READ INSTRUCTIONS CAREFULLY BEFORE PROCEEDING

(1) LOCKBOX # 358210

FEDERAL COMMUNICATIONS COMMISSION

REMITTANCE ADVICE

PAGE NO. 1 OF 1

APPROVED BY OMB 3060-0589

SPECIAL USE

FCC USE ONLY

DEC 11 1998

SECTION A - PAYER INFORMATION

(2) PAYER NAME (if paying by credit card, enter name exactly as it appears on your card)
Satellite CD Radio, Inc.

(3) TOTAL AMOUNT PAID (dollars and cents)
$ 22,010.00

COPY

(4) STREET ADDRESS LINE NO. 1
1180 Avenue of the Americas

(5) STREET ADDRESS LINE NO. 2
14th Floor

(6) CITY
New York

(7) STATE
NY

(8) ZIP CODE
10036

(9) DAYTIME TELEPHONE NUMBER (Include area code)
(212) 899-5000

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

IF PAYER NAME AND THE APPLICANT NAME ARE DIFFERENT, COMPLETE SECTION B
IF MORE THAN ONE APPLICANT, USE CONTINUATION SHEETS (FORM 159-C)

SECTION B - APPLICANT INFORMATION

(11) APPLICANT NAME (if paying by credit card, enter name exactly as it appears on your card)

SAT-MOD-19981211-00099

(12) STREET ADDRESS LINE NO. 1

(13) STREET ADDRESS LINE NO. 2

(14) CITY

(15) STATE

(16) ZIP CODE

(17) DAYTIME TELEPHONE NUMBER (Include area code)

(18) COUNTRY CODE (if not in U.S.A.)

COMPLETE SECTION C FOR EACH SERVICE, IF MORE BOXES ARE NEEDED, USE CONTINUATION SHEETS (FORM 159-C)

SECTION C - PAYMENT INFORMATION

(19A) FCC CALL SIGN/OTHER ID	(20A) PAYMENT TYPE CODE (PTC)	(21A) QUANTITY	(22A) FEE DUE FOR (PTC) IN BLOCK 20A	FCC USE ONLY
	C G W	1	$ 22,010.00	

(23A) FCC CODE 1	(24A) FCC CODE 2

(19B) FCC CALL SIGN/OTHER ID	(20B) PAYMENT TYPE CODE (PTC)	(21B) QUANTITY	(22B) FEE DUE FOR (PTC) IN BLOCK 20B	FCC USE ONLY
			$	

(23B) FCC CODE 1	(24B) FCC CODE 2

(19C) FCC CALL SIGN/OTHER ID	(20C) PAYMENT TYPE CODE (PTC)	(21C) QUANTITY	(22C) FEE DUE FOR (PTC) IN BLOCK 20C	FCC USE ONLY
			$	

(23C) FCC CODE 1	(24C) FCC CODE 2

(19D) FCC CALL SIGN/OTHER ID	(20D) PAYMENT TYPE CODE (PTC)	(21D) QUANTITY	(22D) FEE DUE FOR (PTC) IN BLOCK 20D	FCC USE ONLY
			$	

(23D) FCC CODE 1	(24D) FCC CODE 2

SECTION D - TAXPAYER INFORMATION (REQUIRED)

(25) PAYER TIN 0 5 2 1 7 0 0 2 0 7

(26) COMPLETE THIS BLOCK ONLY IF APPLICANT NAME IN B-11 IS DIFFERENT FROM PAYER NAME IN A-2)
APPLICANT TIN 0

SECTION E - CERTIFICATION

(27) CERTIFICATION STATEMENT

I, Robert D. Briskman (PRINT NAME), Certify under penalty of perjury that the foregoing and supporting information are true and correct to the best of my knowledge, infomation and belief. SIGNATURE Robert D. Briskman

SECTION F - CREDIT CARD PAYMENT INFORMATION

(28)

☐ MASTERCARD

MASTERCARD/VISA ACCOUNT NUMBER:

EXPIRATION DATE: MONTH YEAR

☐ VISA

I hereby authorize the FCC to charge my VISA or MASTERCARD for the service(s)/authorization(s) herein described. ▶

AUTHORIZED SIGNATURE

DATE

SEE PUBLIC BURDEN ESTIMATE ON REVERSE

FCC FORM 159 JULY 1997 (REVISED)

FCC 312
Main Form

FEDERAL COMMUNICATIONS COMMISSION
APPLICATION FOR SATELLITE SPACE AND EARTH STATION AUTHORIZATIONS

Approved by OMB 3060-0678
Est. Avg. Burden Hours Per Response: 10 Hrs.

FCC Use Only
File Number:

Call Sign:

PAYOR AND FILING FEE INFORMATION

a. Payor Name			b. Daytime Telephone Number
Satellite CD Radio, Inc.			(212) 899-5000
c. Mailing Street Address or P.O. Box			d. FCC Account Number
1180 Avenue of the Americas, 14th Floor			0521700207
e. City	f. State	g. Zip Code	h. Country Code (if not U.S.A.)
New York	NY	10036	

i. Payment Type Code	j. Quantity	k. Fee Due for Payment Type Code in (i)	l. Total Amount Paid	FCC Use Only
CGW	1	$22,010.00	$22,010.00	

APPLICANT INFORMATION

1. Legal Name of Applicant		2. Voice Telephone Number
Satellite CD Radio, Inc.		(212) 899-5000
3. Other Name Used for Doing Business (if any)		4. Fax Telephone Number
		(212) 899-5036
5. Mailing Street Address or P.O. Box	6. City	
1180 Avenue of the Americas, 14th Floor	New York	
ATTENTION: Robert D. Briskman	7. State / Country (if not U.S.A.) NY	8. Zip Code 10036
9. Name of Contact Representative (If other than applicant)		10. Voice Telephone Number
Richard E. Wiley		(202) 429-7000
11. Firm or Company Name		12. Fax Telephone Number
Wiley, Rein & Fielding		(202) 429-7049
13. Mailing Street Address or P.O. Box	14. City	
1776 K Street, N.W.	Washington	
ATTENTION: Richard E. Wiley	15. State / Country (if not U.S.A.) DC	16. Zip Code 20006

CLASSIFICATION OF FILING

17. Place an "X" in the box next to the classification that applies to this filing for both questions a. and b. Mark only one box for 17a and only one box for 17b.

- ☐ a1. Earth Station
- ☒ a2. Space Station

- ☐ b1. Application for License of New Station
- ☐ b2. Application for Registration of New Domestic Receive-Only Station
- ☐ b3. Amendment to a Pending Application
- ☒ b4. Modification of License or Registration
- ☐ b5. Assignment of License or Registration
- ☐ b6. Transfer of Control of License or Registration
- ☐ b7. Notification of Minor Modification
- ☐ b8. Other (Please Specify): _____

18. If this filing is in reference to an existing station, enter:
Call sign of station:

19. If this filing is an amendment to a pending application enter:
(a) Date pending application was filed:
(b) File number of pending application:

TYPE OF SERVICE

20. NATURE OF SERVICE: This filing is for an authorization to provide or use the following type(s) of service(s): Place an "X" in the box(es) next to all that apply.

☐ a. Fixed Satellite ☐ b. Mobile Satellite ☐ c. Radiodetermination Satellite ☐ d. Earth Exploration Satellite ☒ e. Other (please specify) Satellite Digital Audio Radio

21. STATUS: Place an "X" in the box next to the applicable status. Mark only one box.

☐ a. Common Carrier ☒ b. Non-Common Carrier

22. If earth station applicant, place an "X" in the box(es) next to all that apply.

☐ a. Using U.S. licensed satellites ☐ b. Using Non-U.S. licensed satellites

23. If applicant is providing INTERNATIONAL COMMON CARRIER service, see instructions regarding Sec. 214 filings. Mark only one box. Are these facilities:

☐ a. Connected to the Public Switched Network ☐ b. Not connected to the Public Switched Network

24. FREQUENCY BAND(S): Place an "X" in the box(es) next to all applicable frequency band(s).

☐ a. C-Band (4/6 GHz)
☐ b. Ku-Band (12/14 GHz) ☒ c. Other (Please specify) 2320.0-2332.5 MHz

TYPE OF STATION

25. CLASS OF STATION: Place an "X" in the box next to the class of station that applies. Mark only one box.

☐ a. Fixed Earth Station ☐ b. Temporary-Fixed Earth Station ☐ c. 12/14 GHz VSAT Network ☐ d. Mobile Earth Station ☒ e. Space Station ☐ f. Other Specify _____

If space station applicant, go to Question 27.

26. TYPE OF EARTH STATION FACILITY Mark only one box.

☐ a. Transmit/Receive ☐ b. Transmit-Only ☐ c. Receive-Only

PURPOSE OF MODIFICATION OR AMENDMENT

27. The purpose of this proposed modification or amendment is to: Place an "X" in the box(es) next to all that apply.

☐ a -- authorization to add new emission designator and related service
☐ b -- authorization to change emission designator and related service
☐ c -- authorization to increase EIRP and EIRP density
☐ d -- authorization to replace antenna
☐ e -- authorization to add antenna
☐ f -- authorization to relocate fixed station
☒ g -- authorization to change assigned frequency(ies)
☒ h -- authorization to add Points of Communication (satellites & countries)
☐ i -- authorization to change Points of Communication (satellites & countries)
☐ j -- authorization for facilities for which environmental assessment and radiation hazard reporting is required
☒ k -- Other (Please specify) authorization to change orbits to non-geostationary

ENVIRONMENTAL POLICY

28. Would a Commission grant of any proposal in this application or amendment have a significant environmental impact as defined by 47 CFR 1.1307? ☐ YES ☒ NO

If YES, submit the statement as required by Sections 1.1308 and 1.1311 of the Commission's rules, 47 C.F.R. §§ 1.1308 and 1.1311, as Exhibit A to this application.

A Radiation Hazard Study must accompany all applications as Exhibit B for new transmitting facilities, major modifications, or major amendments. Refer to OET Bulletin 65.

ALIEN OWNERSHIP

29. Is the applicant a foreign government or the representative of any foreign government?	☐ YES	☒ NO
30. Is the applicant an alien or the representative of an alien?	☐ YES	☒ NO
31. Is the applicant a corporation organized under the laws of any foreign government?	☐ YES	☒ NO
32. Is the applicant a corporation of which more than one-fifth of the capital stock is owned of record or voted by aliens or their representatives or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	☐ YES	☒ NO
33. Is the applicant a corporation directly or indirectly controlled by any other corporation of which more than one-fourth of the capital stock is owned of record or voted by aliens, their representatives, or by a foreign government or representative thereof or by any corporation organized under the laws of a foreign country?	☐ YES	☒ NO
34. If any answer to questions 29, 30, 31, 32 and/or 33 is Yes, attach as Exhibit C an identification of the aliens or foreign entities, their nationality, their relationship to the applicant, and the percentage of stock they own or vote.		

BASIC QUALIFICATIONS

35. Does the applicant request any waivers or exemptions from any of the Commission's Rules? If Yes, attach as Exhibit D, copies of the requests for waivers or exceptions with supporting documents.	☐ YES	☒ NO
36. Has the applicant or any party to this application had any FCC station authorization or license revoked or had any application for an initial, modification or renewal of FCC station authorization, license, or construction permit denied by the Commission? If Yes, attach as Exhibit E, an explanation of the circumstances.	☐ YES	☒ NO
37. Has the applicant, or any party to this application, or any party directly or indirectly controlling the applicant ever been convicted of a felony by any state or federal court?	☐ YES	☒ NO
38. Has any court finally adjudged the applicant, or any person directly or indirectly controlling the applicant, guilty of unlawfully monopolizing or attempting unlawfully to monopolize radio communication, directly or indirectly, through control of manufacture or sale of radio apparatus, exclusive traffic arrangement or any other means or unfair methods of competition?	☐ YES	☒ NO
39. Is the applicant, or any person directly or indirectly controlling the applicant, currently a party in any pending matter referred to in the proceeding two items?	☐ YES	☒ NO
40. By checking Yes, the undersigned certifies, that neither the applicant nor any other party to the application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Act of 1988, 21 U.S.C. Section 862, because of a conviction for possession or distribution of a controlled substance. See 47 CFR 1.2002(b) for the meaning of "party to the application" for these purposes.	☒ YES	☐ NO

41. Description. (Summarize the nature of the application and the services to be provided).

This application seeks modification of CD Radio's existing authorization to provide satellite digital audio radio service in the 2320.0-2332.5 MHz frequency band. Three system enhancements are requested: (1) an increase in the number of satellites from two to three, plus a ground spare; (2) operation of all three satellites in inclined and elliptical (non-geostationary) orbits; and (3)use of the 6/4 GHz frequency band on a non-interfering basis for telemetry, tracking and command.

CERTIFICATION

The Applicant waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests an authorization in accordance with this application. The applicant certifies that grant of this application would not cause the applicant to be in violation of the spectrum aggregation limit in 47 CFR Part 20. All statements made in exhibits are a material part hereof and are incorporated herein as if set out in full in this application. The undersigned, individually and for the applicant, hereby certifies that all statements made in this application and in all attached exhibits are true, complete and correct to the best of his or her knowledge and belief, and are made in good faith.

42. Applicant is a (an): (Place an "X" in the box next to applicable response.)

☐ a. Individual ☐ b. Unincorporated Association ☐ c. Partnership ☒ d. Corporation ☐ e. Governmental Entity ☐ f. Other (Please specify) _____

43. Typed Name of Person Signing	44. Title of Person Signing
Robert D. Briskman	President, Satellite CD Radio, Inc.

45. Signature	46. Date
Robert D. Briskman	12/11/98

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND/OR IMPRISONMENT (U.S. Code, Title 18, Section 1001), AND/OR REVOCATION OF ANY STATION AUTHORIZATION (U.S. Code, Title 47, Section 312(a)(1)), AND/OR FORFEITURE (U.S. Code, Title 47, Section 503).

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

In the Matter of: **Satellite CD Radio, Inc.** Application to Modify Authorization to Launch and Operate a Digital Audio Radio Satellite Service in the 2320.0-2332.5 MHz Frequency Band	49/50-DSS-P/L-90 58/59-DSS-AMEND-90 44/45-DSS-AMEND-92

Application of Satellite CD Radio, Inc. to Modify Authorization

Robert D. Briskman
Satellite CD Radio, Inc.
1180 Avenue of the Americas
14th Floor
New York, New York 10036
(212) 899-5000

Dated: December 11, 1998

TABLE OF CONTENTS

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

In the Matter of: **Satellite CD Radio, Inc.** Application to Modify Authorization to Launch and Operate a Digital Audio Radio Satellite Service in the 2320.0-2332.5 MHz Frequency Band	49/50-DSS-P/L-90 58/59-DSS-AMEND-90 44/45-DSS-AMEND-92

Application of Satellite CD Radio, Inc. to Modify Authorization

I. INTRODUCTION

Satellite CD Radio, Inc. ("CD Radio") submits this application to modify certain technical parameters of its space station authorization to provide satellite digital audio radio services ("satellite DARS") in the 2320.0-2332.5 MHz (space-to-Earth) frequency band.[1] Three satellite system enhancements are requested by this application: (1) an increase in the number of satellites from two to three, plus a ground spare; (2) placement of all three satellites into inclined and elliptical (non-geostationary) orbits; and (3) use of the 6/4 GHz frequency band on a non-interfering basis for telemetry, tracking and command ("TT&C").

[1] *Satellite CD Radio, Inc., Application for Authority to Construct, Launch and Operate Two Satellites in the Satellite Digital Audio Radio Service*, 13 F.C.C. Rcd 7971 (1997) (Order and Authorization) ("*CD Radio Authorization*").

Modification of CD Radio's authorization is warranted because the proposed system changes will permit CD Radio to offer better quality satellite DARS from its spacecraft. Further, the improved satellite system developed by CD Radio will continue to comply with the Federal Communications Commission's (the "Commission" or the "FCC") technical requirements, including Sections 25.114(c) and 25.144 of the Commission's rules, and will not raise additional international coordination or other interference concerns. In short, grant of CD Radio's application will provide the public with an improved satellite DARS service that relies on fewer terrestrial repeaters and offers more channels within the existing spectrum allocation.

Last year, the FCC authorized CD Radio to launch and operate two geostationary satellites at 80° W. Longitude and 110° W. Longitude for the purpose of providing satellite DARS in the United States. Satellite DARS is a "radiocommunication service in which audio programming is digitally transmitted by one or more space stations directly to fixed, mobile, and/or portable stations and which may involve complementary repeating terrestrial transmitters, telemetry, tracking and control facilities."[2] CD Radio's authorization to provide satellite DARS was granted pursuant to CD Radio's winning bid in the FCC's satellite DARS auction,[3] payment of the full bid price, and submission of a formal amended application.[4]

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[2] 47 C.F.R. § 25.201.

[3] CD Radio bid, and paid, $83,346,000 for use of the 2320.0-2332.5 MHz frequency band. *See* Public Notice, *FCC Announces Auction Winners for Digital Audio Radio Service*, 12 F.C.C. Rcd 18727 (1997).

[4] Letter of Robert Briskman, Satellite CD Radio, Inc., to Regina Keeney, Chief International Bureau, Compliance with Satellite CD Radio, Inc. Authorization (Feb. 19, 1998); Letter of Robert Briskman, Satellite CD Radio, Inc., to Regina Keeney, Chief International Bureau, Compliance with Satellite CD Radio, Inc. Authorization (Feb. 17, 1998); Application of Satellite CD Radio, Inc. to Launch and Operate a Digital Audio Radio Satellite Service in the 2320.0-

(continued . . .)

CD Radio's authorization permits it to offer continuous nationwide radio programming with digital quality sound. CD Radio intends to make available to consumers a state-of-the-art satellite DARS service in early 2000. By this application to modify the *CD Radio Authorization*, CD Radio proposes enhancements to its planned satellite system that will better fulfill the potential of satellite DARS, and thus serve the public interest, without raising additional technical or interference issues. Accordingly, CD Radio respectfully requests that the Commission grant this modification to its existing authorization.

II. THE PROVISION OF SATELLITE DARS USING THREE NON-GEOSTATIONARY SATELLITES IN INCLINED AND ELLIPTICAL ORBITS AND USING THE 6/4 GHz BAND FOR TT&C WILL CONFORM TO THE COMMISSION'S TECHNICAL REQUIREMENTS AND WILL RAISE NO ADDITIONAL INTERFERENCE ISSUES

Increasing the number of satellites available for the provision of satellite DARS from two to three, operating such satellites in geosynchronous inclined and elliptical orbits, and using the 6/4 GHz frequency band for TT&C will fully comply with the technical requirements established in the Commission's rules and the *CD Radio Authorization*.[5] In particular, CD Radio's use of three satellites in inclined and elliptical orbits will conform to the technical rules contained in

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(continued . . .)

2332.5 MHz Frequency Band: Submission and Amendment to Application 71-SAT-AMEND-97 (filed May 16, 1997) ("*CD Radio Amendment*"); Application of Satellite CD Radio, Inc. for an All-Digital CD Quality Satellite Sound Broadcasting System, File Nos. 49-DDS-P/LA-90, 50-DDS-P/LA-90 (filed May 18, 1990) ("*CD Radio Application*").

[5] Indeed, the *CD Radio Amendment* originally requested geosynchronous orbits for its proposed DARS satellites. *See CD Radio Amendment* at 21.

Sections 25.114(c) and 25.144 of the Commission's rules, will raise no additional international coordination or interference concerns, and will comply with other technical parameters of the existing authorization.

A. Modification of the CD Radio Authorization Conforms to Section 25.114(c)

CD Radio's proposed modifications to the CD Radio Authorization conform to the technical parameters for space station authorizations under Section 25.114(c). The two significant enhancements in technical design requested by this application concern the satellites' orbits and number of satellites utilized. As the Commission is aware, CD Radio executed a contract with Space System/Loral, Inc. in March 1993 to build its satellite DARS system. These spacecraft are based on the Loral FS-1300 three-axis stabilized design.

CD Radio's enhanced satellite constellation will consist of three satellites placed in inclined, elliptical (non-geostationary) orbits in order to provide improved subscriber services.[6] Each satellite's elevation angle will vary as the satellite travels through its geosynchronous (i.e., 24 hour) orbit north and south of the equator. When each satellite operates during the top half of its figure eight orbit, it will appear at a latitude north of the equator and thus serve the continental United States at a higher elevation angle. When each satellite travels through the lower portion of its figure eight orbit, including south of the equator, CD Radio will cease transmitting from that satellite. With three satellites each operating in a 24 hour inclined and elliptical rotation, at least one satellite will always be operating near the top of its figure eight pattern and, thus, will

[6] See Appendix A, Figure 2, which shows the track of the satellites projected on the earth.

be available to provide service at an elevation angle near 60 degrees in the northern third of the continental United States.

As part of this improvement, CD Radio will segment its band in thirds and use time division modulation for its satellite transmissions and coded orthogonal frequency division modulation for its terrestrial transmissions. CD Radio understands that similar segmentation and modulations will be used by the other satellite DARS licensee, XM Satellite Radio, Inc. ("XM Satellite Radio") formerly, American Mobile Radio Corporation. Also, as described in Appendix A, the satellites' TT&C subsystems will use the normal 6/4 GHz frequency bands, rather than the 7/2 GHz bands originally proposed by CD Radio, for on-orbit operation (6/4 GHz was originally proposed for use in launch, transfer orbit and contingency operation). The TT&C earth stations will be located in South America so they can view the total orbit of each of the satellites. The sites selected by CD Radio are already used for C-band transmit/receive earth stations and thus can easily be coordinated for in-country interference. In addition, transmission from these sites has a low probability of interference into the main receiving beam of any U.S. C-band satellites at the equatorial crossing points.

As required by Section 25.117 of the Commission's rules, Appendix A provides the Section 25.114(c) technical information that corresponds to CD Radio's use of three non-geostationary satellites in inclined and elliptical orbits, as opposed to two geostationary satellites, and use of the 6/4 GHz frequency band for TT&C.[7] CD Radio certifies that information not contained in Appendix A remains unchanged from CD Radio's prior submissions.[8]

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[7] 47 C.F.R. § 25.117(d).

[8] *See* note 4, *supra.*

B. CD Radio's Requested System Enhancements Will Raise No Additional International Coordination Or Other Interference Issues

CD Radio's use of three satellites in inclined and elliptical orbits and use of the 6/4 GHz band for TT&C will raise no additional international coordination or other interference issues.

No Additional International Coordination Concerns. CD Radio's use of three non-geostationary satellites will conform to the satellite DARS coordination agreement recently concluded with Canada and will not adversely affect similar pending coordination with Mexico. The U.S.-Canada agreement limits the satellite DARS power flux density (pfd) level for any angle of arrival to no greater than -119 dB(W/m²/4kHz).[9] CD Radio's provision of satellite DARS using three non-geostationary satellites will be less than this level. In fact, average interference to Canadian fixed systems may well be lower with satellites in inclined and elliptical orbits because the non-geostationary operation of the satellites will result in higher available elevation angles. Please note that the antennas on CD Radio's non-geostationary satellites will continuously pointed to remain focused on the continental United States.

CD Radio's proposal to use three non-geostationary satellites instead of two geostationary satellites will not adversely affect coordination with Mexico for the same reason as noted above for Canada. Also, when any of CD Radio's three non-geostationary satellites are descending below the equator, CD Radio will temporarily cease radio transmissions from the satellite. As a result, the inclined and elliptical orbit of the satellites will not increase harmful

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[9] *Agreement Concerning the Coordination between U.S. Satellite Digital Audio Radio Service and Canadian Fixed Service and Mobile Aeronautical Telemetry Service in the band 2320-2345 MHz*, <http://www.fcc.gov/ib/pnd/agree/darsagr4.pdf> at 2, (Sept. 1, 1998); *see also* FCC News Release, *The United States and Canada Agree on Conditions for Implementation of U.S. Satellite Digital Audio Radio Services (DARS) and Canadian Terrestrial Digital Radio Broadcast Services (T-DRB) Along the U.S./Canada Border Area*, Report No. IN 98-50 (Sept. 3, 1998).

interference to countries to the south of the United States, including Mexico. Overall, adjacent countries will experience no greater interference from CD Radio's operation of three non-geostationary satellites than would be expected from two geostationary satellites.

No Interference From Use of 6/4 GHz for TT&C. CD Radio's additional use of the 6/4 GHz frequency band for on-orbit TT&C will be on a non-interference basis to operators of geostationary satellites at the equator crossings used by CD Radio's non-geostationary satellites. The 6/4 GHz frequency band is allocated to fixed satellite service. Under ITU Radio Regulations, non-geostationary satellites such as those proposed herein may not cause interference to geostationary satellites operating in-band. CD Radio agrees that its proposed use of the 6/4 GHz band for TT&C will be secondary to use of that band by fixed satellite service providers. Further, CD Radio agrees to accept any interference from fixed satellite services provided in the 6/4 GHz band.

CD Radio can and will operate the non-geostationary satellites' on-orbit TT&C on a non-interfering basis. First, CD Radio's TT&C link has a low data requirement in normal operation. Second, only transmissions near the equator could interfere with geostationary fixed systems. To ensure operation of its satellites on a non-interfering basis, CD Radio will either stop transmitting when the non-geostationary satellites operate near the equator or will fully coordinate with the potentially effected geostationary satellite operators. Thus, the Commission can be assured that CD Radio's use of the 6/4 GHz frequency band for its three non-geostationary satellites' on-orbit TT&C will not interfere with geostationary satellites' priority use of the same band.

No Other Interference Issues. CD Radio's operation of a satellite DARS system using three non-geostationary satellites also will not increase interference with the other satellite DARS

licensee, XM Satellite Radio. The two systems will continue to use separate frequencies, and CD Radio's satellites' new proposed orbits will leave adjacent channel interference unchanged.

C. Use of Three Non-Geostationary Satellites to Provide Satellite DARS Complies With All Other Technical Aspects of CD Radio's Authorization

The use of three non-geostationary satellites to provide satellite DARS complies with the remaining technical parameters of the original *CD Radio Authorization*. For example, CD Radio affirms that its modified system will comply with the Commission's licensing provisions for satellite DARS under Section 25.144 of the Commission's rules. CD Radio's construction schedule will remain consistent – indeed, far more rapid – than the milestone schedule established in Section 25.144(b) of the Commission's rules and adopted in its existing authorization. That milestone schedule requires CD Radio to place a satellite DARS system into full operation by October 2003. In fact, CD Radio anticipates implementing high-quality nationwide service in early 2000.

Moreover, CD Radio verifies that its proposed system will comply with the technical qualifications established for satellite DARS in Section 25.144 of the Commission's rules. The three non-geostationary satellites will fulfill CD Radio's obligation to service the full CONUS[10] and will employ a variety of compression rates.[11] CD Radio's space stations will also comply, to the extent applicable, with the Commission's 2 degree spacing requirement for geostationary satellites in the fixed satellite service in that they will not cause any interference to spacecraft two or more degrees away from CD Radio's equator crossing points.

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[10] 47 C.F.R. § 25.144(a)(3)(i).

[11] 47 C.F.R. § 25.144(a)(3)(iii).

CD Radio intends to utilize the 7060.0-7072.5 MHz frequency band for its feeder links, which, as the Commission noted in the *Satellite DARS Order*, is only lightly used, if at all, by the fixed satellite service.[12] CD Radio does not anticipate significant potential for interference to result from its feeder link operations. CD Radio will file with the Commission a technical showing demonstrating acceptable interference as an attachment to any future application for authority to construct and operate a transmit/receive earth station for its satellite DARS system.

Finally, CD Radio's modified system will suppress out-of-band and spurious emissions to the levels specified in Section 25.202(f) of the Commission's rules.

III. CD RADIO'S SATELLITE SYSTEM ENHANCEMENTS WILL SERVE THE PUBLIC INTEREST BY PROVIDING IMPROVED SERVICE, ADDITIONAL CHANNELS AND FEWER TERRESTRIAL REPEATERS

The satellite system enhancements requested in this application will enable CD Radio to offer consumers a premium quality satellite DARS service. Grant of CD Radio's application will provide the public with a satellite DARS service that offers superior coverage coast-to-coast, relies on fewer terrestrial repeaters and offers more channels within the existing spectrum allocation.

Improved Service. CD Radio will improve the quality of its nationwide satellite DARS service by introducing a third satellite and operating all three satellites in inclined and elliptical orbits. The higher elevation angles guaranteed by CD Radio's operation of three non-geostationary satellites will ensure better satellite DARS transmission in difficult signal

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[12] *Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, 12 F.C.C. Rcd 5754, 5808 (1997) (Report and Order) ("*Satellite DARS Order*").

conditions, avoid blockages from buildings and terrain, and significantly improve signal strength through trees and foliage. Overall, the system enhancements will result in a more reliable coast-to-coast service with superior quality audio programming, particularly in the northern United States.

More Channels. As a result of the high service quality offered by the three non-geostationary satellites, CD Radio will offer more channels in its existing spectrum allocation. Additional channel capacity will be available because the higher elevation angles obtained by three satellites in elliptical and inclined orbits will permit CD Radio to use a smaller percentage of available satellite power to compensate for reduced power, fading and shadowing suffered by beams that travel through the atmosphere or foliage at low elevation angles. CD Radio will also employ more efficient channel coding to increase the number of available channels. These modifications will permit CD Radio to provide greater programming diversity and valuable niche programming that currently is not commercially available. Children, Spanish speaking populations, and people with special interests, such as drama, literature, and classic and ethnic music, will benefit from CD Radio's proposed system enhancements.

Fewer Terrestrial Repeaters. Three satellites in non-geostationary orbits will also require fewer terrestrial repeaters, evidencing CD Radio's dedication to a satellite-based system. As currently authorized, the geostationary satellites' lower elevation angles in the northern portion of the continental United States will require CD Radio to employ more terrestrial repeaters to ensure continuous coverage, particularly in mountainous and urban areas of the continental United States. Two geostationary satellites located at 80° W. Longitude and 110° W. Longitude would serve the northern portion of the continental United States at a 30 degree average elevation angle. Under CD Radio's improved system, on average one of its three non-geostationary

satellites will be near the peak of its orbit and thus will be available to serve the northern continental United States at an elevation angle of at least 60 degrees. This improved elevation angle will result from the figure eight pattern of each satellite in an inclined and elliptical geosynchronous orbit. These higher elevation angles will reduce blockage zones and will increase satellite coverage. Thus, fewer terrestrial repeaters will be necessary to serve mountainous and urban areas, especially in the northern continental United States.

These public interest benefits strongly support the Commission's grant of CD Radio's requested system enhancements.

IV. CONCLUSION

CD Radio respectfully requests modification of certain technical parameters of its existing space station authority to provide satellite DARS. As described, operation of three satellites in inclined and elliptical orbits will serve the public interest better than two geostationary satellites without raising any additional technical concerns. Accordingly, the Commission should grant CD Radio's application.

Respectfully submitted,

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Dated: December 11, 1998

APPENDIX A

Section 25. 114(c) Information

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25.114(c)(3). CD Radio seeks a modification of its existing authorization to launch and operate a satellite DARS service. Specifically, CD Radio seeks to operate three non-geostationary, rather than two geostationary, space stations in inclined and elliptical orbits and to use 6/4 GHz for on-orbit telemetry, tracking and command on a non-interference basis.

25.114(c)(4). The modifications requested by this application will improve the overall system's provision of satellite DARS conforming to the FCC's *Satellite DARS Order* and CD Radio's existing authorization. The system will continue to provide audio (e.g., music and voice) and limited auxiliary services (e.g., paging, emergency data, aircraft weather advisories, etc.) directly from satellite to users, particularly those in mobile platforms throughout the continental United States. The system will still consist of multiple direct transponding satellites fed by up-link earth stations whose license applications will be filed after radio frequency

coordination is completed. Additionally, telemetry, tracking and command facilities will be located in South America so that the complete inclined and elliptical orbit is covered in a redundant manner. Terrestrial repeaters will also be placed in the cores of large urban cities in the continental United States.

The modification requested by this application improves the system's overall operation by increasing the number of satellites from two to three, and placing them in a non-geostationary constellation. Each satellite will be placed in an elliptical orbit inclined 63.4 degrees relative to the equator. Each orbit will be geosynchronous with a nominal 24-hour period. The three orbit planes will be spaced evenly (120 degree increments) about the earth resulting in an 8 hour orbital position separation. In this orbit, each satellite will spend approximately 16 hours each day in active service with a ground track location north of the equator. The remaining 8 hours each day will be spent in a ground track location south of the equator with the payload in a standby mode and with no up-link transmission to the satellite. Two satellites will be in active service, transmitting to the 48 contiguous United States coverage area at any time. This orbital constellation will improve elevation angles to the mobile ground receivers, which will minimize multipath fading, line of sight obstruction effects and foliage attenuation, particularly in the northern third of the continental United States.

The orbital elements of the satellite constellation are summarized below in Table 1. Table 2 provides a summary of the spacecraft characteristics.

Table 1

	Satellite 1	Satellite 2	Satellite 3
Perigee Altitude	24469 km	24469 km	24469 km
Apogee Altitude	47102 km	47102 km	47102 km
Eccentricity	0.2684	0.2684	0.2684
Inclination	63.4 °	63.4 °	63.4 °
Argument of Perigee	270 °	270 °	270 °
RAAN	X	X + 120 °	X + 240 °

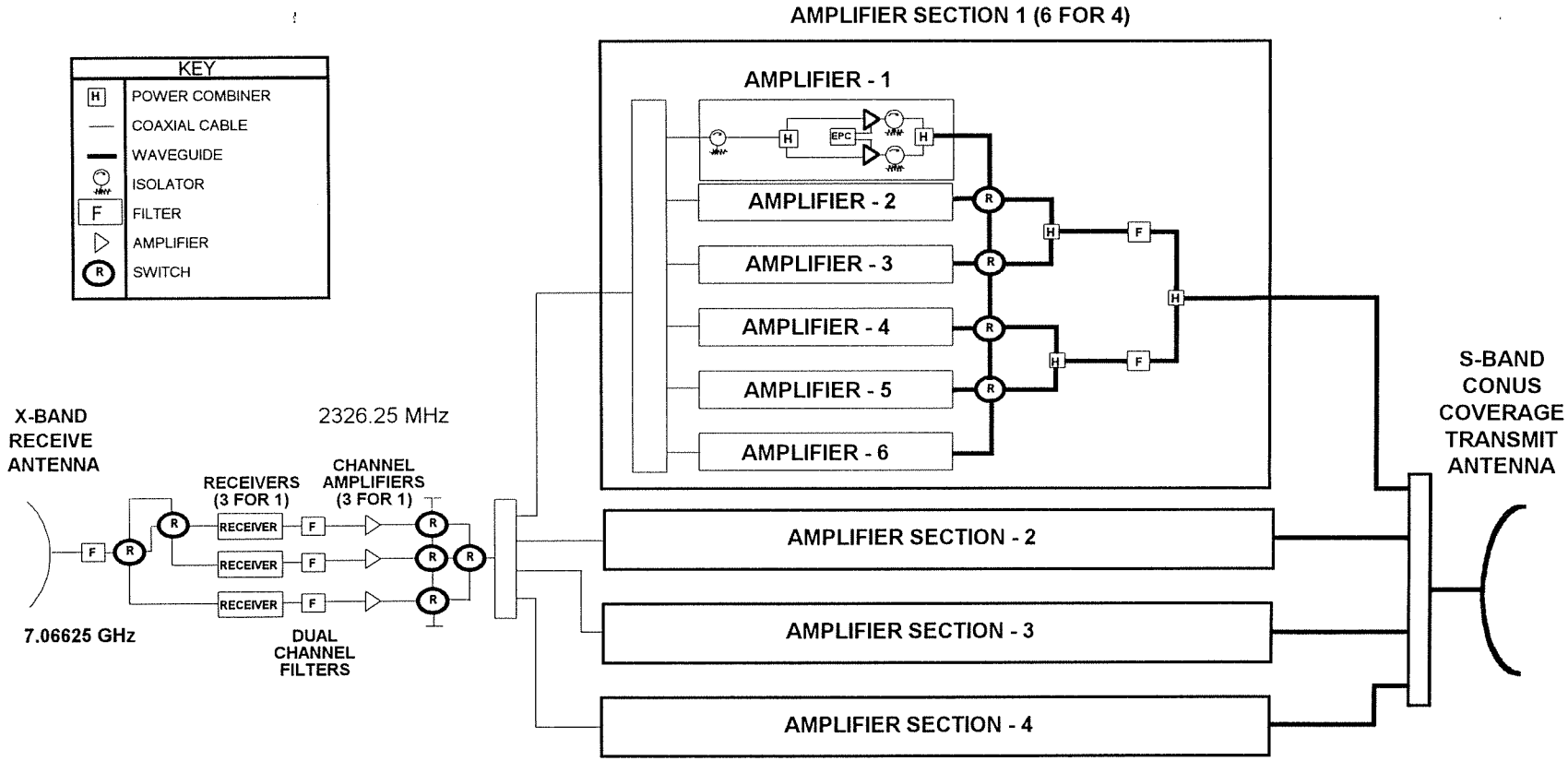
Mean anomaly and Right Ascension of Ascending Node (RAAN) will be chosen for each satellite to provide the desired apogee longitude and are time of launch dependent. Some small modifications of orbital parameters may be made to optimize service coverage further.

Table 2: Spacecraft Characteristics Summary

Parameter	Characteristics
General	
Mission life	15 years
Stabilization	3-axis
Eclipse capability	100%
Antenna pointing	±0.2° rms
Launch vehicle	Compatible with Proton, Atlas III and Sea Launch
Communications	
Frequency band	S-band 2320.0 - 2332.5 MHz
Antenna coverage	48 contiguous states (CONUS)
Polarization	Left Hand Circular (LHCP)
Number of transponders	One
Authorized bandwidth	12.5 MHz
Transmitter RF power	3840 W (32 combined TWTAs)
Receiver redundancy	3:1
TWTA redundancy	Four 6:4 groups of combined TWTAs
Tracking, Telemetry, and Command (TT&C)	
On-station frequency	C-band
Transfer orbit & contingency	C-band

Figure 1 shows the satellites' communications block diagram. All three satellites are identical in terms of communications frequencies and polarizations.[13] The ground track of the constellation is shown in Figure 2 and a view of the constellation from space is shown in Figure 3. Figure 4 shows the block diagram of the spacecraft telemetry, command and ranging subsystem.

[13] CD Radio does not at this time intend to employ cross polarization within its frequency assignment. CD Radio has not yet entered into an agreement with the other satellite DARS licensee with respect to the use of its frequencies for cross-polarized transmissions. *See* 47 C.F.R. § 25.214(c)(4). If CD Radio employs cross polarization within its band or enters into such an agreement in the future, it will inform the Commission.



CD RADIO TRANSPONDER BLOCK DIAGRAM

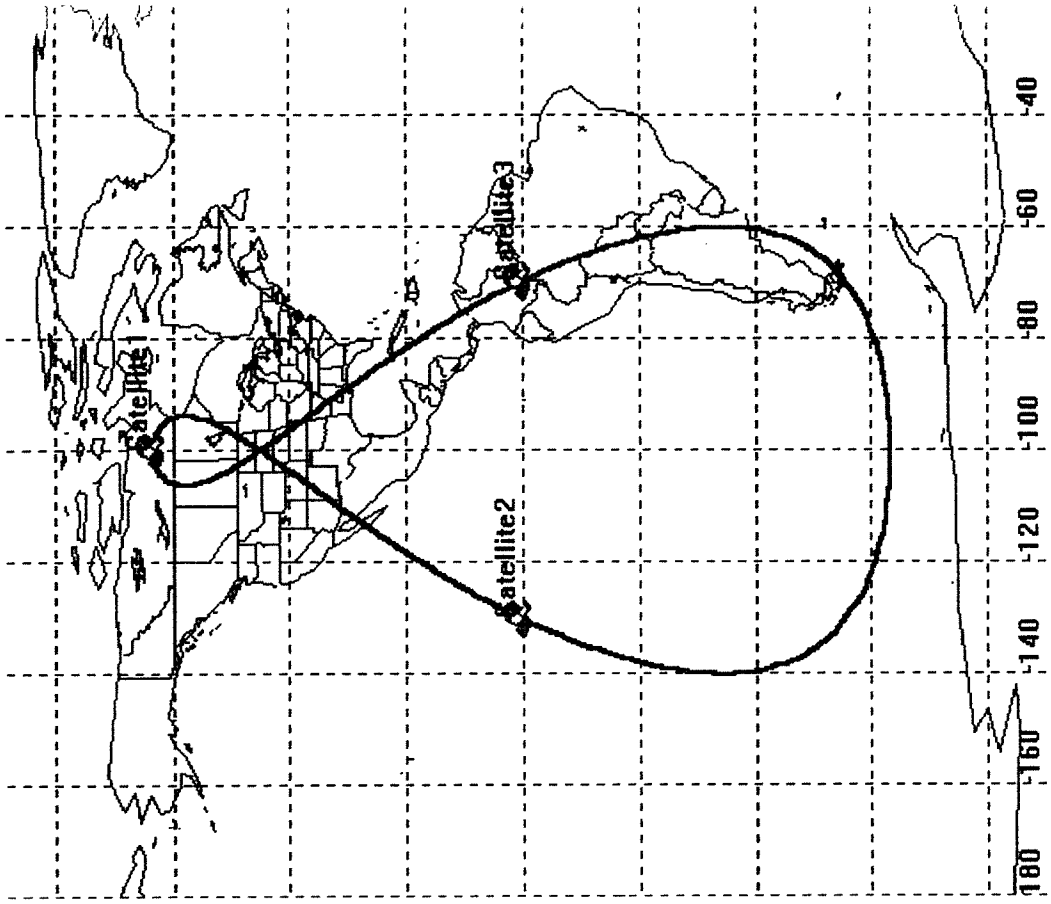

Satellite1
Satellite2
Satellite3
40
60
80
100
120
140
160
180

Figure 2

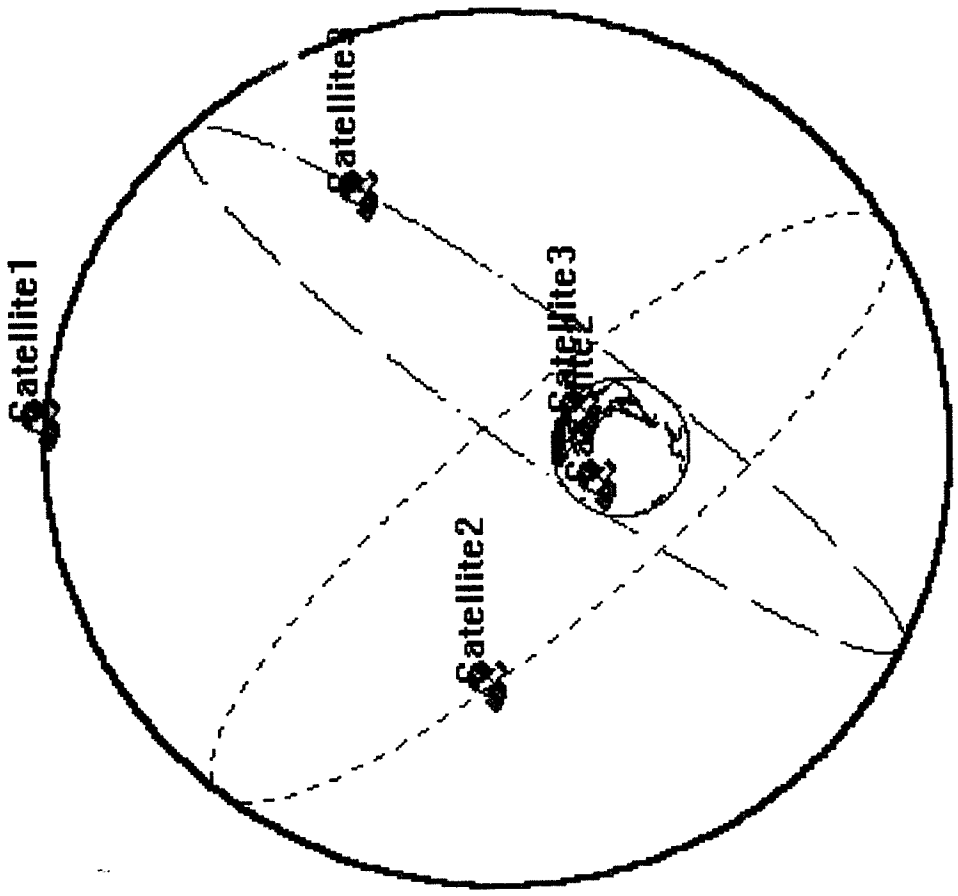
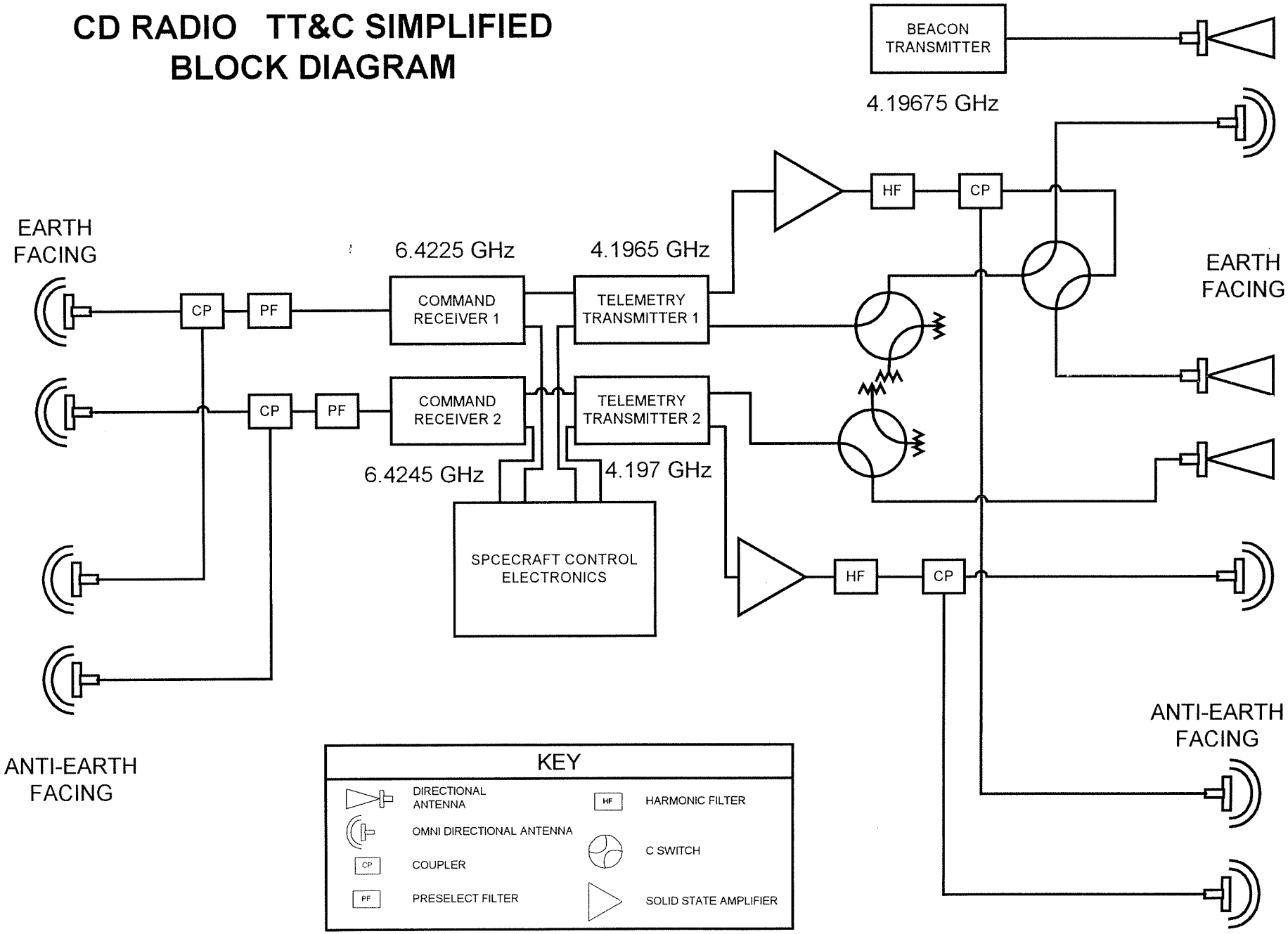


Figure 3

Figure 4

CD RADIO TT&C SIMPLIFIED BLOCK DIAGRAM



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25.114(c)(5).

Satellite Down-links

Payload

Frequency Band:	2320.0-2332.5 MHz
Frequency Center:	2322.1 MHz (Channel 1)[14]
	2330.4 MHz (Channel 2)[14]

Audio Broadcast Transmissions

Emission Designator:	4M20G7E
Allocated Bandwidth:	4.2 MHz
Polarization:	Left-hand Circular
Final Amplifier Power	
Output:	36.0 dBW
Net Loss to Antenna:	1.0 dB
Number of Antenna Beams:	One
Maximum Beam EIRP:	67.3 dBW

Telemetry/Ranging Transmissions

On Orbit (Directional Antennas)

Frequency Band	4196.375 - 4197.125 MHz
Center Frequencies:	4196.5 MHz - TLM1
	4197.0 MHz - TLM2
	4196.75 MHz - Beacon
Emission Designators:	250 KG9D (TLM1 & TLM2)
	100 KNON (Beacon)
Allocated Bandwidth:	750 KHz
Polarization:	Right-hand Circular
Final Amplifier Power	
Output:	-4.0 dBW
Net Loss to Antenna:	0.5 dB
Number of Antenna Beams:	Two (1 for TLM, 1 for Beacon)
Maximum Beam EIRP:	10.5 dBW[15]

Transfer Orbit & Contingency (Omni Directional Antennas)

Frequency Band:	4196.4 - 4197.1 MHz
Center Frequency:	4196.5 MHz TLM1
	4197.0 MHz TLM2
Emission Designator:	200KG9D
Allocated Bandwidth	750 KHz
Polarization:	Right-hand Circular

[14] One channel active at any one time.

[15] Maximum at peak of beam.

Final Amplifier Power

Output:	13 dBW
Net Loss to Antenna:	1.55 dB
Number of Antenna Beams:	2
Maximum Beam EIRP:	14.45 dBW[15]

Satellite Up-links:

Payload

Frequency Band:	7060.0-7072.5 MHz
Frequency Center:	7062.1 MHz (Channel 1)[14]
	7070.4 MHz (Channel 2)[14]
Emission Designator:	4M20G7E
Allocated Bandwidth:	12.5 MHz
Polarization:	Right-hand Circular

Command Reception

Frequency Band:	6422 - 6425 MHz
Frequency Center:	6422.5 MHz (CMD1)
	6424.5 MHz (CMD2)
Emission Designator:	900KF9D
Allocated Bandwidth:	3 MHz
Polarization:	Left-hand Circular

Beam/Transponder Configurations:

Single beam up-link directly connected to single frequency translating transponder whose output feeds a single beam down-link.

Receiving System Noise Temperature:

Payload = 27.0 dBK

Command = 28.0 dBK

Relationship Between Satellite Receive Antenna Pattern, Gain-To-Temperature Ratio (G/T) and Saturation Flux Density (SFD) for the Single Receive Antenna Beam:

The satellite receive antenna gain is equal to the predicted space station antenna directivity contours of Figures 5 and 6 minus 2.6 dB antenna and input section losses.

The satellite G/T is equal to the gain indicated on the predicted space station antenna gain contour minus 27.0 dBK total system temperature.

The satellite nominal SFD is equal to the gain indicated on the predicted space station antenna gain contour minus 68.9 dBW/m^2. Automatic Gain Control (AGC) can maintain an SFD in the range from a value equal to the gain indicated on the predicted space station antenna gain contour minus 58.9 dBW/m^2 to a value equal to the gain indicated on the predicted space station antenna gain contour minus 78.9 dBW/m2.

The gain on the single transponder channel between the output of the receiving antenna and the input of the transmitting antenna is nominally 128 dB. This gain can be adjusted by telecommand in 2 dB steps from 118 dB to 138 dB.

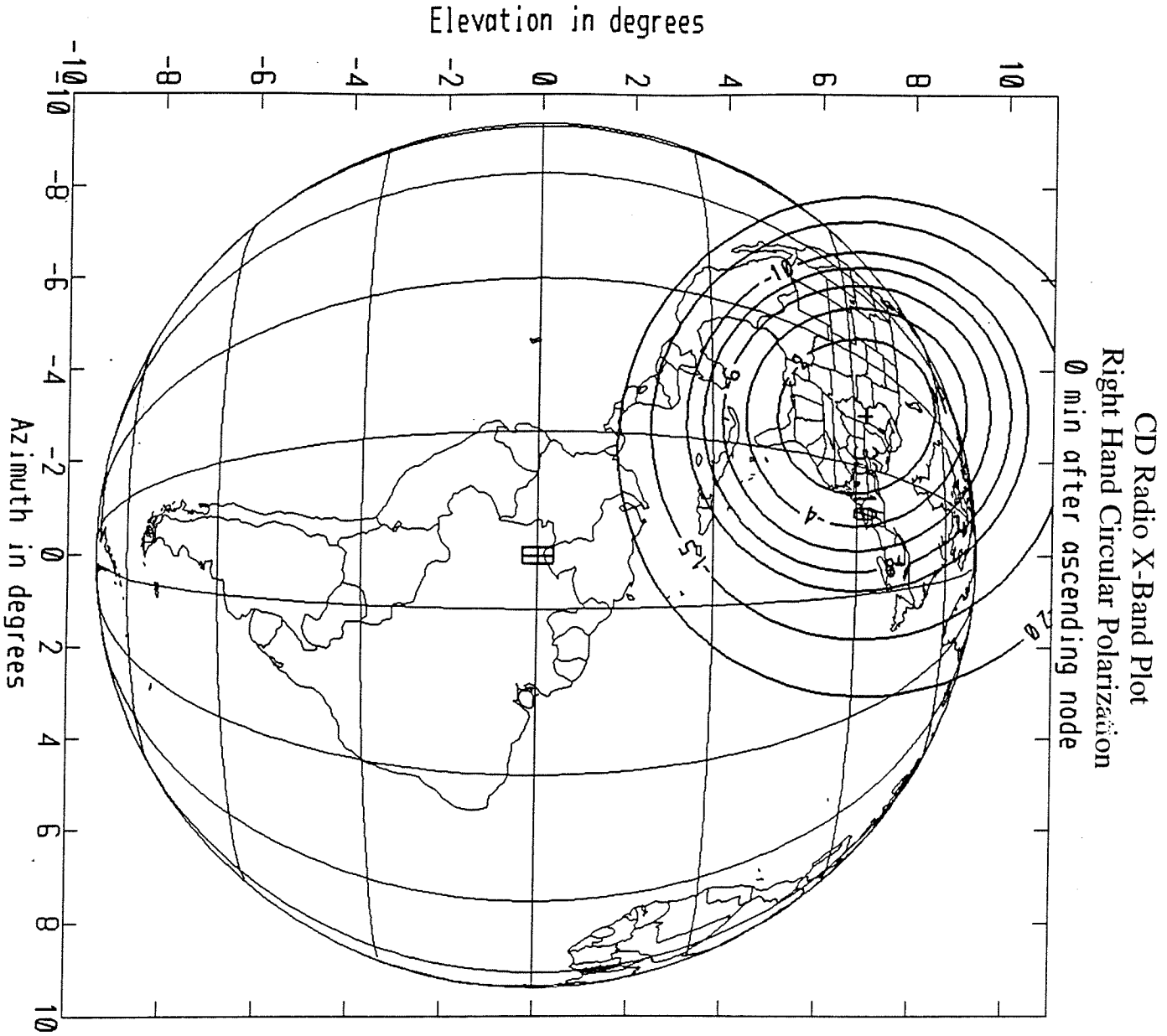
CD Radio X-Band Plot
Right Hand Circular Polarization
0 min after ascending node
Elevation in degrees
Azimuth in degrees
-10
-8
-6
-4
-2
0
2
4
6
8
10
-10
-8
-6
-4
-2
0
2
4
6
8
10

Figure 5

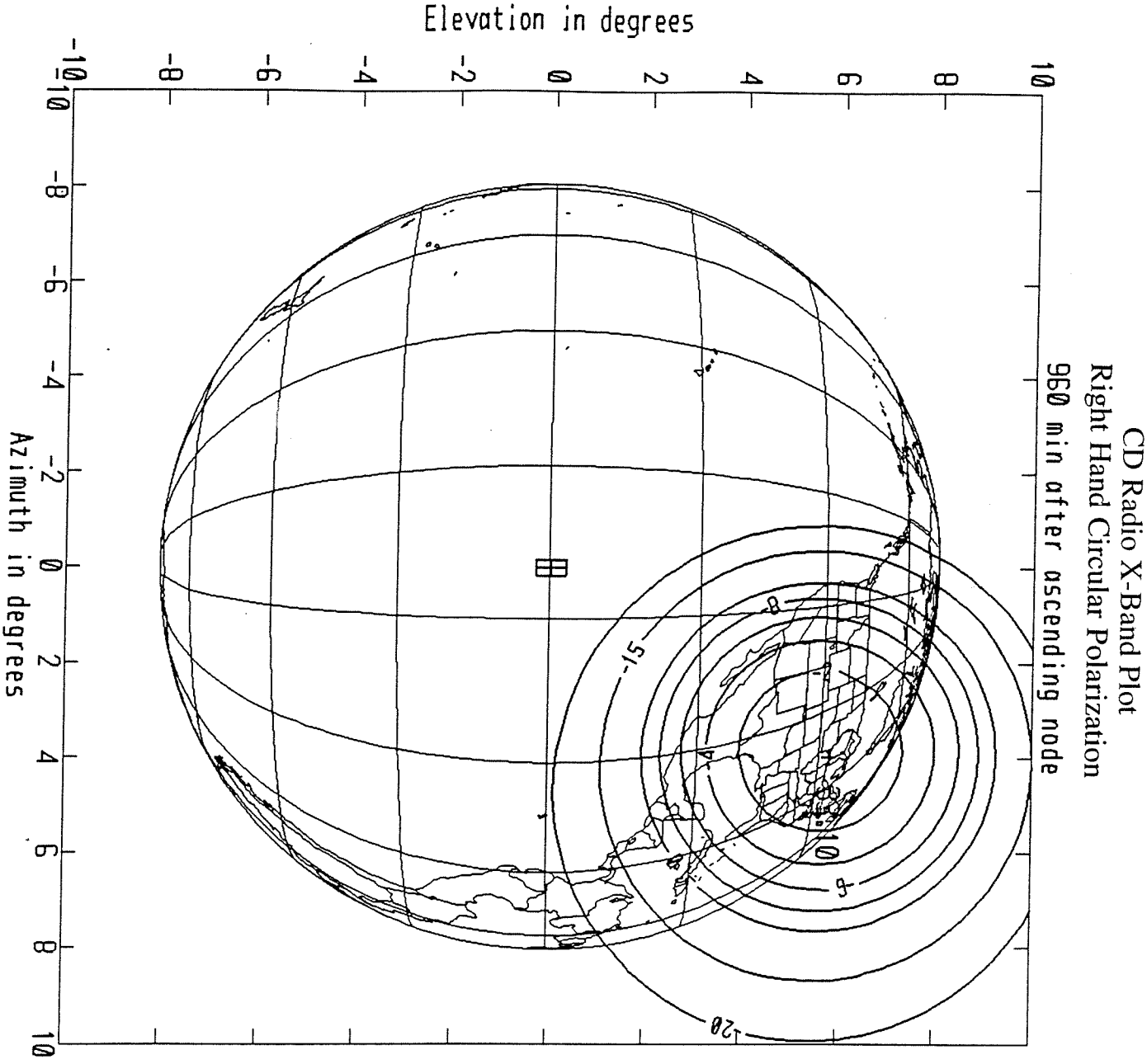
CD Radio X-Band Plot
Right Hand Circular Polarization
960 min after ascending node
Elevation in degrees
Azimuth in degrees
-10
-8
-6
-4
-2
0
2
4
6
8
10
-15
-8
-4
-10
-20

Figure 6

Engineering Model X-Band Receiver Preselect Filter Response Characteristics:

See Figure 7. The Quadrature Phase Shift Keyed (QPSK) final transmission modulation is filtered at the up-link earth station to meet emission requirements after its re-transmission through the satellite.

Engineering Model Channel Filter Response Characteristics:

See Figures 8-A and 8-B for the response of the two channel filters.

Engineering Model S-Band Transmitter Filter Response Characteristics:

See Figure 9.

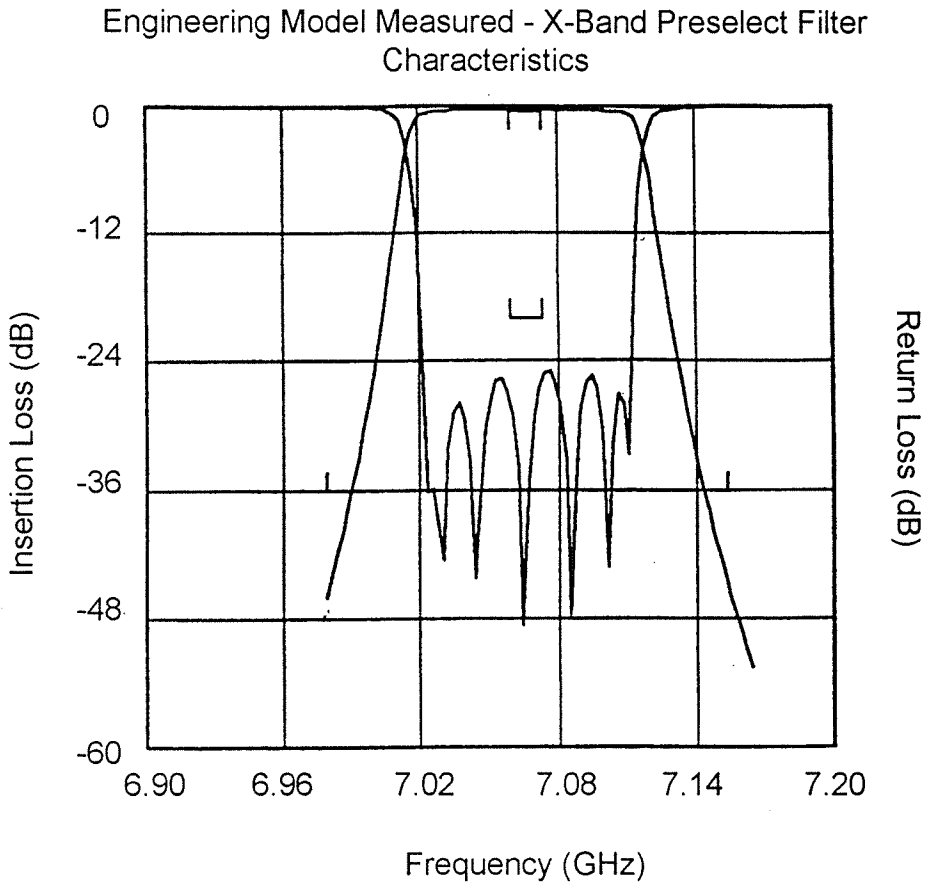
Engineering Model Measured - X-Band Preselect Filter Characteristics
0
-12
-24
-36
-48
-60
Insertion Loss (dB)
Return Loss (dB)
6.90
6.96
7.02
7.08
7.14
7.20
Frequency (GHz)

Figure 7

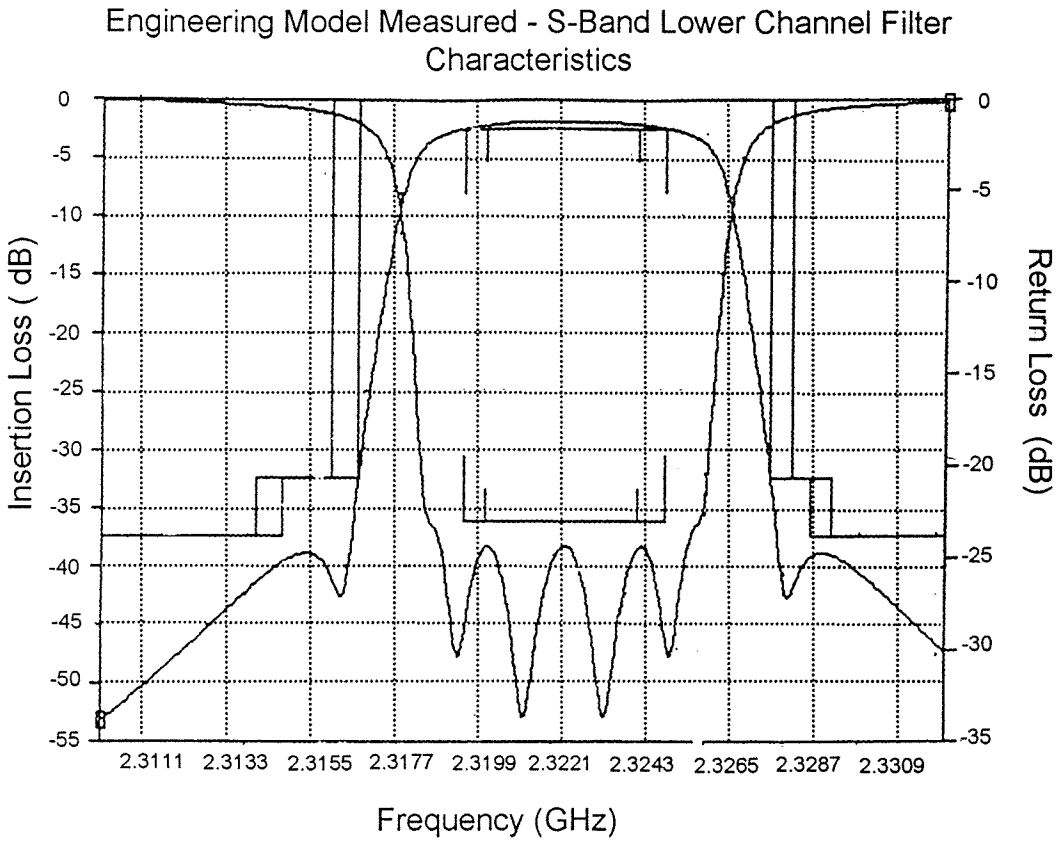
Engineering Model Measured - S-Band Lower Channel Filter Characteristics
Insertion Loss (dB)
Return Loss (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
2.3111
2.3133
2.3155
2.3177
2.3199
2.3221
2.3243
2.3265
2.3287
2.3309
Frequency (GHz)

Figure 8-A

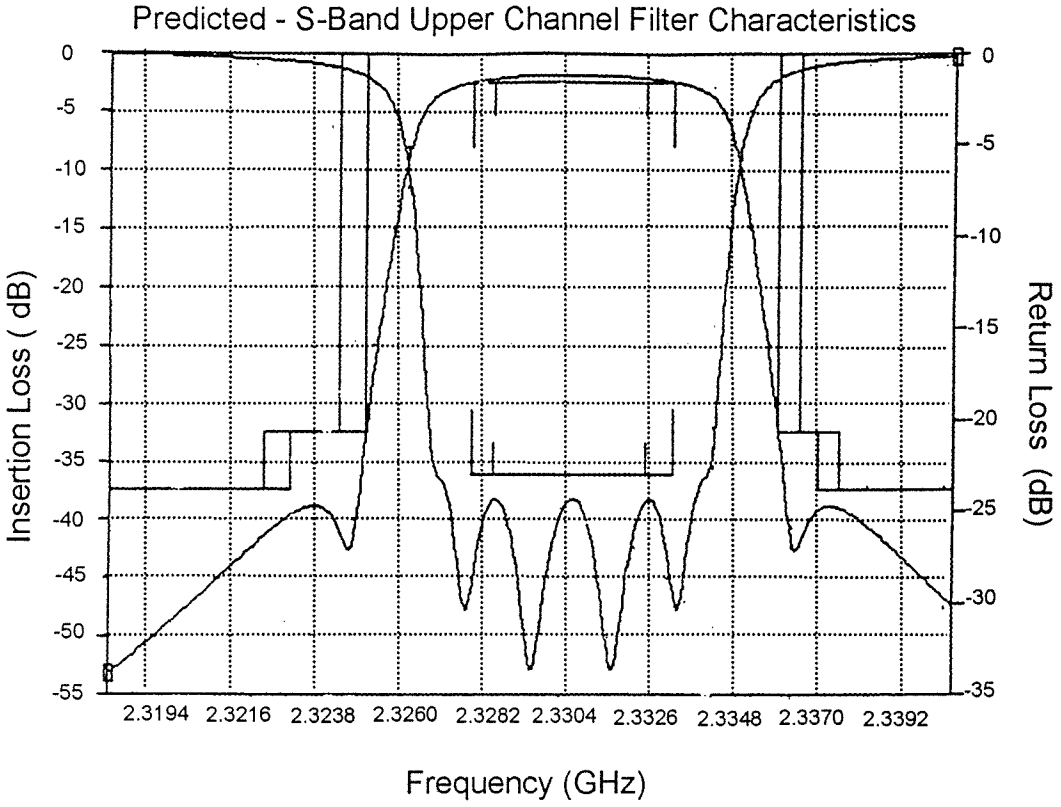
Predicted - S-Band Upper Channel Filter Characteristics
Insertion Loss (dB)
Return Loss (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
2.3194
2.3216
2.3238
2.3260
2.3282
2.3304
2.3326
2.3348
2.3370
2.3392
Frequency (GHz)

Figure 8-B

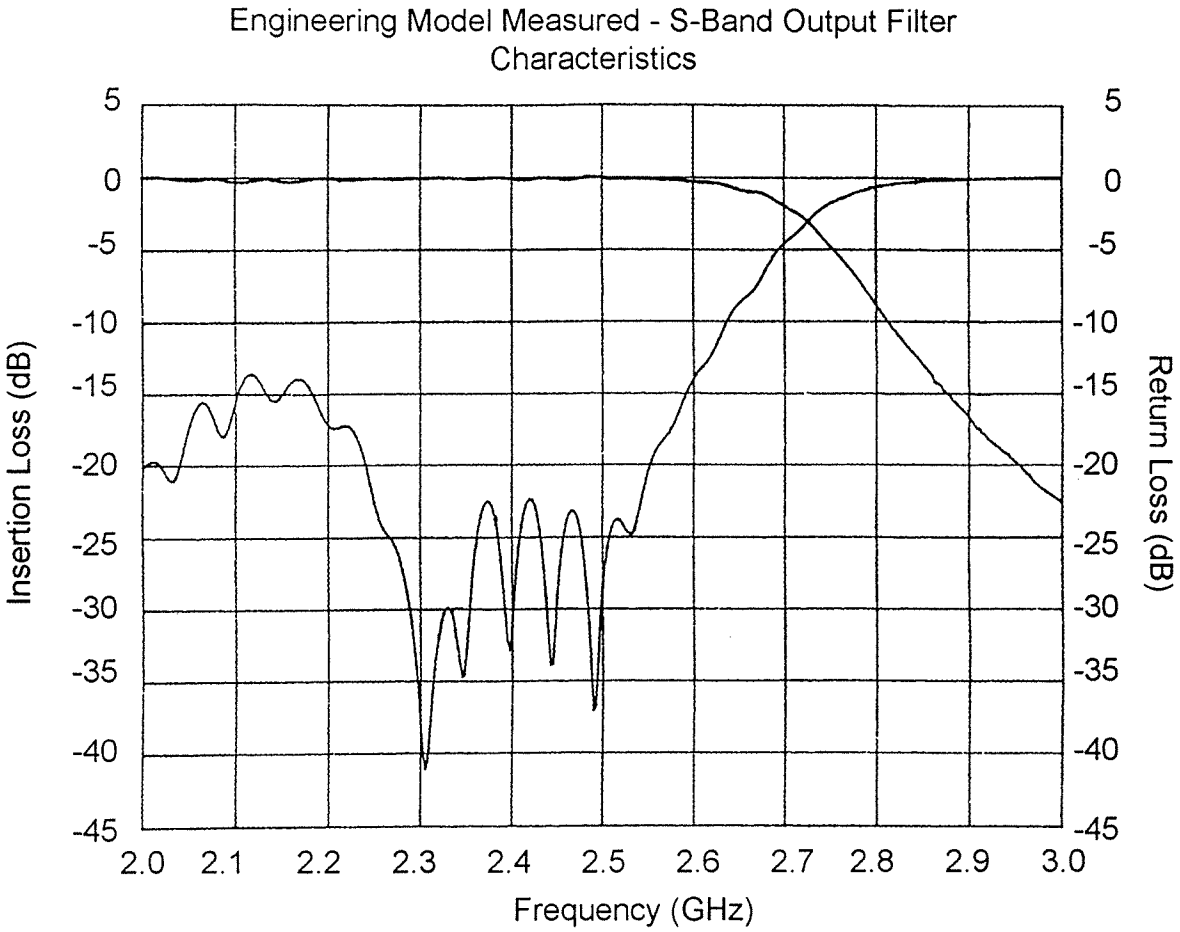
Engineering Model Measured - S-Band Output Filter Characteristics
Insertion Loss (dB)
Return Loss (dB)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
Frequency (GHz)

Figure 9

25.114(c)(6). The three satellites will be placed in an inclined, elliptical geosynchronous constellation with planes separated by 120°. See Table 1 for orbital parameter values. As shown in Figure 2, the ascending node is at approximately 66° W. Longitude and the descending node will be at approximately 127° W. Longitude.

25.114(c)(7). The predicted space station receive antenna directivity contours for a satellite at the ascending node is shown in Figure 5 and for a satellite at the descending node is shown in Figure 6. The directivity contours of the transmit antenna for the ascending node satellite is shown in Figure 10 and for the descending node satellite is shown in Figure 11. Polarizations are given in the foregoing paragraph 25.114(c)(5).

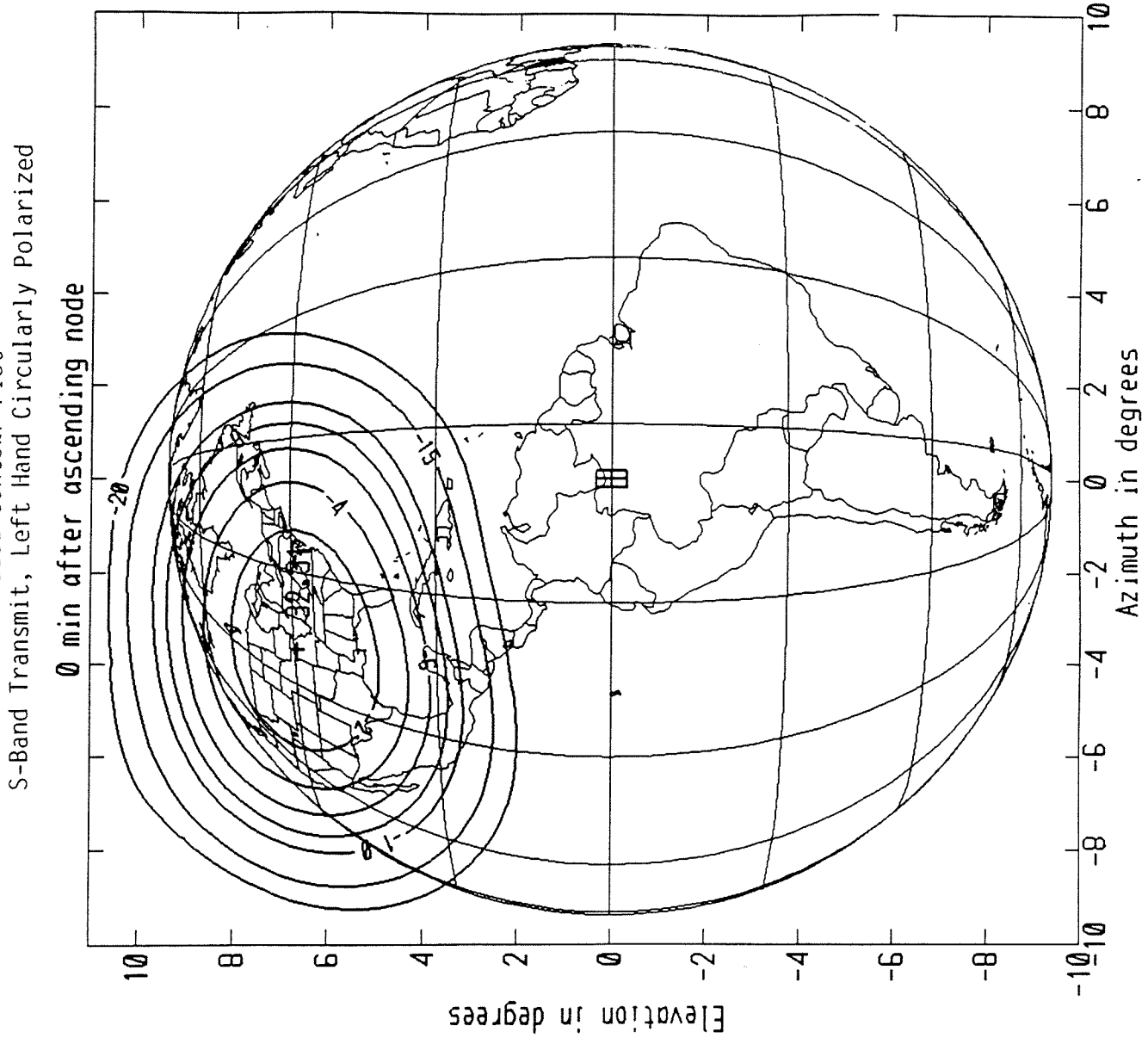
CD Radio Contour Plot
S-Band Transmit, Left Hand Circularly Polarized
0 min after ascending node
-20
-15
-10
-4
-1
0
Elevation in degrees
Azimuth in degrees
10
8
6
4
2
0
-2
-4
-6
-8
-10

Figure 10

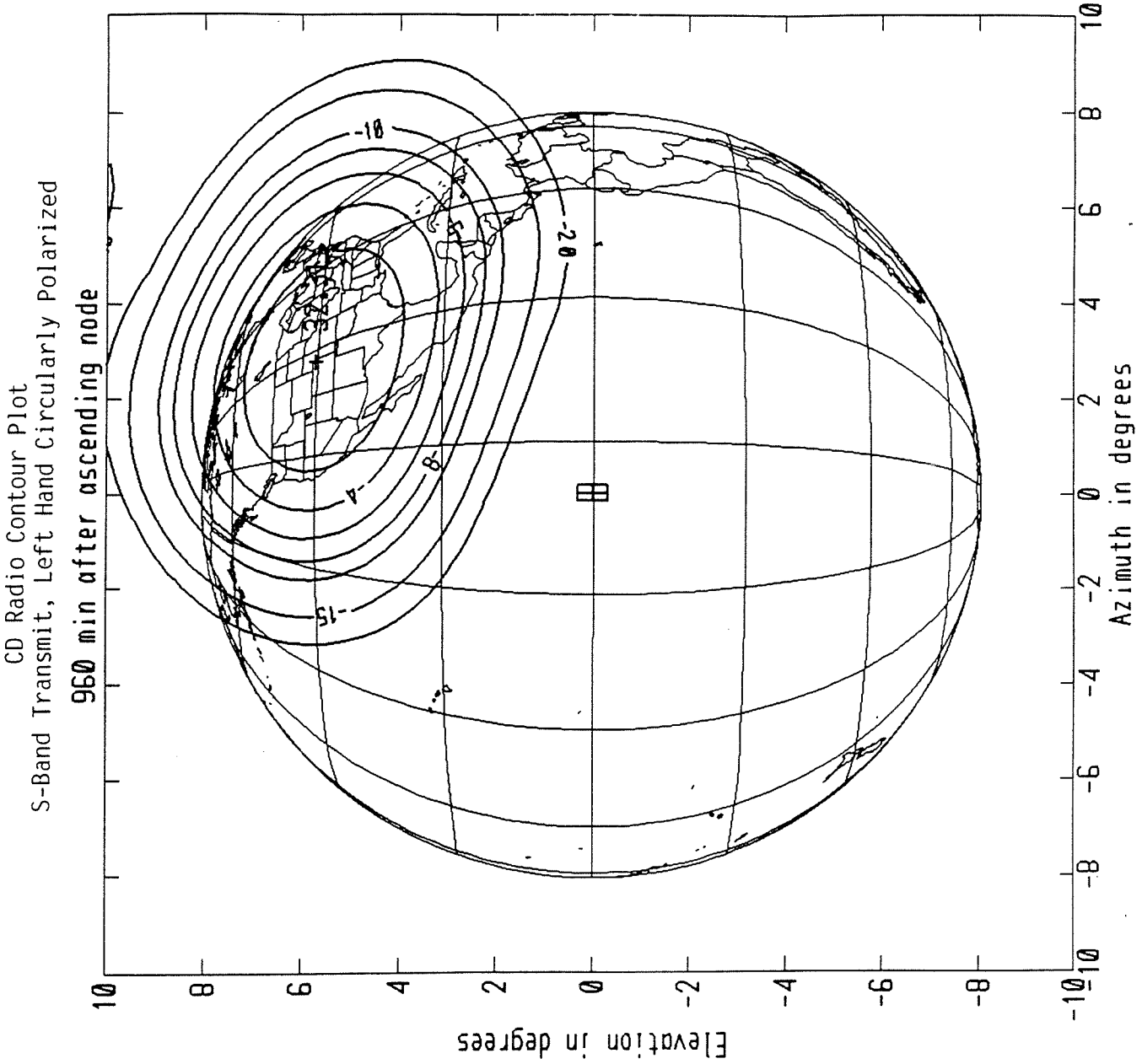
CD Radio Contour Plot
S-Band Transmit, Left Hand Circularly Polarized
960 min after ascending node
-10
-20
-15
-8
-4
Elevation in degrees
Azimuth in degrees
10
8
6
4
2
0
-2
-4
-6
-8
-10

Figure 11

25.114(c)(8). A broad range of broadcast services will be provided to fixed and mobile users throughout the 48 contiguous United States. The predominant service will be digital quality stereo music and 50 such channels will be provided. These will be compressed from the 1.44 Mb/s CD output to 64 kb/s rate by a Perceptual Audio Coding (PAC) algorithm developed by Lucent Technologies. The 64 kb/s rate information streams will be convolutionally encoded with two-third rate k=9 error coding, interleaved, divided into blocks and block error encoded with a 10% depth Reed-Solomon code (128, 120). Another 50 voice channels will also be provided. They will be compressed and encoded similarly to the music channels, except that the compressed information rate will be 24 kb/s.

CD Radio will use time division multiplexing (TDM) for its spacecraft-to-earth down-link. Each satellite's data stream will occupy approximately 4.2 MHz and will have an information rate of 4.4 Mb/s. Final radio frequency modulation will be Quadrature Phase Shift Keyed (QPSK).

Pursuant to the *Satellite DARS Order*, CD Radio is planning to offer some additional services. One of these is a channel to perform operations associated with its subscription service such as turning on and off mobile radios and displaying operational information to customers. The information rate will be low and encryption will be employed. Flexibility on some channels will be maintained to sub-divide them further (i.e., 16 kb/s, 8 kb/s, 4 kb/s, 2 kb/s, 1 kb/s and 0.5 kb/s) for providing auxiliary services such as paging, light aircraft weather advisory, GPS differential data, national emergency alerting, etc. Compression of this type information, if such is provided, would be use specific. At least some of such auxiliary service information would be encoded LPC (linear predictive coding).

The CD Radio transmission system will use both satellite spatial diversity and time diversity (approximately 4 seconds) to avoid outages from blockage, multipath and tree foliage. The satellites will provide good elevation angles to mobile receivers in the contiguous United States and radiate high power transmissions as described earlier. It is still necessary in core urban areas and tunnels to provide service by terrestrial repeaters as noted in the previous paragraph (c)(4). The combination of the above techniques and facilities will result in high quality service continuity throughout the 48 continuous United States for outdoor locations. For indoor reception, an antenna unit on a southfacing window will be normally required.

Several types of customer receivers are to be implemented specifically for mobile, portable and fixed applications. For mobile application, versions of such receivers will be available as adapter units, as integrated after-market radios and, subsequently, as integrated radios delivered with new cars and other automotive vehicles. Receivers for recreational boats and light aircraft are also planned.

The receivers for mobile applications have a G/T of -19 dBK based on a minimum antenna gain of 3 dBi. Table 3 is the receiver's system noise budget. The normal version of the receiver has three demodulator channels, one for each satellite to achieve spatial diversity with one of these two channels containing a 4 second buffer used to achieve time diversity. Each satellite channel will be 4.2 MHz wide and spaced 8 MHz apart providing frequency diversity. The center 4.1 MHz of the frequency band will be used for the terrestrial repeaters. The terrestrial repeaters will use Coded Orthogonal Frequency Division Modulation (COFDM) for transmission modulation, which is similar to Eureka-147. The receivers for other applications will be almost electronically identical, except for a version in fixed applications which will have no diversity demodulator channels and will have a remote unit which will re-transmit the signal

received by the antenna unit to a differently located player unit in the home using an ISM frequency band.

Table 3: SDARS Receiver Noise Temperature

Antenna-Receiver Losses		7° K
Receiver Total Noise		65° K
Antenna Earth Pickup		86° K
	Total	158° K

The up-link earth station also includes the CD Radio programming center and the on-orbit TT&C facilities. Two stations will be built, one in the northeast and a second one subsequently in the west. The radio facilities of the up-link station will be comprised of four 4.5 meter diameter antennas and 200 watt 7 GHz transmitters. Full electronic and electrical redundancy are planned.

Regarding noise and interference sources, the 2320.0-2332.5 MHz radio frequency band has no other significant terrestrial users in the United States. Canada uses the band for terrestrial radio relay and some aeronautical telemetry and Mexico for terrestrial radio relay as well documented elsewhere by the FCC. The United States has already concluded a coordination agreement with Canada for the use of the band and CD Radio's provision of satellite DARS complies with the power flux density levels established in that agreement. Coordination with Mexico, including border situations with mobile receivers and with terrestrial repeaters, is currently being negotiated. The earth station switches up-link illumination and frequency between the ascending node satellite and the descending node satellite which occurs at 8 hour intervals. The satellite design is such that a non-illuminated satellite does not radiate significant S-band flux density (i.e., below -152 dBW/m^2/4 kHz.).

Interference between SDARS systems is also being coordinated with XM Satellite Radio. Adjacent band interference will be coordinated with applicable WCS operators recognizing that the FCC has set an out-of-band interference requirement on these operators. Noise sources such as microwave ovens and ISM out-of-band radiation have been analyzed and are tolerable. Some of these sources, which may be significant in urban core areas, including self-interference, are mitigated by properties of the terrestrial transmitter modulation which is COFDM.

The overall transmission link performance analysis is contained in Table 4.

Table 4: Transmission Link Performance

Satellite EIRP[16]	61.1 dBW
Single Channel EIRP[17]	-18.4 dB
Path Loss[18]	-193.7 dB
Mobile Receiver Antenna Gain[19]	+3.5 dB
Received Power	-147.5 dBW
Received Noise Power[20]	-158.5 dBW
Single Satellite S/N	11.0 dB
Required S/N[21]	5.0 dB
Single Satellite Power Margin[22]	6.0 dB
Diversity Gain[23]	12.0 dB
Effective Multipath Margin	18.0 dB

25.114(c)(8). Two-degree orbital spacing coordination, if applicable, will be accomplished through direct discussions with XM Satellite Radio, the other Region 2 S-band satellite DARS provider, once the precise frequencies and up-link locations are known.

Coordination of TT&C frequencies will be accomplished with the geostationary satellite operators at the equator longitude crossings previously noted over the short transit periods involved.

---

[16] Edge-of-coverage EIRP.

[17] Individual music channel (64 kb/s).

[18] Geosynchronous elliptic inclined orbit for 2326 MHz at apogee to mobile receiver with 35° elevation angle.

[19] Worst case orientation, including ohmic and polarization losses at 35° elevation angle.

[20] B_N = 64 kHz, T_S = 158°K (Table 3), up-link noise contribution is negligible (>26 dB S/N).

[21] Music decompression achieved by PAC decoder with $\geq 10^{-5}$ BER.

[22] Dual satellite reception with maximal ratio combiner S/N = 8.5 dB.

[23] Satellite spatial and time diversity provide at least 12 dB multipath mitigation as well as mitigation against blockage and foliage attenuation.

25.114(c)(9). Accuracy of maintaining longitudinal drift of the six daily geostationary equator longitude crossings will be maintained within ± 2.0°. The satellite's orbital inclination will be maintained within ±7.0° and the antenna axis attitude will be maintained within ±0.4° for pitch, ±0.4° for roll, and ±2.0° for yaw.

25.114(c)(10). The power flux density at the border of the coverage area, herein assumed as the -2 dB antenna gain contour, is -127.6 dBW/m^2/4 kHz using a bandwidth spreading factor of 30.2 dB and a spatial spreading factor of -162.7 dB. Beam shaping has been used to minimize appreciable power flux density over other countries, except for Mexico where potential interference will be handled by bilateral coordination and for Canada where coordination has been completed. The satellite power flux density at the antenna beam center is -125.6 dBW/m^2/4kHz.

25.114(c)(11). The satellite provider (Space Systems/Loral, Inc.) is responsible for launch and transfer orbit TT&C which will be accomplished through its own and leased facilities. The TT&C subsystem will operate at C-band via near-omnidirectional satellite antennas during launch, transfer orbit and on-orbit operations. The redundant command receivers and one telemetry transmitter will be permanently connected to the near-omnidirectional antennas. During normal on-orbit mode operation, one of the telemetry transmitters and the beacon transmitter will be connected to the telemetry directional antennas providing a higher gain coverage pattern towards the CD Radio TT&C ground stations near Quito, Ecuador and Lima, Peru. During normal on-orbit mode operation, both command receivers remain connected to the near-omnidirectional antennas.

The command up-link will be frequency modulated by a command subcarrier or by ranging tones. The nominal carrier deviation will be ±375 kHz peak. The demodulated

command subcarrier will be routed to redundant command processors. The ranging tones will be connected to the telemetry transmitter for retransmission to the TT&C ground stations.

The addressable command processors will decode and process the commands. Commands can be executed autonomously; or stored, verified by ground command, and executed by a subsequent command. Commands can also be time-tagged for autonomous execution at future times.

The telemetry data biphase will modulate a subcarrier. This subcarrier and/or ranging tones phase will modulate the telemetry transmitter.

25.114(c)(12). The physical characteristics of the space station will include a light-weight graphite-reinforced epoxy central cylinder and the surrounding equipment mounting panels that will form a cube of approximately 3 meters on a side. Solar panels will extend from the north and south faces and the transmit antenna reflector will be mounted on the west face. The receive antenna will be mounted on the earth face of the satellite. The structure also will provide a stable platform for preserving the alignment of critical elements of the spacecraft system such as earth sensors. The directional telemetry transmit antennas and one set of the near omnidirectional antennas will also be located on the earth face. The remaining set of telemetry antenna will be located on the anti-earth face.

The major heat dissipating systems, such as TWTAs, batteries, etc. will be located on the north and south equipment panels to radiate heat efficiently. The TWTAs will also employ direct radiating collectors. To provide maximum thermal efficiency, the outside of the north and south panels will be covered with optical solar reflectors (OSRs), and the panels contain heat pipes for spreading the heat over the total panel area.

This system design will fit comfortably within the constraints imposed by several launch

vehicles. The satellite will be compatible with the Proton, Atlas III and Sea Launch launch vehicles. Figure 12 is a view of the spacecraft, the dimensions of which will be 24.8 meters long, 5.6 meters wide and 5.2 meters tall. The first two satellites are scheduled for launch on a Proton and the third will be launched by one of the above launch vehicles.

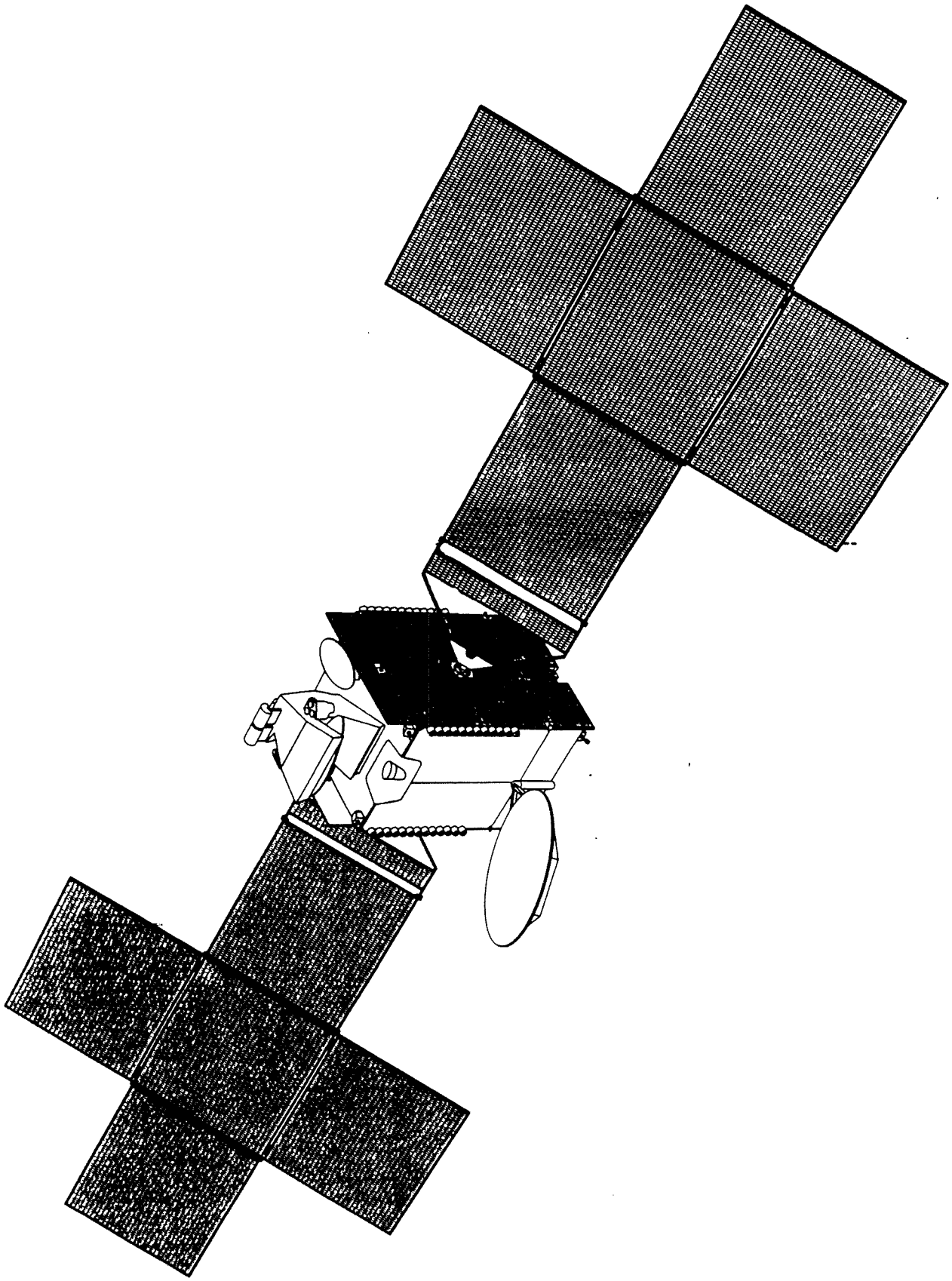

Figure 12

The spacecraft has an estimated operational lifetime of 15 years with a 15 year probability of survival of greater than 0.66. The lifetime and reliability estimates are based on the reliability performance estimates of production, space-qualified components used in the FS-1300 series satellites. The TWTA reliability estimates are based on space-qualified members of the same TWTA design family.

Table 5 is the mass budget reflecting on-ground and in-orbit mass in kilograms. Table 6 is the power budget showing beginning and end-of-life power in watts.

Table 5 - Mass Budget

Component	Mass (kg)
Payload	**285**
Bus and Electrical Power	**1332**
Margin	**82**
Subtotal: On-ground dry mass	**1700**
Propellant & Pressurant	**2220**
Subtotal: On-ground separation mass	**3920**
In Orbit beginning-of-life mass	**2734**
In Orbit end-of-life mass	**1734**

Table 6

SUMMARY	Winter Solstice Sun normal, no Eclipse	Summer Solstice Sun 14° off-normal no eclipse	Summer Solstice Sun normal, eclipse	Summer Soltice Sun 11° off-normal, eclipse
PAYLOAD @ SATURATION	6876	6876	6876	6876
PAYLOAD BACKOFF	0	0	-64	-208
SCE TOTAL	204	204	204	204
ADCS TOTAL	52	52	52	52
TC&R TOTAL	36	36	36	36
POWER TOTAL	234	234	234	234
PROPULSION TOTAL	5	5	5	5
THERMAL TOTAL	519	519	138	138
All SUBSYSTEMS TOTAL	7926	7926	7481	7337
Harness loss	40	40	37	37
Battery charging (High rate)	0	0	1219	1219
Battery charging (Trickle)	81	81	0	0
Battery harness	0	0	0	0
Low Voltage converter loss	46	46	46	46
Discharge converter loss	0	0	0	0
Charge converter loss	20	20	166	166
TOTAL POWER CONSUMPTION	8113	8113	8949	8805
ARRAY POWER AVAILABLE (15 yers.)	8735	8735	8977	8812
POWER MARGIN (15 yrs.)	62	622	28	7

25.114(c)(15). Construction of the satellites commenced last year and the first is scheduled for completion with delivery at the launch site in November 1999. Three launches are scheduled in the November 1999-March 2000 time period. Estimated date of placement into system operational service is March 2000.

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