S2242 SAT-LOA-19970605-00049 75-SAT-P/LA-97
DIRECTV ENTERPRISES, INC.
S2242

S2243 SAT-LOA-19970605-00050 76-SAT-P/LA-97
DIRECTV ENTERPRISES, INC.
S2243

S2244 SAT-LOA-19970605-00051 77-SAT-P/LA-97
DIRECTV ENTERPRISES, INC.
S2244

FEDERAL COMMUNICATIONS COMMISSION

Approved by OMB 3060-0589 Expires 2/28/97

FCC REMITTANCE ADVICE

SPECIAL USE

FCC/MELLON JUN 03 1997

FCC USE ONLY

PAYOR INFORMATION

(1) FCC ACCOUNT NUMBER: 0 9 5 4 3 2 1 4 6 5

Did you have a number prior to this? Enter it.

(2) TOTAL AMOUNT PAID (dollars and cents): $ 81,330.00

Received JUN 11 1997 Satellite Policy Branch International Bureau

(3) PAYOR NAME (If paying by credit card, enter name exactly as it appears on your card)
Direct TV Enterprises, Inc.

(4) STREET ADDRESS LINE NO. 1
2230 East Imperial Highway

(5) STREET ADDRESS LINE NO. 2

(6) CITY	(7) STATE	(8) ZIP CODE
El Segundo	CA	90245

(9) DAYTIME TELEPHONE NUMBER (Include area code): (310) 535-5000

(10) COUNTRY CODE (if not U.S.A.)

ITEM #1 INFORMATION

(11A) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR: DIRECTV Enterprises, Inc.

FCC USE ONLY

(12A) FCC CALL SIGN/OTHER ID	(13A) ZIP CODE	(14A) PAYMENT TYPE CODE	(15A) QUANTITY	(16A) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14
	90245	M T D	3	$ 7,410.00

(17A) FCC CODE 1

(18A) FCC CODE 2

(19A) ADDRESS LINE NO. 1	(20A) ADDRESS LINE NO. 2)	(21A) CITY/STATE OR COUNTRY CODE
2230 E. Imperial Way		El Segundo, CA

ITEM #2 INFORMATION

(11B) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR: DIRECTV ENTERPRISES, INC.

FCC USE ONLY

(12B) FCC CALL SIGN/OTHER ID	(13B) ZIP CODE	(14B) PAYMENT TYPE CODE	(15B) QUANTITY	(16B) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14
	90245	M X D	3	$71,850.00

(17B) FCC CODE 1

(18B) FCC CODE 2

(19B) ADDRESS LINE NO. 1	(20B) ADDRESS LINE NO. 2	(21B) CITY/STATE OR COUNTRY CODE
2230 E. Imperial Hwy.		El Segundo, CA

CREDIT CARD PAYMENT INFORMATION

(22) MASTERCARD/VISA ACCOUNT NUMBER:

☐ Mastercard

EXPIRATION DATE: Month Year

☐ Visa

(23) I hereby authorize the FCC to charge my VISA or Mastercard for the service(s)/authorization(s) herein describe.

AUTHORIZED SIGNATURE

DATE

See public burden estimate on reverse

FEDERAL COMMUNICATIONS COMMISSION

Approved by O[illegible]
3060-0589
Expires 2/28/[illegible]

ADVICE (CONTINUATION SHEET)

PAGE NO. 2 OF 2

ITEM #____ INFORMATION

FCC ACCOUNT #	NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR	FCC USE ONLY
0 9 5 4 3 2 1 4 6 5		

FCC CALL SIGN/OTHER ID	ZIP CODE	PAYMENT TYPE CODE	QUANTITY	FEE DUE FOR PAYMENT TYPE CODE
	90245	M P D	3	$ 2,070.00

FCC CODE 1	FCC CODE 2

ADDRESS LINE NO. 1	ADDRESS LINE NO. 2)	CITY/STATE OR COUNTRY CODE
2230 E. Imperial Highway		El Segundo, CA

ITEM #____ INFORMATION

FCC ACCOUNT #	NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR	FCC USE ONLY

FCC CALL SIGN/OTHER ID	ZIP CODE	PAYMENT TYPE CODE	QUANTITY	FEE DUE FOR PAYMENT TYPE CODE
				$

FCC CODE 1	FCC CODE 2

ADDRESS LINE NO. 1	ADDRESS LINE NO. 2)	CITY/STATE OR COUNTRY CODE

ITEM #____ INFORMATION

FCC ACCOUNT #	NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR	FCC USE ONLY

FCC CALL SIGN/OTHER ID	ZIP CODE	PAYMENT TYPE CODE	QUANTITY	FEE DUE FOR PAYMENT TYPE CODE
				$

FCC CODE 1	FCC CODE 2

ADDRESS LINE NO. 1	ADDRESS LINE NO. 2)	CITY/STATE OR COUNTRY CODE

ITEM #____ INFORMATION

FCC ACCOUNT #	NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR	FCC USE ONLY

FCC CALL SIGN/OTHER ID	ZIP CODE	PAYMENT TYPE CODE	QUANTITY	FEE DUE FOR PAYMENT TYPE CODE
				$

FCC CODE 1	FCC CODE 2

ADDRESS LINE NO. 1	ADDRESS LINE NO. 2)	CITY/STATE OR COUNTRY CODE

COPY

75/76/77-SAT-P/LA-97

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

Application of

DIRECTV Enterprises, Inc.

for

Authority to Construct, Launch and
Operate an Expansion System of
Direct Broadcast Satellites

E. W. Hartenstein
President
DIRECTV Enterprises, Inc.
2230 E. Imperial Highway
El Segundo, CA 90245
(310) 535-5000

Gary M. Epstein
John P. Janka
James H. Barker
LATHAM & WATKINS
Suite 1300
1001 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
(202) 637-2200

June 5, 1997

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of the Application of	)	
DIRECTV Enterprises, Inc.	)	File No.
For Authority to Construct, Launch and Operate an Expansion System of Direct Broadcast Satellites	)	

APPLICATION

DIRECTV Enterprises, Inc. ("DIRECTV"), a majority-owned subsidiary of Hughes Electronics Corporation, hereby requests authority to construct, launch and operate a system of six direct broadcast satellites, to be known as DIRECTV Expansion-1 (or DX-1) through DIRECTV Expansion-6 (or DX-6), which will provide advanced direct broadcast satellite services at 17.3-7.8 GHz. The proposed expansion system will provide service to the U.S. from three orbital locations: 96.5° W.L., 101° W. L. and 105.5° W. L.

DIRECTV is the United States' leading provider of DBS services. DIRECTV initiated its DBS service in June 1994, and presently provides full-CONUS DBS service using 3 high-powered HS 601 spacecraft employing dual mode 120/240 watt transponders. DIRECTV today provides approximately 175 channels of all-digital, entertainment, educational and informational programming to customers purchasing the DSS®[1] satellite receiving system, which features an 18-inch satellite dish antenna.

Although the multichannel video programming distributor ("MVPD") industry in which DIRECTV competes continues to be dominated by cable operators in most local markets, DIRECTV nevertheless has experienced tremendous growth since its inception, and currently serves in excess of 2.5 million subscribers nationwide. The Federal Communications Commission recently determined that DBS providers have a

1 DSS® is a registered trademark of DIRECTV, Inc.

higher combined subscribership than any other MVPD alternative to incumbent cable systems,[2] and DIRECTV hopes to continue and advance that trend.

This proposed expansion system will provide attractive, competitive DBS programming and services across all portions of the forty-eight contiguous states (CONUS), Hawaii and major portions of Alaska. The use of 240 watt transponders will allow the utilization of antennas as small as 45 cm in diameter over most of CONUS. Satellite compatibility with existing modulation and coding schemes, as well as advanced modulation and coding schemes, will ensure economic utilization of this important spectrum for the entire life of each satellite.

The satellites will be used for direct-to-home and, secondarily, direct-to-business delivery of video, audio, data and multimedia services. The video services are anticipated to include NTSC (transported digitally), standard-definition and high-definition ATSC formats. These services will complement the existing satellite broadcasting business of DIRECTV using the band 12.2-12.7 GHz.

DIRECTV today is filing, concurrently with this application, a Petition for Rulemaking to allocate the 24.75-25.25 GHz band for the fixed satellite service ("FSS") in the Earth-to-space direction for "feeder links" for the broadcasting satellite service ("BSS"), and also to provide for use of the 17.3-17.8 GHz band in the space-to-Earth direction for BSS. These allocations will increase greatly the potential capacity of BSS systems, and will benefit U.S. consumers by permitting U.S.-licensed BSS operators to offer a much wider variety of programming and service offerings. DIRECTV requests expedited approval of this application and permission to begin operation by the year 2000 to implement the Commission's general goal of promoting increased competition among multichannel video programming distributors, including competition to incumbent cable television operators.

---

2 Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming, CS Docket No. 96-133, Third Annual Report (released Jan. 2, 1997), at ¶ 39 ("1996 Competition Report").

ITEM A. Name and Address of Applicant

DIRECTV Enterprises, Inc.
2230 E. Imperial Highway
El Segundo, California 90245
Attn.: E. W. Hartenstein, President

ITEM B. Name, Address and Telephone Number of Counsel

Gary M. Epstein
John P. Janka
James H. Barker
LATHAM & WATKINS
Suite 1300
1001 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
(202) 637-2200

ITEM C. System Description

1. Generally

The DIRECTV expansion satellite system will consist of a space segment and a ground segment. The space segment will consist of the in-orbit satellites and their associated launch vehicles. Each of the satellites will be capable of being launched by one of the currently available commercial launch vehicles. The six satellites will be located, in pairs, at the nominal orbital locations of 96.5°, 101° and 105.5° West Longitude. Each satellite will provide transmit coverage to CONUS, Hawaii and major portions of Alaska in the band 17.3-17.8 GHz. Each satellite will be capable of receiving transmissions from CONUS in the band 24.75-25.25 GHz.

The DIRECTV expansion band ground segment will consist of: (i) earth stations to perform the necessary telemetry, tracking and command ("TT&C") functions for the satellites, (ii) earth station(s) to provide the communications uplink signal(s) and (iii) receive-only antennas to provide direct-to-home services.

Satellite TT&C operations will be performed by DIRECTV's affiliate PanAmSat or another respected satellite services provider. PanAmSat owns and operates an Operations Control Center ("OCC") in Long Beach, California, which performs the complex tasks associated with on-orbit satellite operations. This OCC currently provides the hands-on operational control of DIRECTV's existing three-satellite DBS fleet. Hughes Space and Communications Company, another DIRECTV affiliate, operates a separate Mission Control Center ("MCC") in El Segundo, California, which directs each satellite through transfer orbit and on-orbit deployment activities and performs in-orbit testing once the satellite is in its geostationary position. Once operational, spacecraft control is handled entirely by the OCC.

Current plans call for transfer orbit and on-station TT&C links to operate in the BSS band 12.2-12.7 GHz (downlink) and FSS band 14.0-14.5 GHz (uplink).

Telemetry data from each satellite will be received by a primary TT&C earth station and a backup TT&C earth station. Both stations will be located in the United States, at dispersed geographic locations, to ensure continued satellite support in the event of a major outage at one location. Information from the TT&C stations is transmitted to the OCC over communications lines where it is processed, archived and analyzed. Commands to control the spacecraft are issued from the OCC and subsequently routed to the TT&C earth stations for processing and uplinking to the satellite. Although the earth stations are under the overall control of the OCC, at least one TT&C station may operate independently of the OCC, if necessary. Separate license applications will be filed for the TT&C stations needed to support the DIRECTV expansion satellites.

DIRECTV anticipates that it will own and operate the majority of the transmit/receive stations used to communicate to its expansion satellites. These sites typically will use dishes in the 9-13 meter range to uplink digital carriers in the band 24.75-25.25 GHz. The stations will monitor the satellite downlink in the 17.3-17.8 GHz band. Depending on the final business plans, a number of those stations may be needed in different cities across the United States. Separate license applications will be submitted for these facilities.

Most receive-only antennas for reception of signals from the DIRECTV expansion satellites will be owned by the end users of the service. Through the use of shaped reflectors, the satellites will be able to focus their RF power on areas with the greatest population and heaviest rainfall. This will permit the use of 45 cm receive dishes over most of CONUS at an availability of at least 99.7% as indicated by the Crane rain model. For certain regions, larger dishes may be recommended to improve service availability and/or transponder throughput. This level of service quality will permit an integrated service offering with DIRECTV's existing DBS business at 12.2-12.7 GHz.

2. Services

The satellites will be used for direct-to-home and, secondarily, direct-to-business, delivery of television, audio, data and multimedia services. These services will complement DIRECTV's existing multichannel video programming distribution business at 12.2-12.7 GHz.

Direct-to-home video services using the proposed expansion system are anticipated to include NTSC (transported digitally) and standard-definition and high-definition ATSC formats. The ATSC streams will be encapsulated with modulation and coding appropriate for satellite transmission. Increased video capacity is needed to both increase the number of channels and improve the technical quality of each channel available to subscribers. Channel demands are driven by the growing consumer interest in receiving niche services and a wider variety of entertainment, educational, informational and ethnic programming from multiple sources. The marketplace will expect increased technical quality as it is exposed to digital satellite and cable services, Digital-VHS, Digital Versatile Disk and terrestrial digital broadcasting. Although DIRECTV has improved both the quantity and quality of its video transmission by signal processing improvements, future major improvements must rely on access to additional capacity.

New data and multimedia services are also expected to require significant increases in satellite capacity. The multimedia information will be displayed on television or computer screens in formats similar to existing Internet web pages or CD-ROM multimedia. The first PCs capable of directly displaying satellite-delivered information should be in the marketplace before the end of 1997. The new data and multimedia services are expected to include financial, sports and news "tickers," information from Internet web sites, web-page-like information that complements certain television channels, and new multimedia formats with embedded full-motion MPEG2 video. This new delivery mechanism is also expected to be valuable for data delivery, on an efficient national basis, to businesses and the Small Office in the Home (SOHO). These delivered "data objects" are expected to include PC software updates, information from databases for use in spreadsheets and high quality graphics and video clips for use in business reports.

All the planned digital services will be transported using fixed-length packets and time-division multiplexing to provide high data rate streams. The streams will then be encoded and modulated using a satellite-optimized forward error control code and modulation. The planned technology is either the concatenated RS/convolutional coding and QPSK modulation currently employed by DIRECTV, or, possibly, an even more advanced technology that is more efficient in terms of information capacity per transponder.

ITEM D. General Technical Information

1. Operational Characteristics

a. Frequency Plan

The satellites will operate using the 24.75-25.25 GHz frequency band for Earth-to-space (uplink) transmissions and the 17.3-17.8 GHz frequency band for space-to-Earth (downlink) transmissions.

Each satellite will contain 16 active transponder channels, consisting of 24 MHz channels with a 29.16 MHz spacing. Each satellite pair employs full frequency reuse by using dual polarization for both uplink and downlink frequencies. Linear polarization will be utilized on the uplink and circular polarization on the downlink. The radio frequency and polarization plan is shown in Figure D-1. Center frequencies and polarization assignments are listed in Table D-1.

Current plans call for TT&C operation in the BSS band at 12.2-12.7 GHz (downlink) and the FSS band at 14.0-14.5 GHz (uplink) during transfer orbit and on-station operation. The exact frequencies will be selected after analysis of the existing and planned FSS and BSS systems in the neighborhood of 101° W. L. During transfer orbit, command signals will be received through a bicone antenna. When the satellite is at its final orbit position, the primary command uplink will utilize a dedicated tracking/command antenna, with a pipe antenna available as a backup.

DIRECTV requests transfer orbit and on-station telemetry in the 12.2-12.7 GHz band. This is to avoid interference between DBS feeder links at 17.3-17.8 GHz and TT&C stations in the same band, where these sites are co-located. DIRECTV believes that the 12.2-12.7 GHz band can accommodate these telemetry carriers without interference to communications traffic and other telemetry links serving expansion band BSS satellites.

It is important that the transfer orbit command frequency be in the 14.0-14.5 GHz band. A command link at 24 GHz would suffer greater atmospheric attenuation and would thereby increase the risk during transfer orbit, a critical phase. In addition, transfer orbit ground stations with 24 GHz command links do not exist and would need to be developed.

DIRECTV requests an on-station command link in the 14.0-14.5 GHz band to eliminate the need to fly two sets of command receivers, one pair at 14 GHz, and one at 24 GHz. Otherwise, switching capability between the two receivers would also need to be incorporated on the spacecraft, reducing reliability. Such switching between receivers would also reduce command uplink availability at 24 GHz due to atmospheric effects. DIRECTV believes that the 14.0-14.5 GHz band can accommodate these command carriers without interference to existing communications traffic. DIRECTV will submit such additional information as the Commission may require with respect to these proposed TT&C bands.

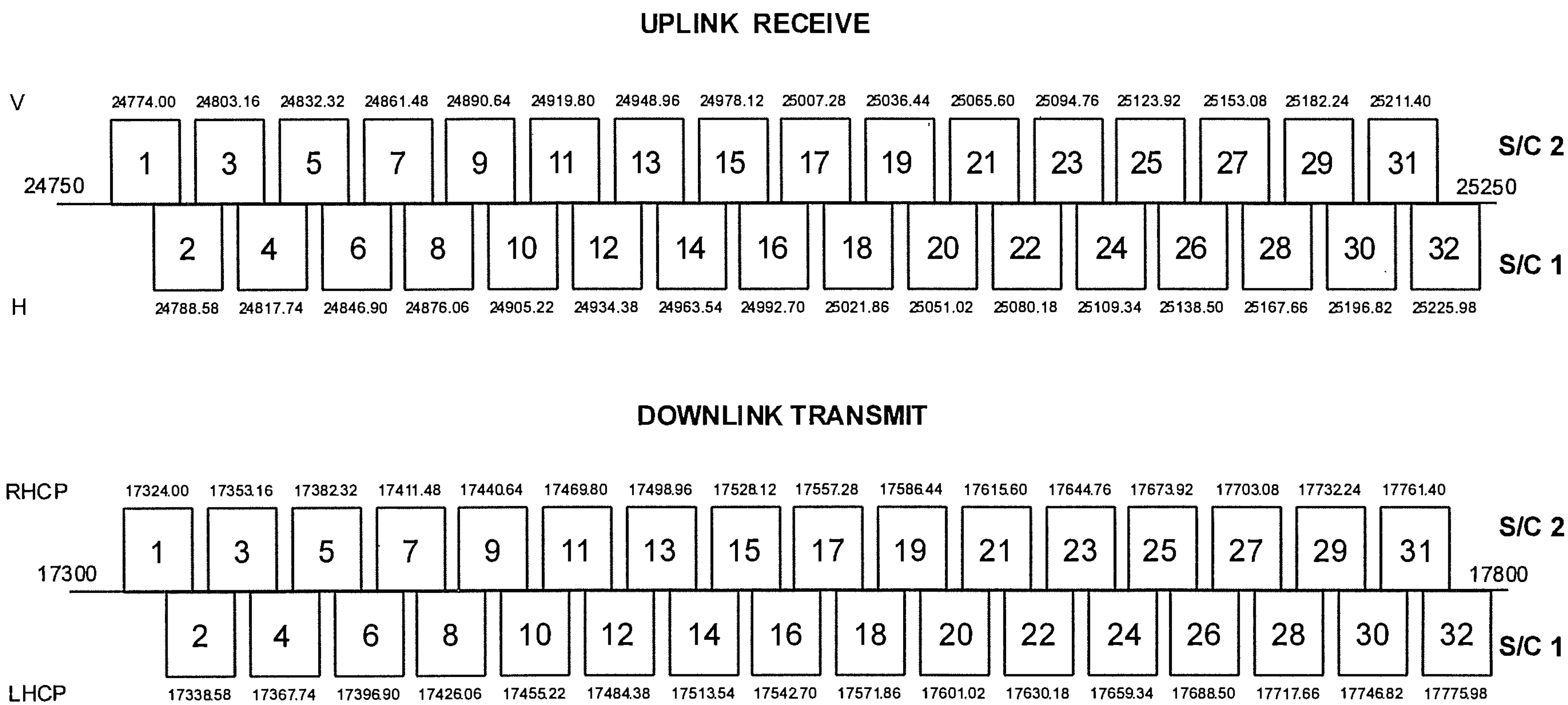


FIGURE D-1

FREQUENCY AND POLARIZATION PLAN

Spacecraft 1

Channel	Uplink Polarization	Uplink Center Frequency (MHz)	Downlink Polarization	Downlink Center Frequency (MHz)	Transponder Bandwidth (MHz)
2	H	24788.58	LHCP	17338.58	24 MHz
4	H	24817.74	LHCP	17367.74	24 MHz
6	H	24846.90	LHCP	17396.90	24 MHz
8	H	24876.06	LHCP	17426.06	24 MHz
10	H	24905.22	LHCP	17455.22	24 MHz
12	H	24934.38	LHCP	17484.38	24 MHz
14	H	24963.54	LHCP	17513.54	24 MHz
16	H	24992.70	LHCP	17542.70	24 MHz
18	H	25021.86	LHCP	17571.86	24 MHz
20	H	25051.02	LHCP	17601.02	24 MHz
22	H	25080.18	LHCP	17630.18	24 MHz
24	H	25109.34	LHCP	17659.34	24 MHz
26	H	25138.50	LHCP	17688.50	24 MHz
28	H	25167.66	LHCP	17717.66	24 MHz
30	H	25196.82	LHCP	17746.82	24 MHz
32	H	25225.98	LHCP	17775.98	24 MHz

Spacecraft 2

1	V	24774.00	RHCP	17324.00	24 MHz
3	V	24803.16	RHCP	17353.16	24 MHz
5	V	24832.32	RHCP	17382.32	24 MHz
7	V	24861.48	RHCP	17411.48	24 MHz
9	V	24890.64	RHCP	17440.64	24 MHz
11	V	24919.80	RHCP	17469.80	24 MHz
13	V	24948.96	RHCP	17498.96	24 MHz
15	V	24978.12	RHCP	17528.12	24 MHz
17	V	25007.28	RHCP	17557.28	24 MHz
19	V	25036.44	RHCP	17586.44	24 MHz
21	V	25065.60	RHCP	17615.60	24 MHz
23	V	25094.76	RHCP	17644.76	24 MHz
25	V	25123.92	RHCP	17673.92	24 MHz
27	V	25153.08	RHCP	17703.08	24 MHz
29	V	25182.24	RHCP	17732.24	24 MHz
31	V	25211.40	RHCP	17761.40	24 MHz

TABLE D-1
FREQUENCY AND POLARIZATION ASSIGNMENTS

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

b. Emission Designators

Commands to the satellite from the TT&C station will be angle-modulated with a large deviation on the uplink carrier. Telemetry data from the satellite will be angle-modulated on the downlink carrier. Communications signals are all wideband, digital signals.. The emission designators for the various signals are as follows.

Signal	Emission Designator
Command	750KF2D
Telemetry/Ranging	136K69D
Communications I	24MOG7W
Communications II	13MOG7W

c. Communications Coverage

Each spacecraft will provide (i) transmit coverage to CONUS, Hawaii and Alaska (to the extent technically feasible) and (ii) receive coverage over portions of CONUS. Each satellite will use shaped receive and transmit beams.

Figures D-2 through D-7 provide CONUS and Hawaii EIRP patterns for each of the three planned orbital locations, 96.5° W.L., 101° W.L. and 105.5° W.L., respectively. Figures D-8, D-9 and D-10 provide satellite receive gain patterns for each of the three orbital locations.

d. Power Flux Density

The maximum EIRP (beam peak) of the satellite is 58.6 dBW. The maximum power flux densities for the frequencies of 17.7 -17.8 GHz are specified in 47 CFR § 25.208(c). The satellites will meet these PFD limits with a margin of 11.6 to 17.6 dB. Because all traffic of this satellite will be wideband digital, the spectral density will be spread over 24 MHz, or 13 MHz as a minimum. Table D-2 shows that downlinks always will have sufficient spectral content such that the above reference limits will not be exceeded for all arrival angles.

2. Satellite Characteristics

Each satellite will be a Hughes HS-601 or HS-702 or other type of satellite with similar capabilities and characteristics. The major spacecraft characteristics are shown in Table D-3. The estimated weight and power budgets, listed in Tables D-4 and D-5, are based on a mission life of 12 years and include sufficient redundancy to give high probability to be fully operational after 12 years.

FIGURE D-2

EIRP CONTOUR
96.5°W

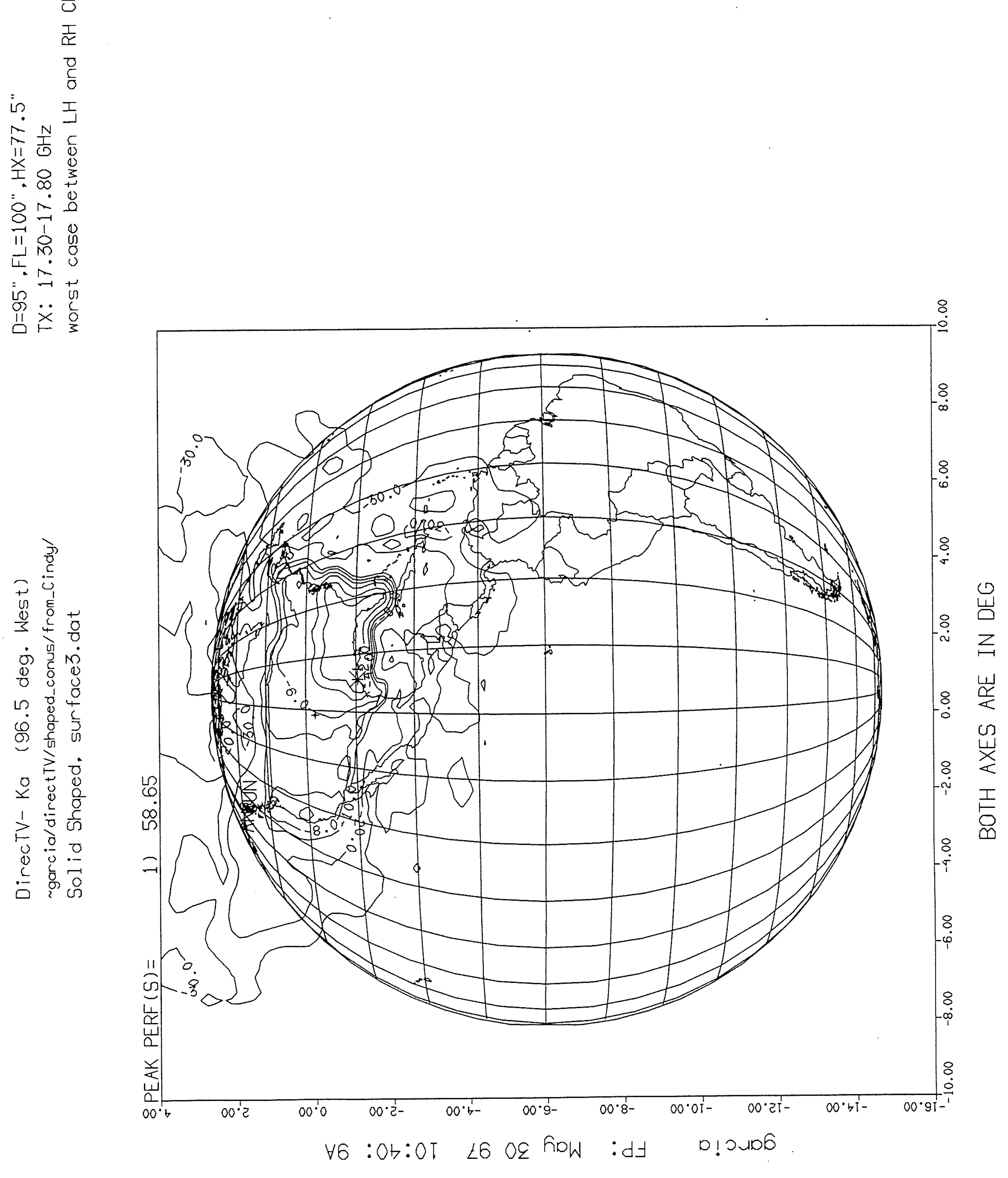


FIGURE D-3

HAWAII EIRP CONTOUR
96.5°W

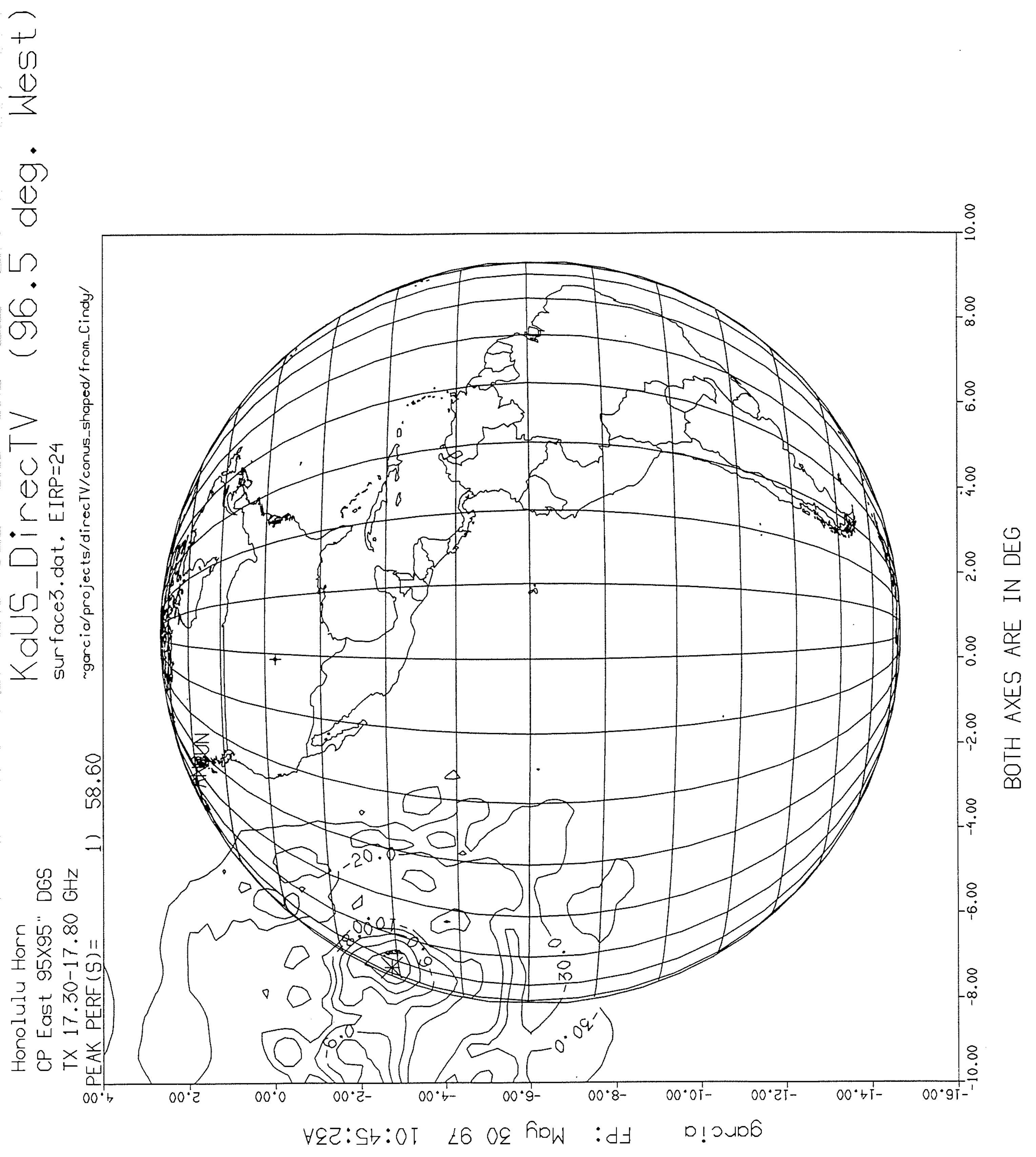


FIGURE D-4

EIRP CONTOUR
101°W

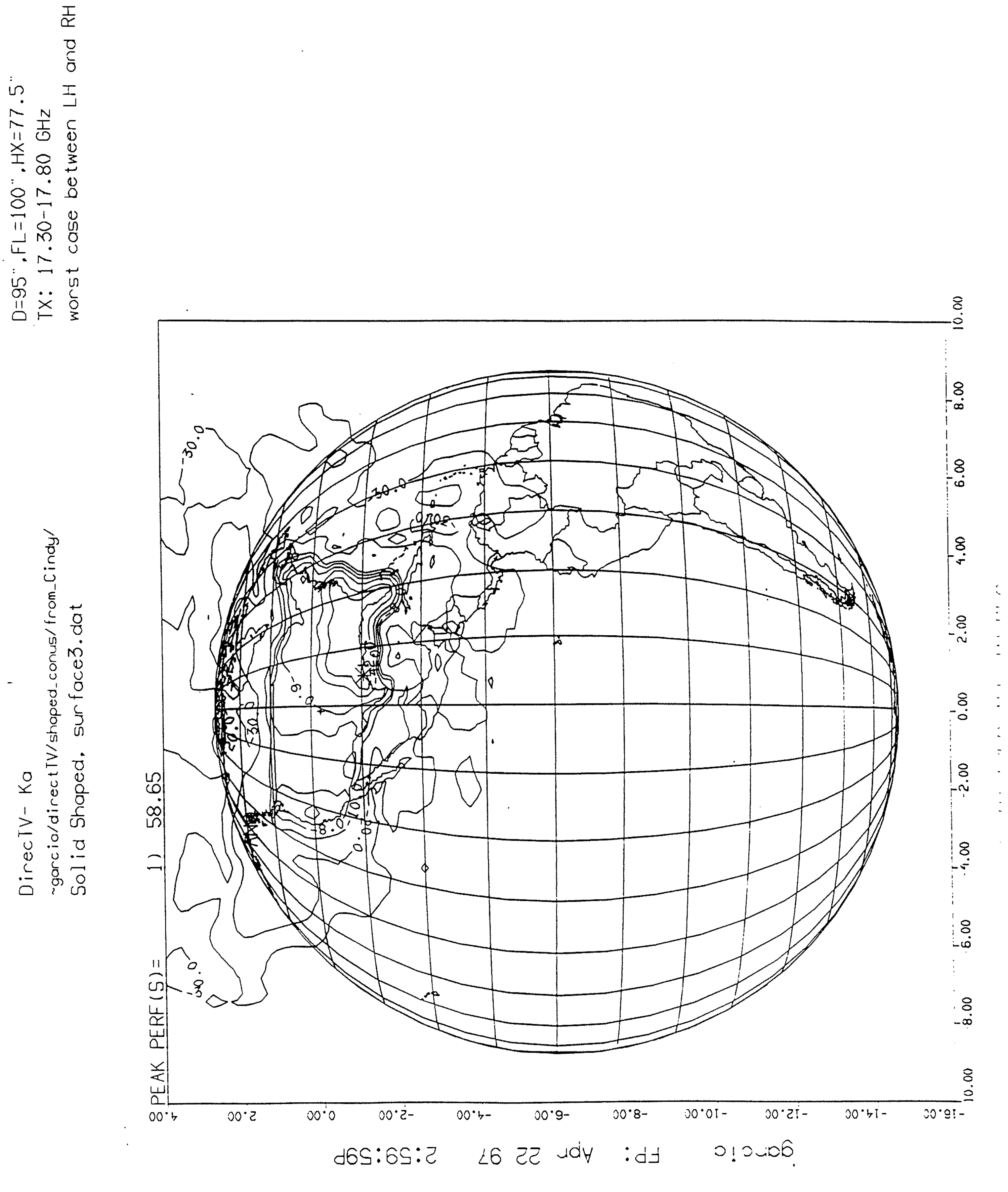


FIGURE D-5

HAWAII EIRP CONTOUR
101°W

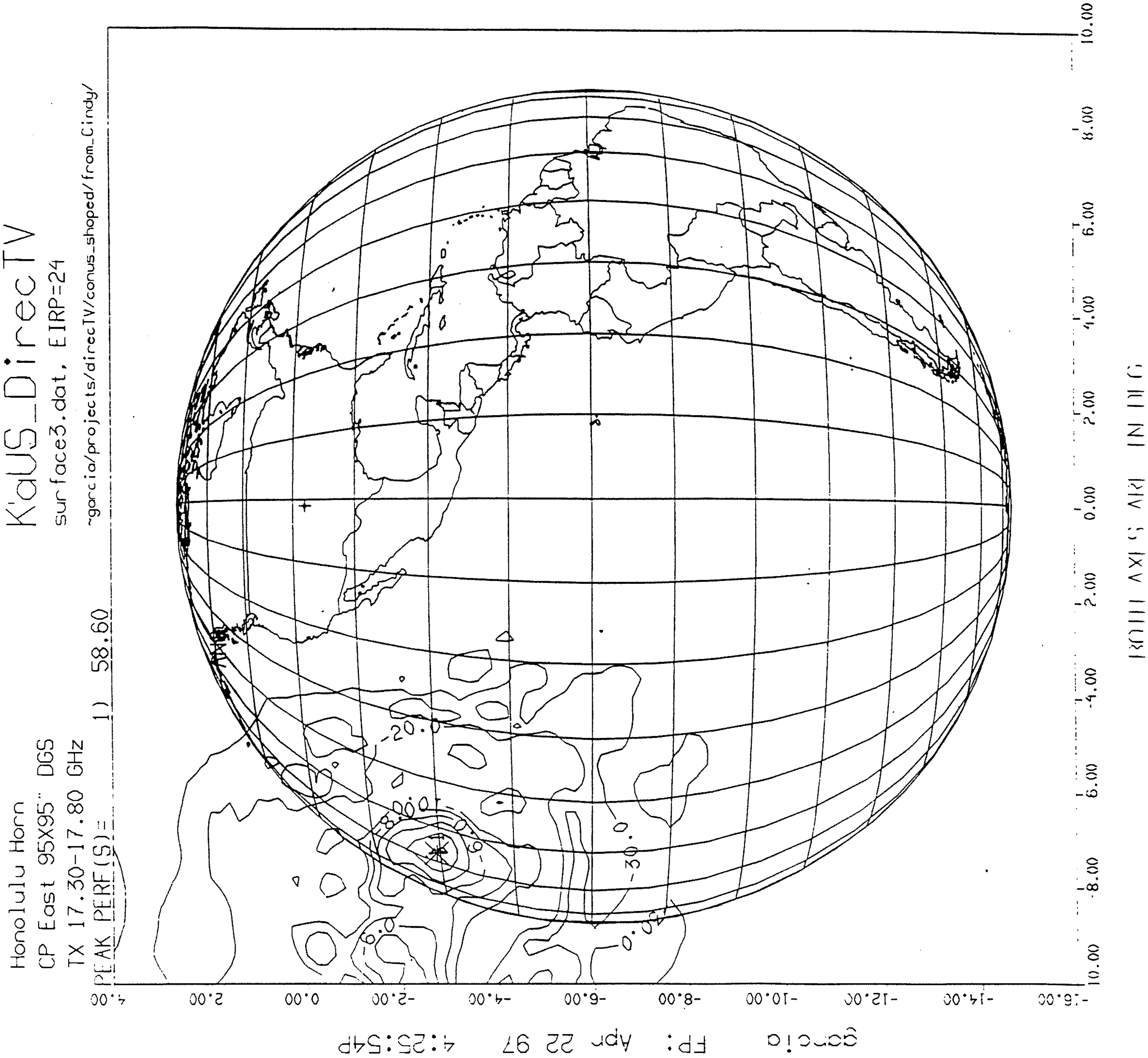


FIGURE D-6

EIRP CONTOUR
105.5°W

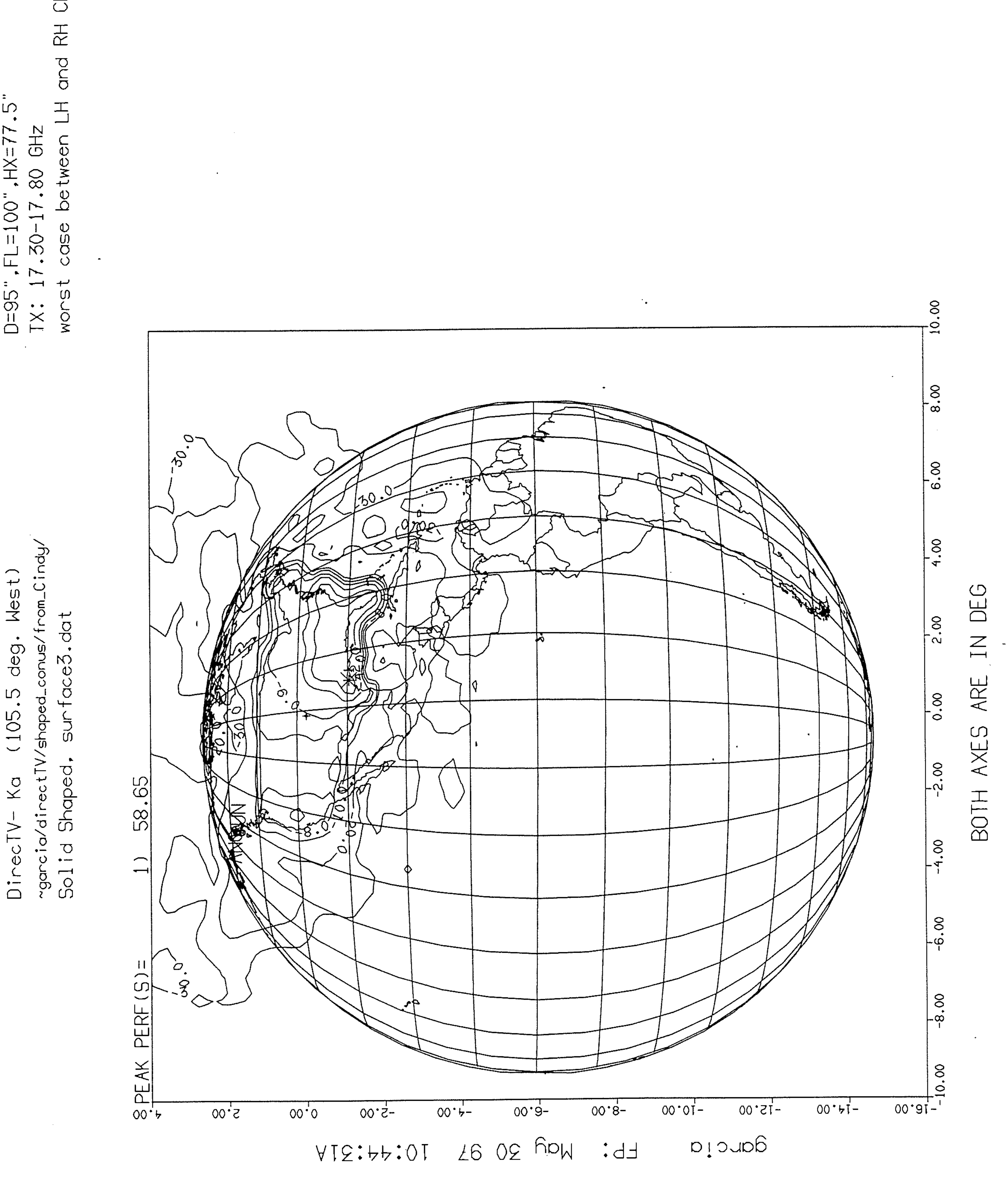


FIGURE D-7

HAWAII EIRP CONTOUR
105.5°W

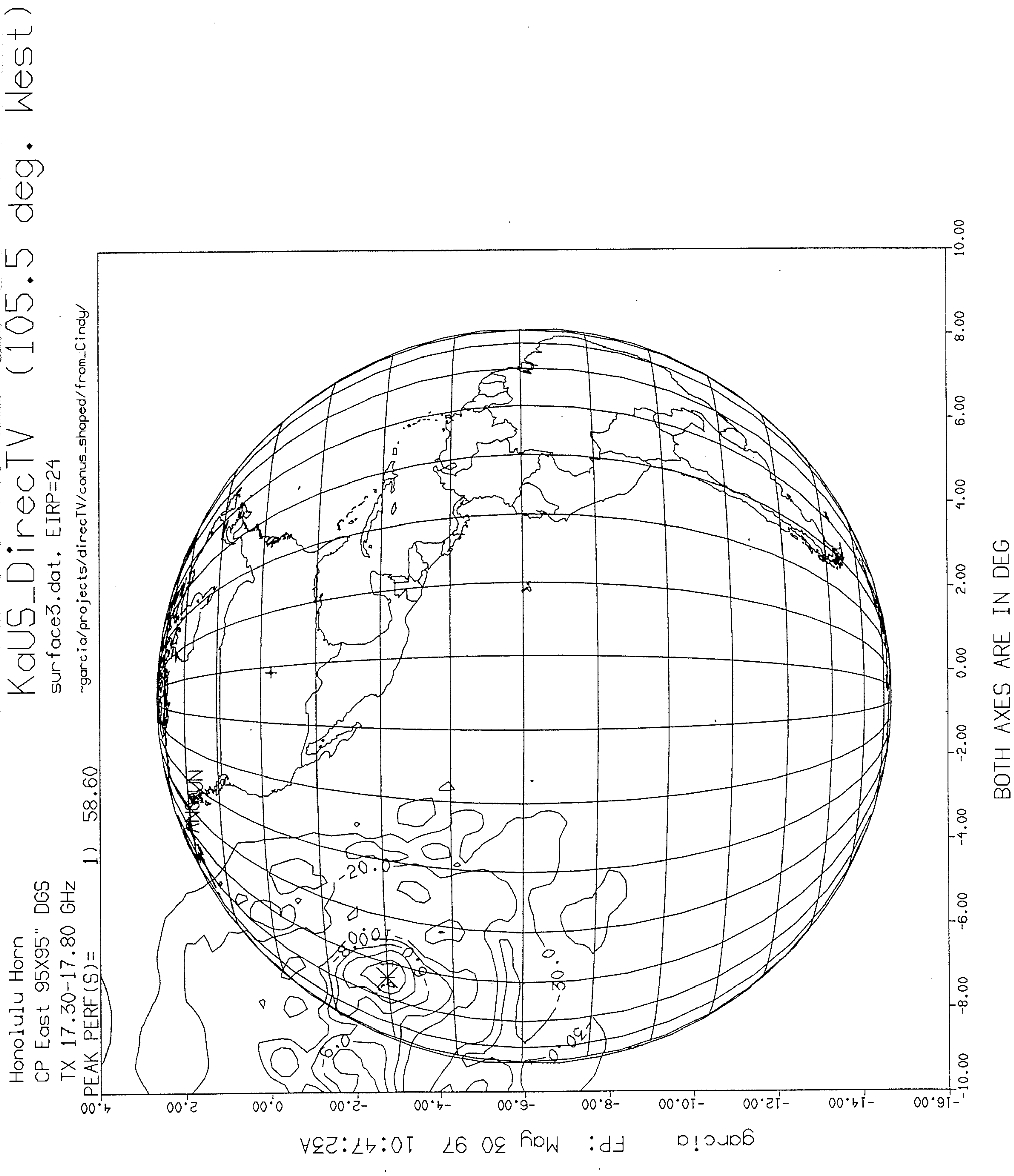


FIGURE D-8

RECEIVE GAIN PATTERN
96.5°W

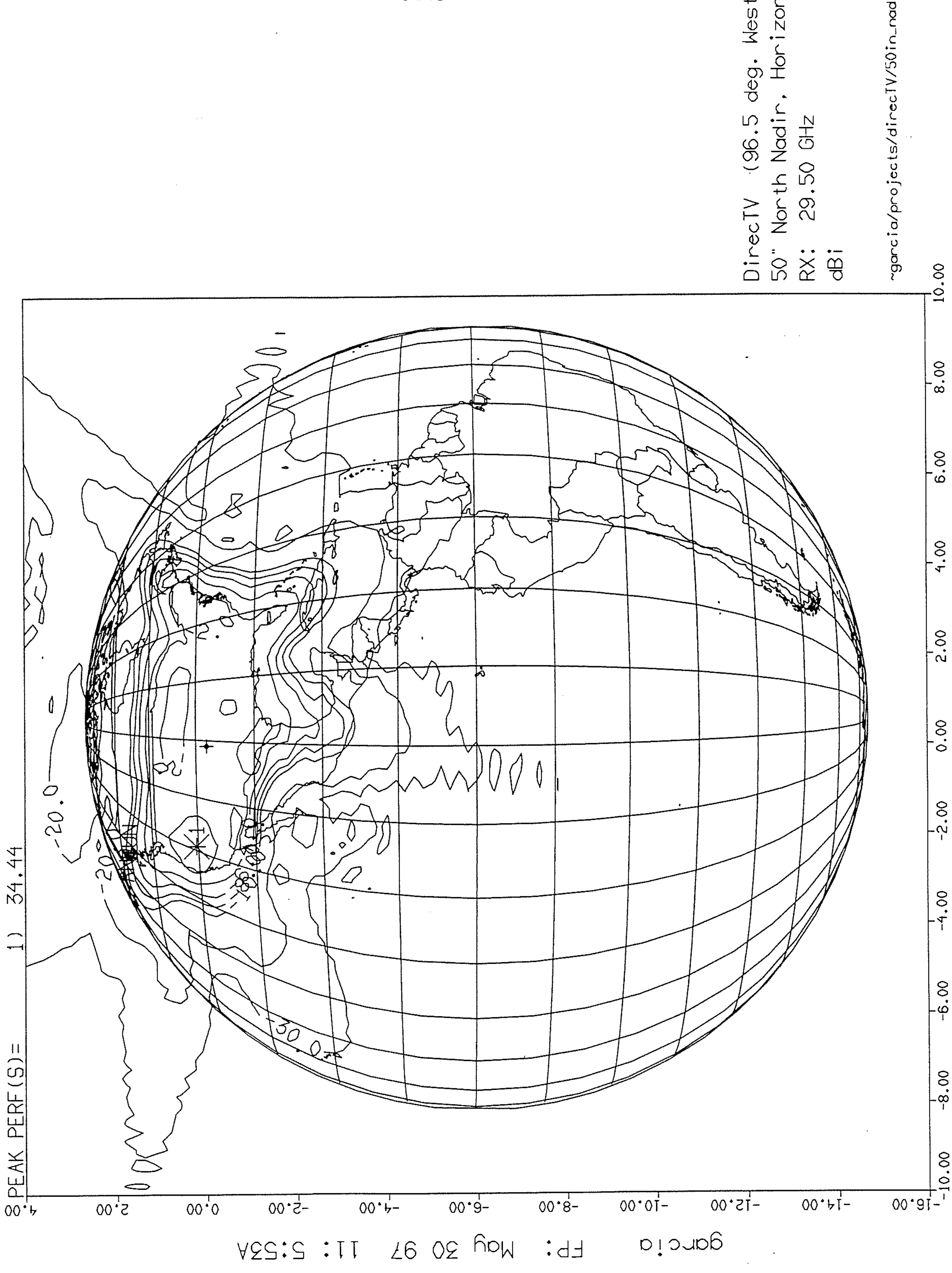


FIGURE D-9

RECEIVE GAIN PATTERN
101°W

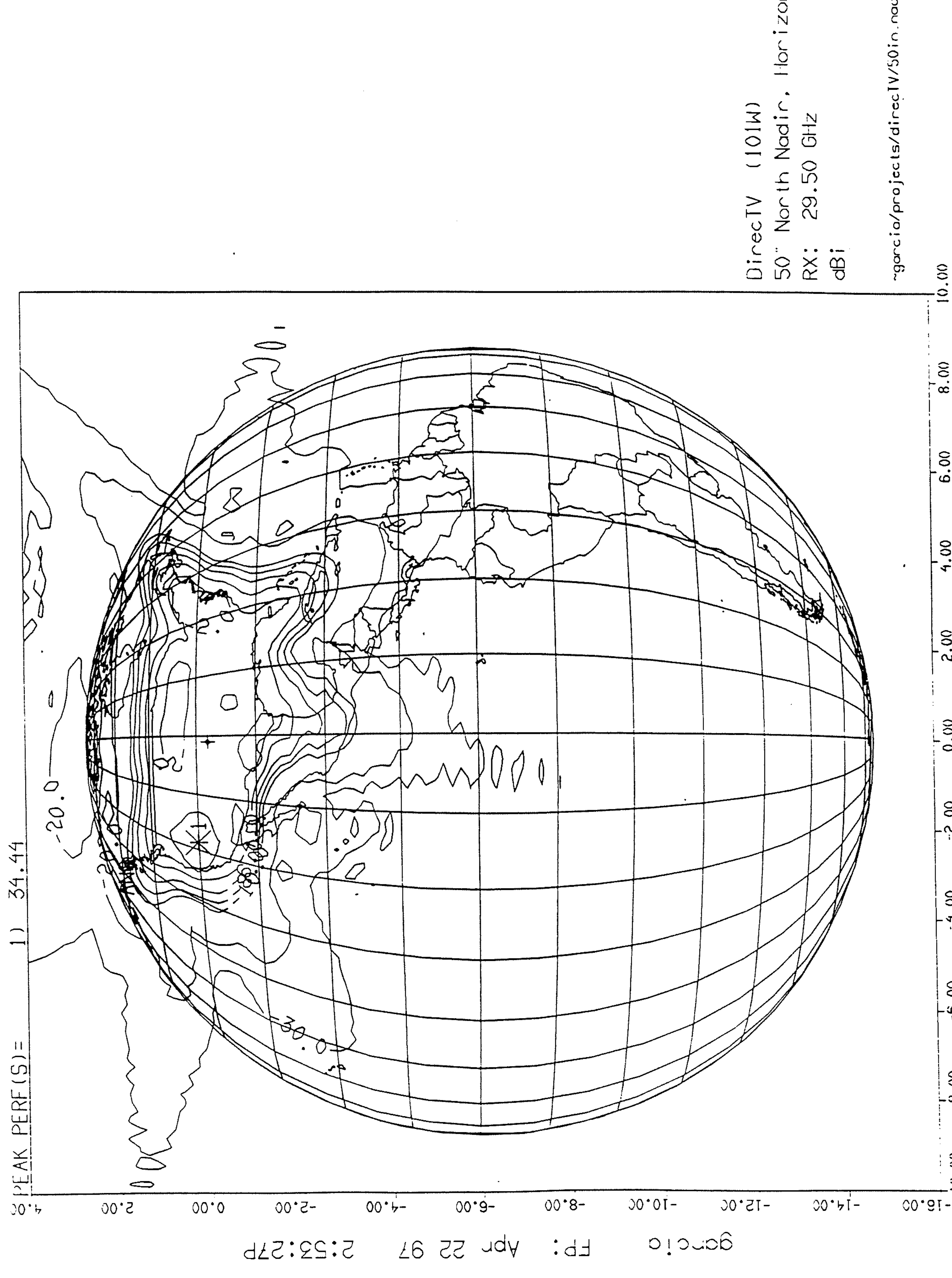


FIGURE D-10

RECEIVE GAIN PATTERN
105.5°W

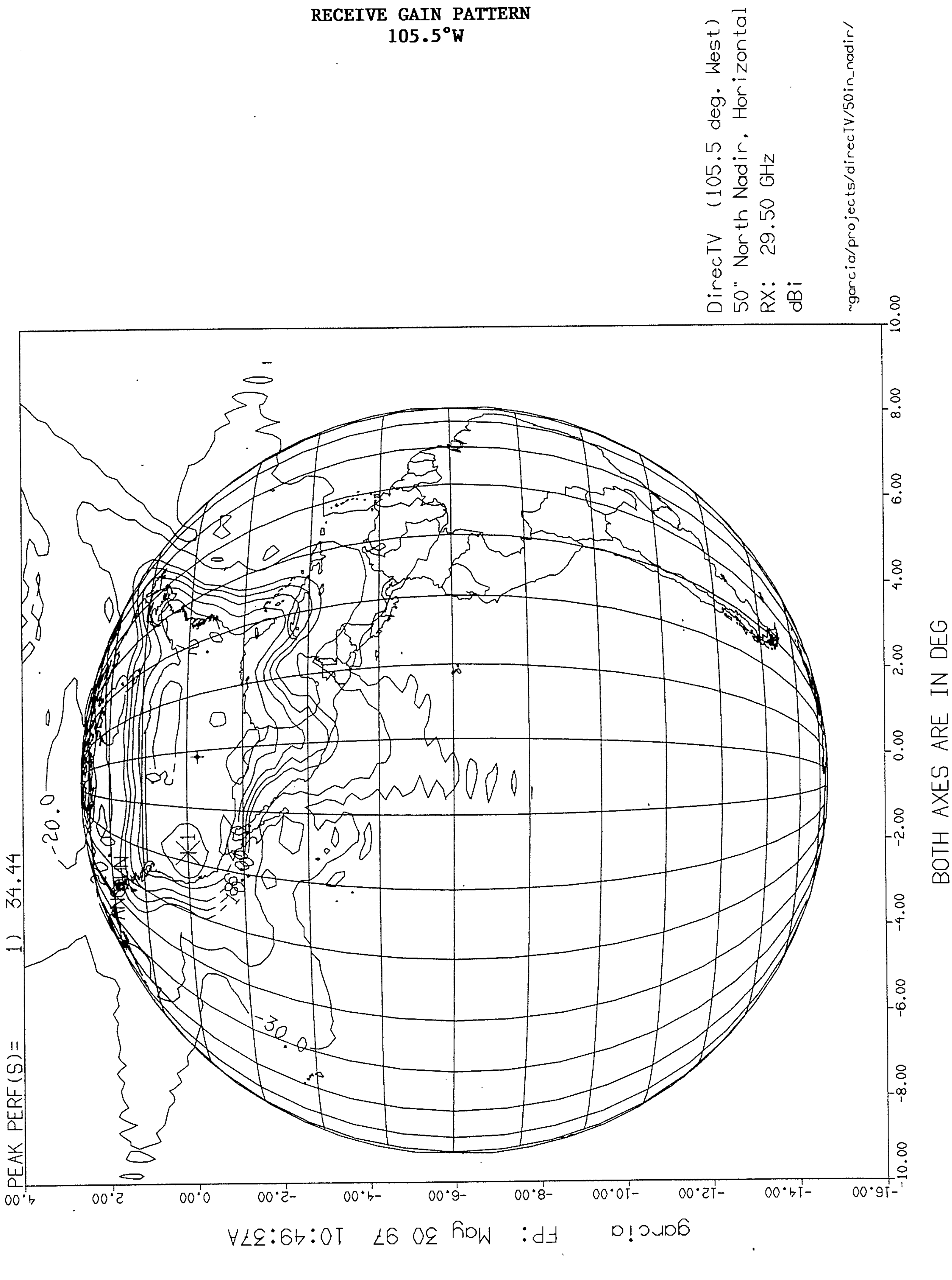


TABLE D-2

DOWNLINK POWER FLUX DENSITY (101° W.L.)

Location	Coordinates		Elevation Angle (°)	PFD Limit (dBW/m2/MHz) (1)	EIRP (dBW)	PFD (dBW/m2/MHz) (2)	Margin to PFD Limit (dB)
	LAT (N=+)	LONG (E=+)					
Boston	42.35	-71.07	32.5	-105.0	54.0	-119.6	14.6
Chicago	41.82	-87.62	39.8	-105.0	54.0	-119.6	14.6
Denver	39.73	-104.98	43.8	-105.0	51.0	-122.6	17.6
Houston	29.77	-95.35	54.7	-105.0	56.0	-117.6	12.6
Los Angeles	33.88	-118.23	46.5	-105.0	51.0	-122.6	17.6
Miami	25.78	-80.24	52.0	-105.0	57.0	-116.6	11.6
Minneapolis	44.97	-93.25	37.6	-105.0	51.5	-122.1	17.1
New York	40.67	-73.97	35.4	-105.0	54.0	-119.6	14.6
San Antonio	29.42	-98.50	55.6	-105.0	52.5	-121.1	16.1
San Francisco	32.60	-117.30	48.2	-105.0	51.0	-122.6	17.6
Seattle	47.60	-122.33	31.5	-105.0	51.0	-122.6	17.6
Utah	32.30	-111.00	50.9	-105.0	51.0	-122.6	17.6
Anchorage	61.13	-149.54	10.1	-112.5	44.0	-129.6	17.1
Honolulu	21.30	-157.83	22.6	-106.2	54.0	-119.6	13.4

1) PFD limit is currently only specified for frequencies above 17.7 GHz
2) Based on 13 MHz occupied bandwidth (communications II signal format)

TABLE D-3

SPACECRAFT CHARACTERISTICS

General	
Spacecraft bus	Hughes, HS-601 or HS-702
Stabilization	
Transfer orbit	Spin stabilization
On station	3 axis, momentum bias
Mission life	12 years
Design life	15 years
Eclipse capability	100 percent (16 channels)
Stationkeeping	
North-South (orbital inclination)	±0.05°
East-West (longitudinal drift)	±0.05°
Antenna pointing	
Normal (precision two-axis RF beacon tracking)	±0.07° N-S and E-W
Backup (Earth sensor)	±0.2° N-S and E-W
Beam rotation (antenna axis attitude)	±0.25°

TABLE D-3 (continued)

<u>Communications</u>	
Frequency	
Receive	24750 to 25250 MHz
Transmit	17300 to 17800 MHz
Polarization	Uplink: Linear Downlink: Circular
Number of transponders	16
Transponder bandwidth	16 at 24 MHz
Receive G/T	0 dB/K, edge of coverage
Saturated transponder gain	180 to 197.5 dB with automatic level control
Receive saturation	-100 to -82.5 dBW/M^2 at 2 dB/K contour and adjustable by ground command in 1 dB steps
Transmit EIRP	50.0 dBW (edge of coverage)
Transmitter (TWTA) RF power	240W (120W x 2) (per transponder)
Transmitter redundancy	Two rings of 10 for 8
Emission limitations (percentage of authorized bandwidth)	
50 to 100%	>20 dB attenuation in any 4 KHz
100 to 250%	>40 dB attenuation in any 4 KHz
Greater than 250%	>50 dB attenuation in any 4 KHz

TABLE D-3 (continued)

Tracking, Telemetry and Command

Frequency	
Command, ranging and tracking beacon	14000 to 14003 MHz transfer orbit and on station 14497 to 14500 MHz backup pipe
Telemetry and ranging	2 signals within 12200-12003 MHz
Polarization	
Command, ranging and tracking	
Transfer orbit	Circular
On station	Circular
Backup	Circular
Telemetry/Ranging	Circular
Peak deviation	
Command, ranging and tracking beacon	±300 KHz
Modulation index	
Telemetry/ranging	1.0 ± 0.1 radians
Telemetry EIRP	
Transfer orbit	7.0 dBW maximum
On station	22.0 dBW maximum
Command threshold (flux density)	
Transfer orbit	-82.0 dBW/m^2

TABLE D-3 (continued)

On station	-111.0 dBW/m^2
Coverage	
Command	
Transfer orbit	Omni
On station	Planar array
Backup	Pipe
Telemetry	
Transfer orbit	Omni
On station	Reflector
Backup	Pipe

TABLE D-4

WEIGHT BUDGET

Category	Weight, lbs.
Communications subsystem weight	750
Bus weight	2,700
Estimated spacecraft dry weight	3,450
Margin	150
Maximum allowable dry weight (Ariane IV, shared)	3,600
Fuel, expendables	3,100
Total launch weight	6,700

TABLE D-5

POWER BUDGET

Category	Power, Watts
Communications subsystem power	6,820
Bus power	760
Total power requirement	7,580
Beginning-of-life array capability	9,540
Beginning-of-life margin	1,960
End-of-life array capability (12 years)	8,050
End-of-life margin	470

Tables D-6 and D-7 show the estimated receive gain-to-noise temperature (G/T) and EIRP budgets, respectively.

3. Satellite Description

a. General

The satellite is an advanced body-stabilized spacecraft from Hughes Telecommunications and Space Company. The satellite design is compatible with launch by one of the currently available commercial launch vehicles. Final injection into geosynchronous orbit is accomplished by an integral liquid propulsion system.

Deployment of antennas and solar cell arrays takes place in four separate operations. The first operation consists of erecting the omni antenna for the command, telemetry, and ranging functions to its transfer orbit configuration. After the spacecraft has been injected into synchronous orbit, the large communications antennas are deployed and the solar cell arrays are extended. Finally, the omni antenna is deployed to its final on-orbit configuration.

b. Structural Design

The spacecraft is divided into three parts for ease of manufacturing and integration. Communications equipment is mounted on the payload module that forms the nadir facing wall and the north and south faces. Heat pipes are embedded in the north and south faces to distribute thermal dissipation over these prime radiating surfaces. Propulsion equipment is mounted on a central structure with tank loads being carried by a cylinder into the launch vehicle interface. A bus module is formed by the anti-nadir surface.

c. Thermal Control

Thermal control is accomplished with heaters and heat pipes. The primary payload heat rejection surfaces are the north and south facing radiators, which have been sized using flight data for quartz mirror degradation predictions. Battery temperatures are maintained within limits dictated by life consideration using direct dedicated radiating surfaces on the north and south faces plus heaters.

d. Power

Satellite power will be provided by solar arrays of fused silica-covered gallium arsenide solar cells that convert solar energy to the required electrical power. The arrays are deployed after the satellite attains synchronous orbit.

Nickel-hydrogen batteries provide sufficient electrical power during eclipse to operate the full communications and housekeeping loads. Similar batteries have been used on HS-601 satellites.

The electrical power subsystem has been designed so that no single failure in the subsystem will cause a spacecraft failure. Sufficient power will be available at the end of the satellite's life to support all 16 active transponder channels and the housekeeping loads.

e. Attitude Control

The Attitude Control Subsystem (ACS) maintains the spacecraft attitude during the transfer orbit, initial acquisition period, and geostationary operations. The ACS employs sun and earth sensors to perform all attitude determination functions. Beacon tracking is the prime pointing mode providing steady-state accuracy of ± 0.5 degrees. Control of attitude and spacecraft orbit is accomplished by using momentum wheels and by pulsed or continuous firing of selected thrusters by the ACS during ground controlled maneuvers.

f. Propulsion

The spacecraft will use both a liquid bipropellant and a Xenon Ion propulsion system (XIPS). The liquid bipropellant system is based on proven technology from the Leasat and Intelsat VI programs. XIPS technology has been incorporated into other Hughes satellites. High performance is achieved through the use of a hyperbolic propellant: nitrogen-tetroxide (N_2O_4) oxidizer and monomethyl-hydrazide (MMH) fuel, or by applying electrostatic forces to positively charged ions of Xenon, respectively.

g. Communication Payload

The transmit coverage is derived using two solid, circular shaped surface reflectors each fed by a single feed horn. Each antenna provides both RHCP and LHCP polarizers, although only one sense will be used on-orbit on a given spacecraft. Receive coverage is provided by one solid, circular, shaped surface reflector which is fed by a single feed horn. The horn provides both senses of linear polarization. Again only one sense will be used on-orbit on a given spacecraft. Relative to the desired polarization, the cross-polarization component of the receive and transmit signals will be at most -27 dB over the required coverage region.

The spacecraft antenna will have autonomous on-board pointing controllers, which will use the RF beacon tracking data to control the antenna positioning mechanism. In case of loss of beacon lock, the spacecraft attitude control reference will revert to earth sensors.

TABLE D-6

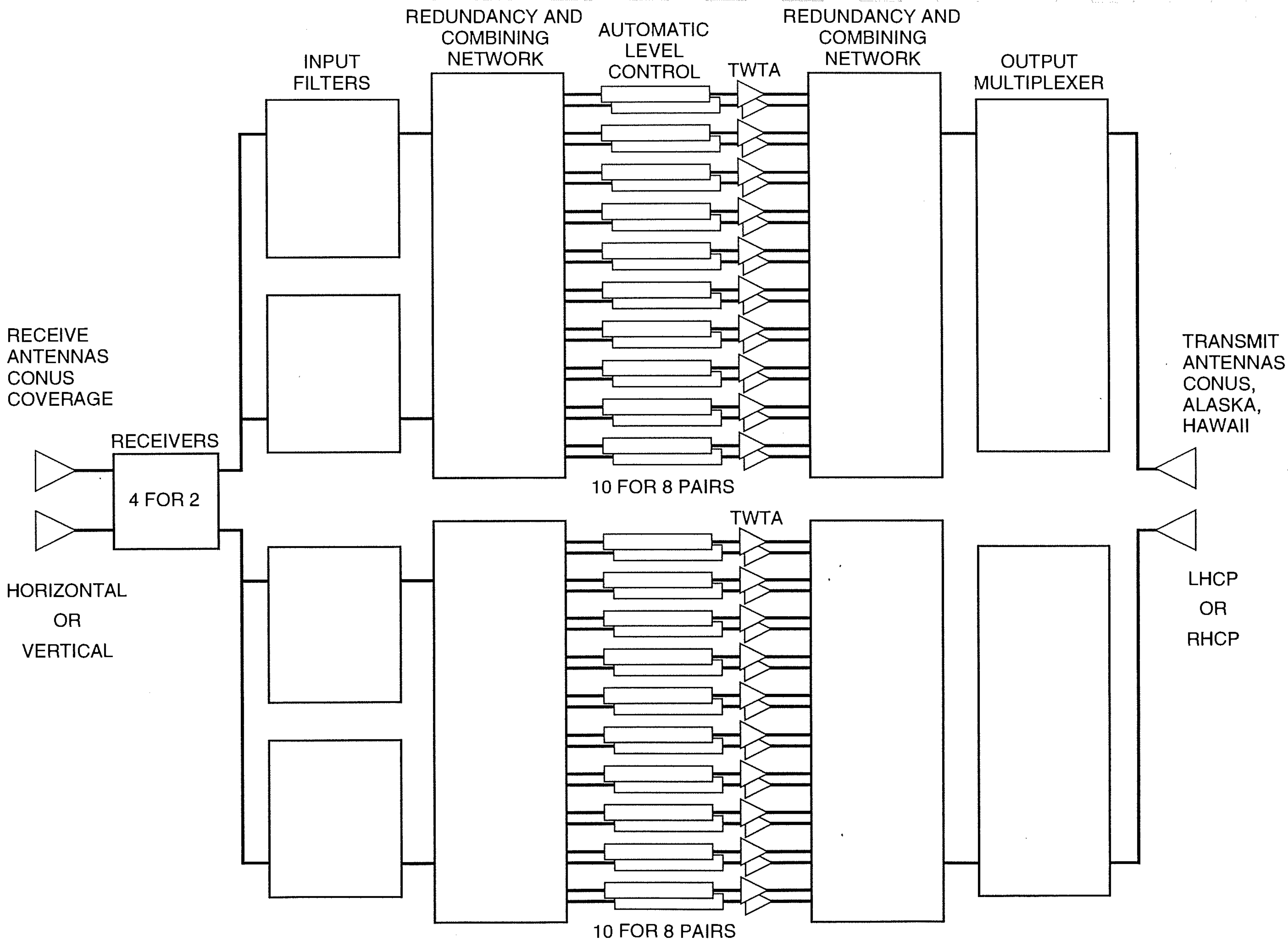
SATELLITE UPLINK G/T BUDGET

Parameter	Value
Antenna gain (-2dB contour)	32.4 dBi
System noise temperature	29.1 dB-K
G/T	3.3 dB/°K

TABLE D-7

SATELLITE DOWNLINK EIRP BUDGET

Parameter	Value
TWTA output power (240 W)	23.8 dBW
Output losses	2.7 dB
Effective antenna gain (-2 dB contour)	35.4 dB
EIRP	56.5 dBW



BROADCAST SUBSYSTEM SIMPLIFIED BLOCK DIAGRAM

FIGURE D-11

h. Satellite Communications Subsystem

The communications subsystem will consist of a 16 channel repeater; each channel has 240 watts of output power by employing two 120 watt TWTAs in parallel. Subsystem components, including the high power TWTAs, will be selected to optimize the performance of the end-to-end link between the uplink facility and the low-cost customer premises terminals.

A block diagram of the communications subsystem is given in Figure D-11.

The redundant wideband receivers will be connected directly to the receive antenna. The receiver output is then channelized with the input filters and amplified by the channel amplifiers consisting of an automatic level control (ALC) and TWTA, and multiplexed into two shaped surface reflector antennas.

Each wideband receiver has been designed to have high sensitivity (good noise performance) and low crosstalk coefficients (good linearity characteristics). The high sensitivity is required for detection and amplification of extremely low-level signals received by the satellite from the earth station transmitters. The low crosstalk coefficients are necessary since eight separate signals pass through the wideband receivers prior to channelization by the narrow bandpass filters. A highly linear receiver is necessary in order to minimize coupling of interference among these signals in the receiver.

The wideband receiver will consist of a low noise amplifier followed by a downconverter that will translate the input 25 GHz frequencies to the satellite transmit frequencies at 17 GHz through a net frequency subtraction 7450 MHz without frequency inversion, and with a net translation error, including initial tolerance, not greater than ± 10 parts in 10^6 over the operating lifetime of the satellite. Variations in net translation frequency over one day will not exceed a total of one part in 10^6, including eclipse effects. Following the downconverter will be a medium-level amplifier that will amplify the translated signals sufficiently to drive the channel amplifier in each transponder. This medium-level drive amplifier has been designed for highly linear operation.

Following the input filters is a bank of redundancy switches and combining hardware which form the channel amplifier redundancy combining network. Two rings of ten for eight redundancy are provided. Each channel amplifier provides automatic level control (ALC) to set the desired high power amplifier (HPA) operating point. The ALC also provides ground commandable attenuation of up to 17.5 dB in 1.0 dB increments. For final amplification, two high power amplifiers in parallel provides a net saturated RF output power of 240 watts. Following the HPAs is an output redundancy combining network which is the mirror image of the input redundancy network.

Spurious emissions that are beyond the usable bandwidth of each transponder and within the 17.3-7.8 GHz band are attenuated by a combination of the input and output multiplexer filters. Out-of-band emissions beyond the 17.3-7.8 GHz band, including harmonics, are attenuated by a combination of the output multiplexer filter and low pass filtering.

The telemetry system will have two identical links consisting of two encoders that modulate either of two transmitters via a cross-strap switch. Data pertaining to unit status, spacecraft attitude, and spacecraft performance will be transmitted continuously for spacecraft management and control. The telemetry transmitters will also serve as the downlink transmitter for ranging tones and command verification. The primary telemetry data mode will be PCM. For normal on-station operation, the telemetry transmitters will be connected via a filter to the transmit feeds of the communications antenna. In transfer orbit, each telemetry transmitter will drive the omni antenna.

The command system will control spacecraft operation through all phases of the mission by receiving and decoding commands to the spacecraft. Additionally, it will serve as the uplink receiver for ranging signals and provide closed loop tracking of a ground beacon for spacecraft pointing. It will perform the latter function without interfering with the command function. The command signals will be fed through a filter diplexer into a redundant pair of tracking command receivers. The composite signal of the receivers' total output will drive a pair of redundant decoders. The decoders will provide command outputs for all satellite functions. The command bicone antenna will be used in transfer orbit for command and ranging, while the reflector antenna will be used on-station for ground RF beacon tracking, command and ranging.

i. Satellite Useful Lifetime

The design lifetime of the satellite in orbit (other than with respect to stationkeeping) is 15 years. This has been determined by a conservative evaluation of the effect of the synchronous orbit environment on the solar array, the effect of the charge-discharge cycling on the life of the batteries, and the wearout of the TWTAs. The mass allocation of propellant for spacecraft stationkeeping is 12 years. To enhance the probability of survival, spacecraft equipment will be redundant wherever possible. Materials and processes will be selected so that aging or wearing effects will not adversely affect spacecraft performance over the estimated life. The following paragraphs discuss dominant lifetime factors.

(i) Fuel

A conservative mission analysis indicates a 12 year lifetime. The mission has not yet been optimized since the exact sequence of maneuvers will be determined after the actual selection of the launch vehicle. Any remaining spacecraft weight margin can be converted to mission life.

(ii) Battery

Life testing to date indicates that a longevity of 12 years can easily be achieved. In order to ensure this longevity, the spacecraft design incorporates the following required provisions: C/20 charge rate at end of life, thermal control during all phases, and proper selection of cell components.

(iii) Solar Panel

Predictions concerning the useful life of the solar panels are backed by decades of Hughes experience in predicting and measuring in-orbit solar panel performance. These predictions are based on conservative assumptions concerning the radiation environment.

(iv) Electronics

All critical electronics units and components are redundant. There is a four-for-two redundancy employed for the communications receivers and two ten-for-eight redundancy rings employed for the power amplifier chains. For other electronics units a minimum of two-for-one redundancy is employed. The electrical design follows well-established criteria regarding parts selection, testing and design, among others. Most electronic units are modeled after their counterparts in HS-601 spacecraft, which have already experienced a significant number of years in orbit.

(v) Non-electronic

Full redundancy has been employed for non-electronic components wherever practical.

(vi) Eclipse Considerations

The satellite battery capacity will be more than adequate to power all 32 output TWTAs during eclipses throughout mission life.

(vii) Sun Outages

During predictable twice-yearly periods of approximately eight days, the sun briefly transits the field of view of an earth station pointing at a geostationary satellite. The rise in thermal noise in the earth station receivers caused by the sun's radiation disrupts satellite reception (i.e., causes sun outage). Such disruption of satellite reception is predictable and is well understood by satellite users.