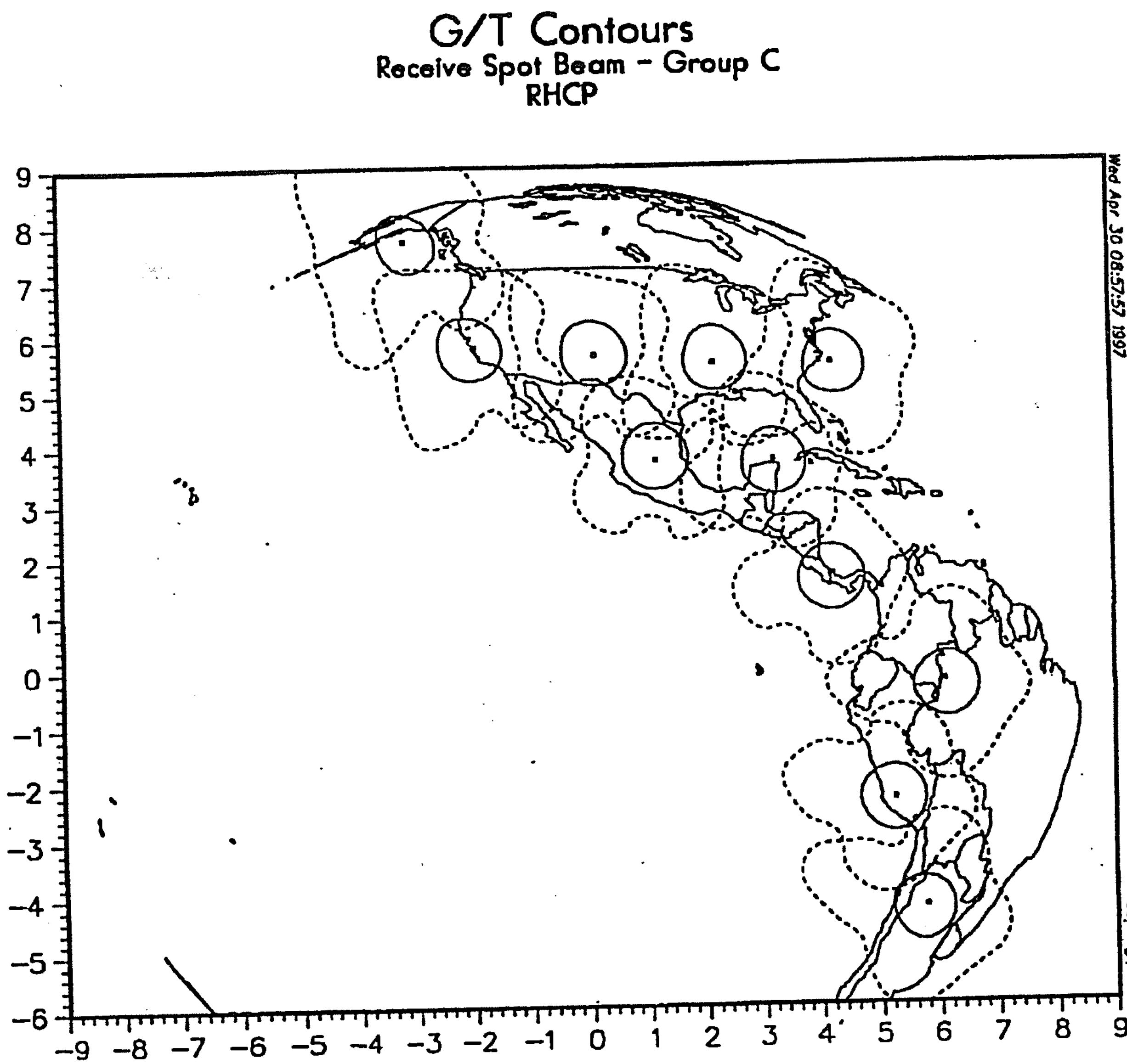

Figure VII.A.4-16 109.2°W Ka-band antenna: G/T beam family "C" contour levels: 12.0, -6.0 dB/K

Figure VII.A.4-16 109.2°W Ka-Band Antenna:

G/T Beam Family "C" Contour Levels: 12.0, -6.0 dB/K

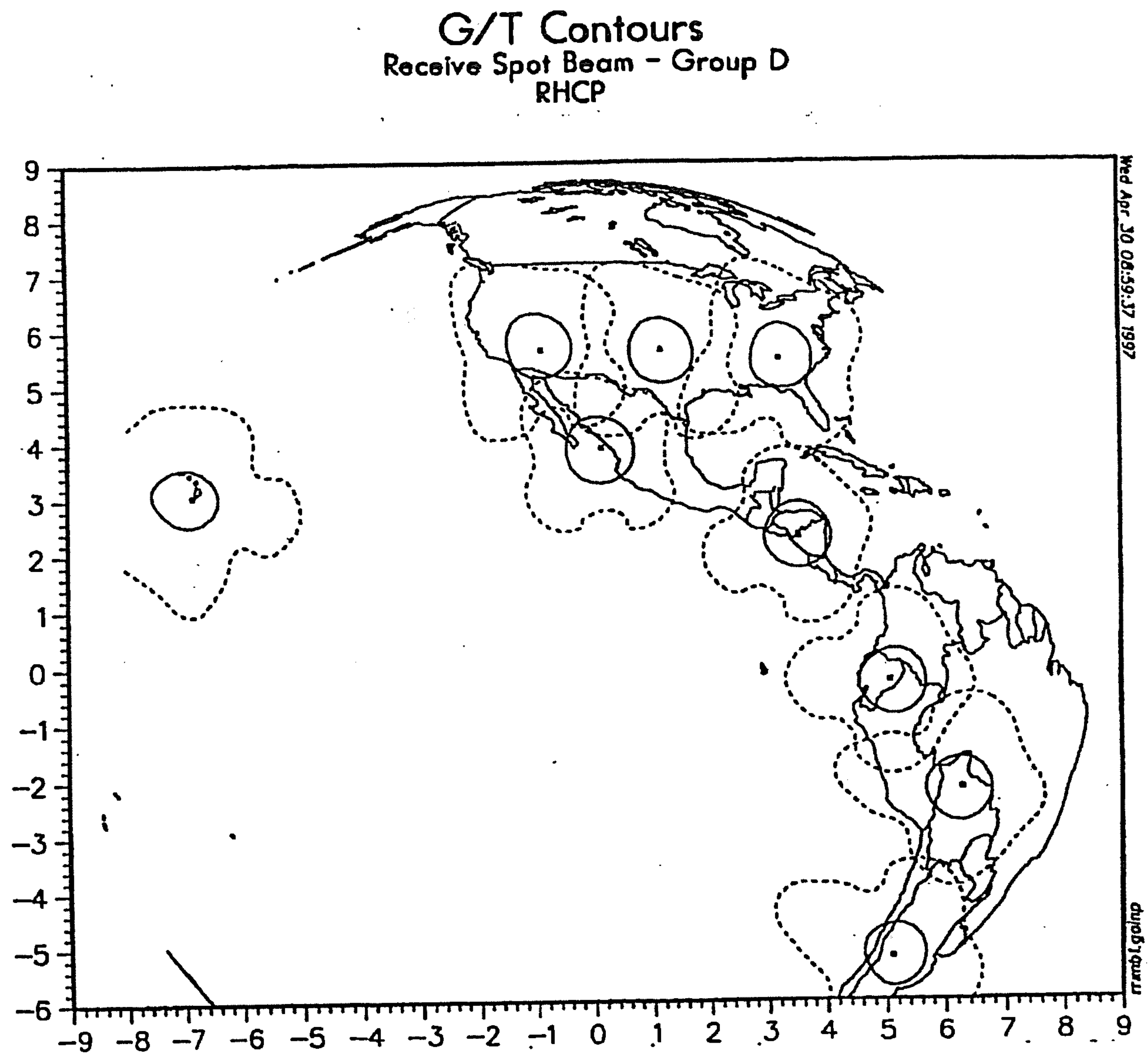

Figure VII.A.4-17 109.2°W Ka-band antenna: G/T beam family "D" contour levels: 12.0, -6.0 dB/K

Figure VII.A.4-17 109.2°W Ka-Band Antenna:

G/T Beam Family "D" Contour Levels: 12.0, -6.0 dB/K

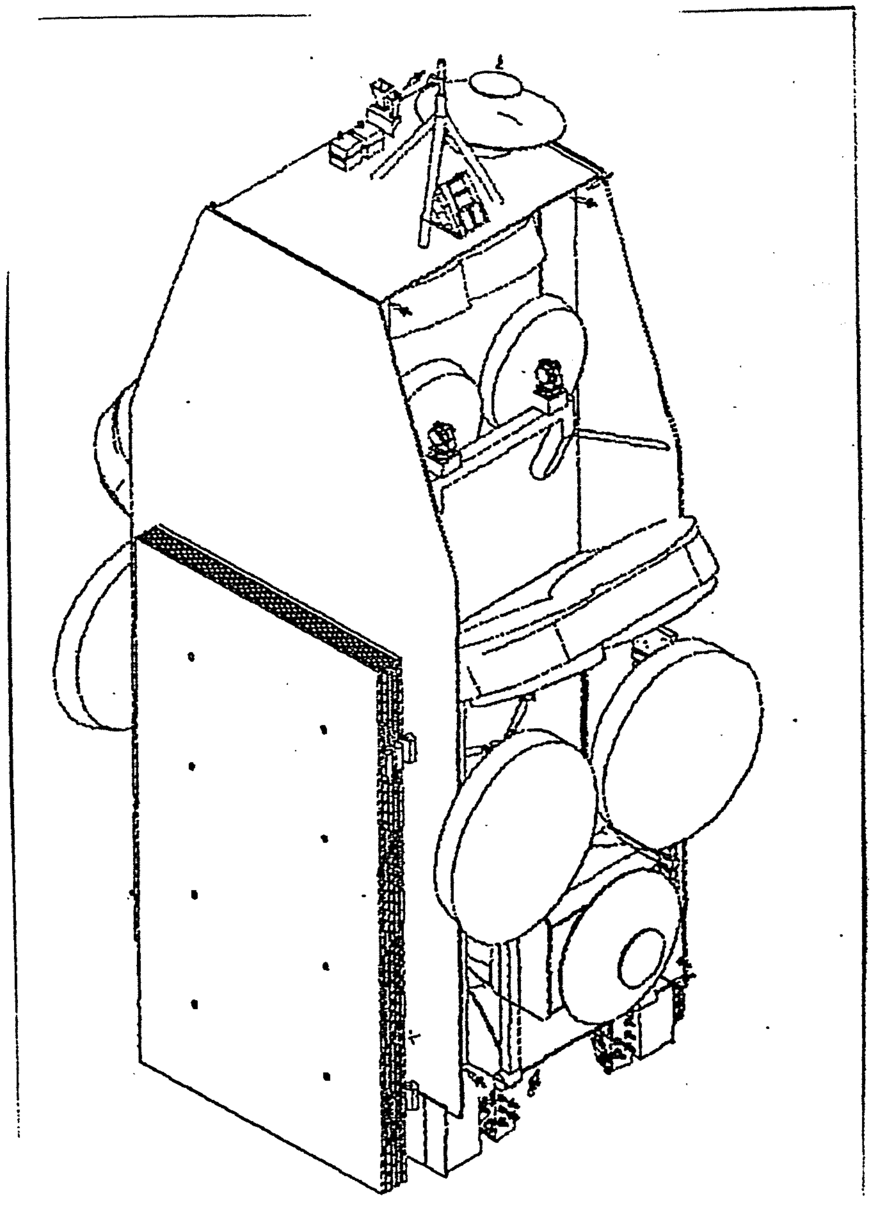

Figure VII.B.1-1 KaSTARCOM. Launch Configuration

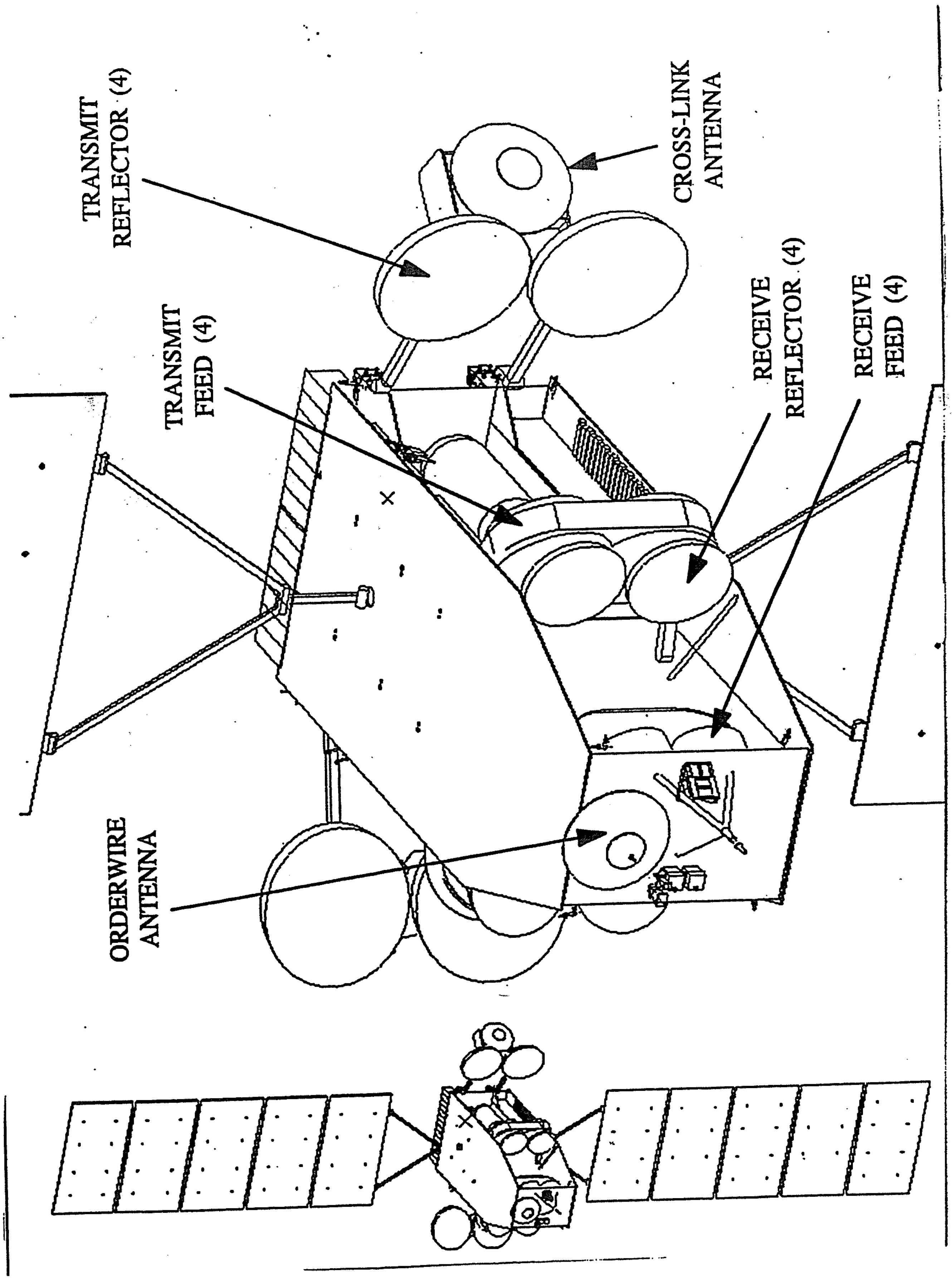

Figure VII.B.1-2 KaSTARCOM. Orbital Configuration

axis stabilized transfer orbit phase. Transfer orbit commanding and telemetry is through a deployed C-band omni, located on the earth facing panel. On station, the satellite is 3 axis stabilized. Solar arrays are deployed north and south along the satellite Z-axis. Payload downlink transmission is performed through two dual 1.3m dish reflector assemblies, deployed from the east and west sides of the satellite. Uplink reception is achieved using two dual 1.0m dish assemblies also deployed from the east and west sides of the satellite. Additionally, an intersatellite link 0.75m antenna is deployed. On station primary command and telemetry data is provided via the communications payload antenna.

The spacecraft employs the A2100 modular structural architecture to simplify assembly, integration, and test operations. The payload module, the core module and the antennas are separate assemblies that allow parallel integration, test and alignment, thereby maximizing the activity time available to each module while minimizing the overall scehdule.

The payload module externally supports the antenna assemblies and attitude sensors. The module configuration allows 100% access to transponder components as the assembly is being integrated and tested. In addition, this configuration allows efficient conductive thermal interchange among all panels. High power components such as TWTS, processor, output filters, and EPC's are mounted directly over heat pipes to provide for optimal spreading of dissipative heat, thereby lowering panel temperatures. To optimize payload efficiency, careful consideration is given to minimizing waveguide and harness runs between components.

The **KaSTARCOM.** spacecraft is designed to be compatible with the available commercial launch vehicles. Compatibility with the Proton is shown in Figure VII.B.1-3.

VII.B.2 Communications Subsystem Description

A block diagram of the communications subsystem is shown in Figure VII.B.2-1. Uplink signals are received by four receive antennas, which provide 30 beams on each of two circular

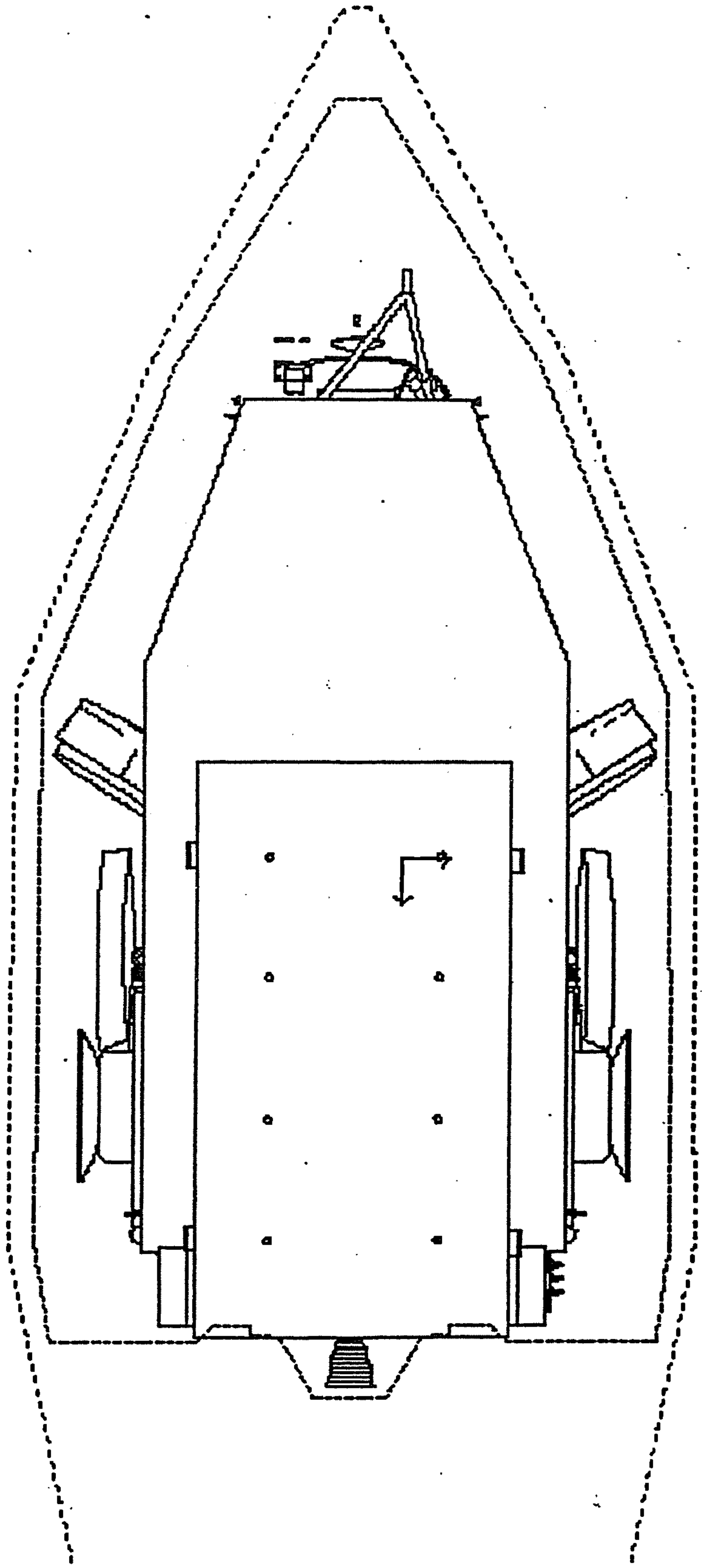

Figure VII.B.1-3 KaSTARCOM. Launch Compatibility with Proton

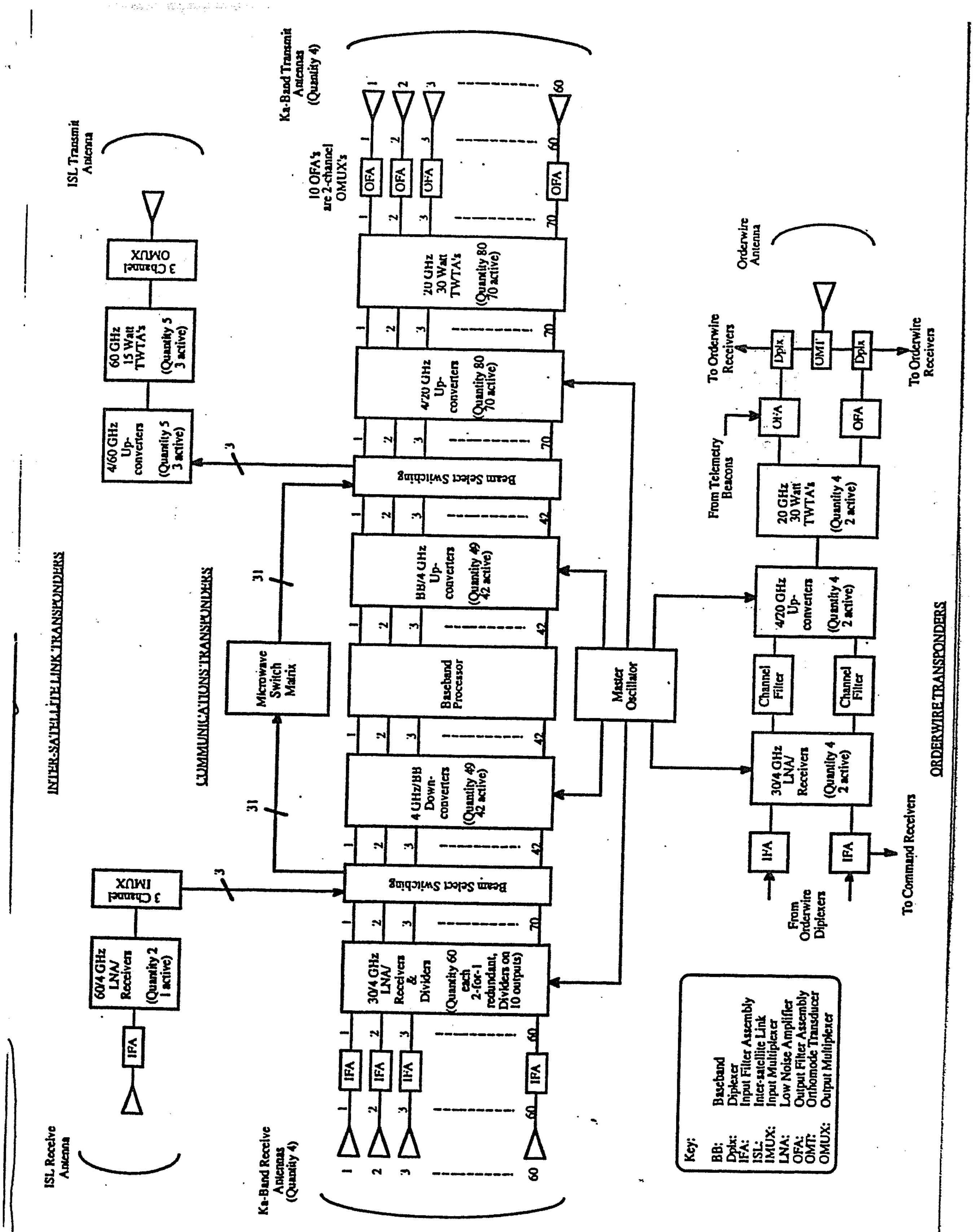

Figure VII.B.2-1 KaSTARCOM. Payload Block Diagram

conventional 10-MHz wide transponders used for communications between users and the control station to set up signal routing and uplink bit rates of the user communications. The Orderwire signals are received with a single beam that encompasses all of the spot beam coverages. These signals are amplified, downconverted, and amplified further before being transmitted from a downlink antenna that also encompasses all of the spot beam coverages in a single beam. Ka-band commands are received by the same antenna used for Orderwire reception and the Ka-band telemetry beacon is combined with one Orderwire downlink signal and is radiated from the Orderwire transmit antenna.

VII.B.3 Bus Subsystems

The **KaSTARCOM.** spacecraft is based upon the mass and power efficient Lockheed Martin A2100AX spacecraft and the major bus subsystems are described hereafter.

VII.B.3.a Propulsion Subsystem

The **KaSTARCOM.** propulsion subsystem maintains the satellites at the proper orbital locations within ±0.05 degrees in latitude and longitude. **KaSTARCOM.** uses arcjet thrusters for North-South stationkeeping, offering a substantial improvement in efficiency over conventional thrusters. This improved arcjet efficiency provides 10+ years of stationkeeping.

VII.B.3.b Attitude Control Subsystem

The attitude control subsystem measures and controls the spacecraft orientation during transfer orbit, acquisition, drift orbit, and on-station operations. The attitude control subsystem consists of four reaction wheels, redundant control electronics and redundant sun and earth sensors. Control of attitude is accomplished using reaction wheels and pulsed firing of selected thrusters. An on-board processor maintains the **KaSTARCOM.** attitude to within 0.15 degrees of desired antenna boresight.

VII.B.3.c Electrical Power Subsystem

The electrical power subsystem provides energy for all electrical loads throughout the life of the spacecraft. The primary electrical power source consists of solar cells adequately protected from the radiation environment. Energy for eclipse operations is supplied by nickel-hydrogen batteries. Power units are protected to prevent complete bus pull down should a short occur. The electrical power subsystem provides sufficient power for the simultaneous operation of the entire **KaSTARCOM.** payload as well as the telemetry, tracking and command, beacons, and all housekeeping functions including battery charging, control, and interconnection loads.

VII.B.3.d Telemetry, Tracking, and Command Subsystem

The telemetry, tracking, and command subsystem provides full operational access to the spacecraft during its entire mission life by providing control and status monitoring of all spacecraft systems. This system permits the Satellite Control Facility to monitor satellite status, performance, and equipment settings, and to command the satellite to new configurations. For example, when a transponder is switched to a redundant configuration, the command system is used to verify that a change has taken place. The command, telemetry, and ranging subsystem receives demodulates, decodes, and executes commands. The command receivers are accessible from both the omnidirectional antennas and the communication antennas. Two redundant telemetry beacons are used for telemetry downlink from the spacecraft. The downlink beacons may also be used for antenna alignment and polarization tracking at certain earth stations. The subsystem is commandable into a ranging module in which multiple ranging tones can modulate the uplink command carrier, be demodulated by the spacecraft command subsystem, and be remodulated and transmitted with PCM data to the Satellite Control Facility by way of the downlink telemetry beacon subsystem.

VII.B.3.e Thermal Control Subsystem

The thermal control subsystem maintains all spacecraft components within safe temperature limits encountered during the entire mission.

VII.B.3.f Mechanisms

Various mechanical mechanisms on the spacecraft are used to provide physical movement when required. Major mechanisms include antenna gimbals that precisely point the antennas and the solar array drives that continuously point the solar arrays to the sun.

VII.B.3.g On-Board Processor

The on-board processor is used to decode and distribute commands, collect and format telemetry, control attitude, control thruster firings during stationkeeping maneuvers, and provide autonomous power and redundancy management. These functions can also be controlled in a manual mode via commands and telemetry at the SCF.

VII.B.4 Spacecraft Reliability

The **KaSTARCOM.** satellite has a minimum design life requirement of 10 years and includes sufficient margin for expendables and design degradation to accommodate an additional 3 years of on-orbit operation, depending on the launch vehicle. Active elements of the payload include sufficient redundancy to provide a reasonable probability of survival over the design life. The spacecraft bus, where practical, has been designed to eliminate all single point failures and provides a highly reliable spacecraft design for the **KaSTARCOM.** mission life. The two spacecraft on-orbit, including overlapping coverages, yields a high system availability for the proposed services.

PART VIII COMMUNICATION PERFORMANCE

The overall communication link performance is a function of the service to be provided, the design of the ground terminals (both transmit and receive stations), and the choice of modulation parameters including Forward Error Correction encoding. For stations located in high rain regions (such as the Southeast U.S.), more robust links are required to overcome the rain attenuation and accommodate a high availability. It is expected that the **KaSTARCOM.** System will provide availabilities of 99.2 to 99.9% achievable with nominal end-to-end link characteristics. (Table VIII-1 lists typical availabilities).

Table VIII-1 Estimated Communication System Availabilities *

City	System Availability (%)
Atlanta, GA	99.3
Chicago, IL	99.5
Denver, CO	99.9
Houston, TX	99.3
Los Angeles, CA	99.9
Miami, FL	99.2
New York, NY	99.6
Boston, MA	99.5
Seattle, WA	99.9
Anchorage. AK	99.3
Honolulu, HI	99.2

* Based on Crane data Rain Model Statistics

The satellite communication payload provides for both high data rate and low data rate transmission links. The low data rates are characterized by rates of 1.544 Mbps, 768 Kbps, and 384 Kbps. The uplink transmissions utilize Frequency Division Multiplexing. **KaSTARCOM.** provides on-board Baseband demodulation and processing by the satellite payload and remodulation and routing of the signals to the proper downlink beam designation by wide bandwidth Time Division Multiplexing. Because of this on-board processing the performance on the uplink and downlink are independent. The high bit rate data links are processed differently and the **KaSTARCOM.** payload acts as a repeater ("bent pipe") for these links. Single channel transmission bandwidths up to 155.52 Mbps are permitted in this mode of operation.

The following is a summary of the **KaSTARCOM.** communication system performance parameters:

VIII.A LOW DATA RATE (LDR) COMMUNICATIONS LINKS

It is anticipated that user terminals will employ transmit and receive terminals with antennas ranging from 0.66 m to 2 m in diameter; 0.5 w to 1.0 w transmitter power with uplink power control; and an LNA yielding a system noise temperature of approximately 400°K (26 dB/K).

Tables VIII.A-1 & 2 show typical **KaSTARCOM.** performance for a minimum size terminal in this class. FEC coding providing 4 dB processing gain for both the uplink and downlink is assumed.

Table VIII.A-1: Low Bit Data Rate Link Budget

Parameter	Uplink	Remarks
Ground Station EIRP	49.5 dBW	.66 m antenna and 4 watt HPA
Path Loss	213.5 dB	29.5 GHz
Antenna Pointing Loss	0.6 dB	Satellite and ground station
Atmospheric Loss	0.9 dB	29.5 GHz
Uplink Rain Loss	8.0 dB	99.5% availability
Satellite G/T	14.0 dB/K	EOB
Bit Rate	61.9 dB Hz	1.544 mbps
Boltzmann's Constant	-228.6 dB/K/Hz	
Thermal Eb/No	7.2 dB	
System Interference	0.5 dB	Internal and external sources
Coding Gain	4.0 dB	
Total Eb/No	10.7 dB	

Table VIII.A-2: Low Bit Data Rate Link Budget

Parameter	Downlink	Remarks
Ground Station EIRP	56 dBW	Edge of Beam
Path Loss	210 dB	19.5 GHz
Antenna Pointing Loss	0.6 dB	Satellite and ground station
Atmospheric Loss	0.5 dB	19.5 GHz
Downlink Rain Loss	4.0 dB	99.5% availability
Ground Station G/T	18.0 dB/K	System noise temperature 400° K
Bit Rate	80.8 dB Hz	120 mbps
Boltzmann's Constant	-228.6 dB/K/Hz	
Thermal Eb/No	6.7 dB	
System Interference	1.0 dB	Internal and external sources
Coding Gain	4.0 dB	
Total Eb/No	9.7 dB	

VIII.B HIGH DATA RATE (HDR) COMMUNICATIONS LINKS

High Data Rate Links will employ more robust terminals in order to accommodate higher bit rates and link performance. Typical parameters of such a station include a 3.4m antenna; up to 100 watt HPA; and an LNA providing a system noise temperature of approximately 400° K(26 d B/K). Tables VIII.B-1 & 2 show typical **KaSTARCOM.** performance for such a terminal. With Forward Error Correction Coding a Bit Error Rate greater than 10^{-10} is achievable.

Table VIII.B-1: High Data Rate Link Budget

Parameter	Uplink	Remarks
Ground Station EIRP	76 dBW	3.4 m antenna and 100 watt HPA
Path Loss	213.5 dB	29.5 GHz
Antenna Pointing Loss	0.6 dB	Satellite and ground station
Atmospheric Loss	0.9 dB	29.5 GHz
Uplink Rain Loss	8.0 dB	99.5% availability
Satellite G/T	19.0 dB/K	Near beam center
Bit Rate	81.9 dB Hz	OC-3 (155.52 Mbps)
Boltzmann's Constant	-228.6 dB/K/Hz	
Thermal Eb/No	18.7 dB	
System Interference	1.0 dB	Internal and external source
Total Eb/No	17.7 dB	

Table VIII.B-2: High Data Rate Link Budget

Parameter	Downlink	Remarks
Satellite EIRP	60 dBW	Near beam center
Path Loss	210 dB	19.5 GHz
Pointing Loss	0.6 dB	Satellite and ground station
Atmospheric Loss	0.5 dB	19.5 GHz
Rain Loss	4.0 dB	99.5% Availability
Ground Station G/T	27.5 dB/K	System noise temperature 400° K
Bit Rate	81.9 dBHz	155.52 Mbps
Boltzmann's Constant	-228.6 dB/K/Hz	
Thermal Eb/No	19.1 dB	
System Interference	1.0 dB	Internal and external sources
Downlink Eb/No	18.1 dB	
Total Eb/No	14.9 dB	Uplink and downlink

VIII.C INTERSATELLITE CROSSLINKS

In order to provide connectivity between the **KaSTARCOM.** satellites located at 73° W.L., 109.2 ° W.L., 175° W.L. and 52°E.L. Longitude a W-band cross-link is employed. The design of this includes a non-tracking antenna (0.75m diameter) on each satellite; a 60 watt TWTA per 120 MHZ channel; and a system noise temperature of 290 degrees Kelvin. Table VIII.C-1 summarizes the ISL link performance. The design of this link will be such as to not significantly affect the overall end-to-end link performance.

Table VIII.C-1: ISL Link Budget

Parameter		Remarks
Satellite EIRP	74.7 dBW	200 Watt HPA; 0.75 m antenna
Path Loss	226 dB	60 GHz; 133° longitudinal
Antenna Pointing Loss	1 dB	
Satellite G/T	27.1 dB/K	System noise temperature 290° K
Bandwidth	87.0 dB Hz	500 MHz
Boltzmann's Constant	-228.6 dB/K/Hz	
C/No	16.4 dB	

PART IX INTERFERENCE ANALYSIS

IX.A ADJACENT SATELLITE INTERFERENCE

The FCC has currently granted Applications for the allocation of orbital slots for Region A Ka-Band Fixed Satellite services from:

Morning Star:	147° W.L.
Orion:	127° W.L.
PanAmSat:	125° W.L.
EchoStar:	121° W.L.
Loral:	115° W.L.
VisionStar:	113° W.L.
KaStar:	109.2° W.L.
GE Americom:	105° W.L.
Hughes:	101° W.L.
Hughes:	99° W.L.
LockheedMartin:	97° W.L.
NorSat:	95° W.L.
Motorola:	91° W.L.
Orion:	89° W.L.
Motorola:	87° W.L.
GE Americom:	85° W.L.
EchoStar	83° W.L.
Orion:	81° W.L.
PanAmSat:	79° W.L.
Motorola:	77° W.L.
Motorola:	75° W.L.
KaSTAR:	73° W.L.
Hughes:	67° W.L.

The FCC has currently granted Applications for the allocation of orbital slots for Region B Ka Band Fixed Satellite Services from:

Morning Star Satellite Company, L.L.C.	62° W.L.
PanAmSat Corporation	58° W.L.
Hughes Communications Galaxy, Inc.	49° W.L.
Orion Atlantic, L.P.	47° W.L.
Lockheed Martin Corporation	21.5° W.L.
GE American Communications Inc.	17° W.L.
Hughes Communication Galaxy, Inc.	25° E.L.
Loral Aerospace Holdings, Inc.	28° E.L.
Morning Star Satellite Company, L.L.C.	30° E.L.
Hughes Communications Galaxy, Inc.	36° E.L.
Lockheed Martin Corporation	38° E.L.
Hughes Communications Galaxy, Inc.	40° E.L.
Hughes Communications Galaxy, Inc.	48° E.L.
Hughes Communications Galaxy, Inc.	54° E.L.
GE American Communications Inc.	56° E.L.
Orion Network Systems, Inc.	78° E.L.
Hughes Communications Galaxy, Inc.	101° E.L.
Loral Aerospace Holdings Inc.	105.5° E.L.
Morning Star Satellite Company, L.L.C.	107.5° E.L.
Hughes Communications Galaxy, Inc.	111° E.L.
GE American Communications. Inc.	114.5° E.L.
Hughes Communications Galaxy, Inc.	124.5° E.L.
Orion Network Systems, Inc.	126.5° E.L.
Lockheed Martin Corporation	130° E.L.
Hughes Communications Galaxy, Inc.	149° E.L.
Hughes Communications Galaxy, Inc.	164° E.L.
Hughes Communications Galaxy, Inc.	173° E.L.
Lockheed Martin Corporation	175.25° E.L.

The **KaSTARCOM.** satellite locations (52° East and 175° West) are removed from these systems by at least 2 degrees which should expedite coordination between them. Furthermore, it is anticipated that each of the above systems, (like **KaSTARCOM.**), will utilize a digitally encoded transmissions with FEC coding making them insensitive to interference from other sources. Other system characteristics such as satellite EIRP, G/T, Frequency plans, Polarization, and sidelobe performance assures that potential interference between **KaSTARCOM.** and these other Ka-Band systems will not affect intra-system coordination.

The FCC 2° spacing study for C-band and Ku-band users addressed the appropriate protection ratios for various traffic modes. Table IX.A-1 is taken from the FCC Phase One Report of the FCC 2° spacing Advisory Committee. Similar performance for Ka-Band systems, with suitable consideration for the wide bandwidth nature of Ka-band systems and digital encoding techniques, may be applied. **KaSTARCOM.** in its preliminary assessment, in the absence of detailed coordination, sees no significant cause for interference to or from the **KaSTARCOM.** Network plans and the existing plans of other U.S. operators in this band.

Table IX.A-1: Protection Ratios

COMMUNICATIONS TRAFFIC MODE	SINGLE ENTRY CO-FREQUENCY PROTECTION RATIO
1. Frequency Modulated-Television (FM-TV) Channels	C/Ise = 22.0 dB to 28.0 dB
2. Frequency Division Multiplexed-Frequency Modulated (FDM-FM) Channels	Interference from an adjacent satellite shall contribute a maximum of 1,000 picowatts of noise in the worst baseband channel.
3. Digital data Channels - Full Transponder Power Occupying Full Transponder Bandwidth	Eb/Io = 25 dB
4. Single Channel per Carrier (SCPC) T1 (1.544 Mbps) Digital Data	Eb/Io = 20 dB
5. Single Channel per Carrier (SCPC) 56 kbps Digital Data	Eb/Io = 20 dB
6. Frequency Modulated-Single Channel per Carrier (FM-SCPC) Message Voice Service	Interference from an adjacent satellite shall contribute a maximum of 1,000 picowatts of noise in the worst baseband channel.
7. Frequency Modulated Single Channel per Carrier (FM-SCPC) Program Audio	C/Ise = 24 dB
8. Companded Single Sideband Channel	Interference from an adjacent satellite shall contribute a maximum of 1,000 picowatts of noise in the worst baseband channel.
9. Spread Spectrum Channels	Eb/Io = 20 dB

IX.B INTER SYSTEM INTERFERENCE

The satellite antenna design includes cross-polarization isolation of 30 dB and co-polarized, co-frequency spatial separation assuring at least 18 dB isolation. Thus, the coverage design and link performance for **KaSTARCOM.** is optimized considering these system attributes. The use of digital transmission with robust Error Correction coding makes the Network internally insensitive to interference.

IX.C COORDINATION WITH TERRESTRIAL SYSTEMS

Because of the Ka BAND frequency allocations by the FCC **KaSTARCOM.** does not anticipate any significant interference into fix service terrestrial, Ka-band antennas. If necessary **KaSTARCOM.** will coordinate with terrestrial Ka-band systems to eliminate any possibility of interference as required by the commission.

PART X PREFERRED LOCATIONS

X.A REQUESTED ORBITAL LOCATION

KaSTARCOM. World Satellite LLC requests the orbital locations of 175° W.L. and 52° E.L. be assigned to **KaSTARCOM.** for its global satellite system.

Additionally, **KaSTARCOM.** World Satellite LLC requests the approval of a W-Band inter-satellite link (ISL) between the other **KaSTARCOM.** satellites. Interconnecting of the separately located satellites with a microwave ISL provides the functional equivalent of co-located satellites and has significant system and program advantages, as the following discussion will show:

X.A.1 MAXIMIZING TERMINAL CONNECTIVITY

The system is intended to provide an extremely flexible means for end-Users to make on-demand connections, either directly or indirectly (via the PSTN), with other end-Users. The User terminals will be fixed in geographic location and permanently pointed to the particular **KaSTARCOM.** orbital location. Communications access to the available beams within the requested 750 MHz of total will then be handled by frequency agile receivers and transmitters as part of the User terminals. The ISL between the two satellites guarantees single hop connections between Users, whereas separate locations for each satellite without an ISL requires an intermediate system hub and double hops for communications between Users on different satellites. This would result in higher operating costs and, consequently, two times higher User charges. It would also cause inferior system performance as a result of the double delay time and the increased probability of call blocking arising from the two satellite communications payloads being in series.

X.A.2 MAXIMIZING SYSTEM UTILIZATION

The ISL between the two satellites achieves the highest level of traffic utilization with the lowest system operating costs, leading to lower User charges. Two separately located and unconnected satellites would not allow this efficiency of system utilization. The ISL also reduces the possibility of call blockage due lack of downlink beam capacity on the transmitting User's host satellite since the NCC can divert the downlink traffic to a downlink beam on the other satellite, connecting through the ISL.

The cost penalty arises because separate unconnected satellites would require the Users to repoint their terminals from one satellite to the other to reduce the probability of call blockages. This is, in reality, impossible to implement without severe cost and loss of service for the User because the User terminals are effectively permanently pointed. So call blockages would increase and the overall service would be worsened, to the disadvantage of the Users. The only solution to this if the satellites are not co-located or interconnected through an ISL is for the User terminals to be steerable – at a significant terminal cost increase – but the User would still lose service revenue while the antenna was being repointed and the new satellite acquired. And the practicality of performing this operation repeatedly as traffic loads on the satellites varied must be questioned.

X.A.3 EXPLOITING SYNERGIES WITH OTHER SATELLITE SYSTEMS

KaSTARCOM. will welcome the capability of "speaking" to other satellite systems.

- It will encourage the development of common, "integrated" User terminals operable at all the frequencies: C, Ku and Ka by a simple change of the microwave front-end equipment. Indeed, we can envision the development of integrated terminals able to address all the bands of interest to the User.;

- It will encourage the provision of the full range of communication, entertainment and information services from a single orbital location;

X.A.4 AVAILABILITY

The FCC has assigned orbital slots in Region "B" for Ka-Band Fixed Satellite Services to those companies described in Part IX.A.

X.B MISCELLANEOUS ALTERNATIVES

If the FCC is unable to approve the locations requested, **KaSTARCOM.** World Satellite LLC would request orbital locations permitting global coverage with its currently authorized affiliate satellites at 109.2°W.L. and 73°W.L. Each **KaSTARCOM.** satellite will carry sufficient fuel for one orbital shift at one degree per day. Hence, the satellites could be relocated to accommodate new orbital assignments by the FCC.

PART XI SCHEDULE

XI.A CONTRACT MILESTONES

The key contract program decisions and commitments will be made on the following schedule:

i. Satellite RFP issued – within eight months after grant of the satellite construction permit.

ii. Satellite contractor selected – within twelve months after grant of construction permit

iii. Satellite contract executed – appropriate authorizations executed within fourteen months after grant of construction permit.

iv. Launch services contract executed – within 24 months after grant of satellite construction permit.

v. Financing completed – within 24 month after grant of satellite

XI.B SATELLITE MILESTONES

KaSTARCOM. proposes the time table for construction, launch and implementation of its system that is practical and will follow the Commission's guidelines regarding a minimum of thirty (30) months between the execution of a spacecraft manufacturer contract and the launch of a satellite.

The key events of the satellite program will be achieved by the following dates:

i. Construction of the first satellite will begin within fourteen months after the grant of the construction permit.

ii. Construction of the first satellite is expected to be complete within thirty six months of commencement of the construction and in no event later than forty eight months after commencement.

iii. Satellite launch within six months following the completion of construction.

iv. Satellite in service within sixty days after launch.