UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, D.C. 20549

FORM 10-Q/A
(AMENDMENT NO. 1)

QUARTERLY REPORT PURSUANT TO SECTION 13 OR 15 (D) OF
THE SECURITIES EXCHANGE ACT OF 1934

For The Quarterly Period Ended June 30, 1998

Commission file number 0-24710

CD RADIO INC.

(Exact name of registrant as specified in its charter)

Delaware	52-1700207
(State or other jurisdiction of incorporation or organization)	(I.R.S. Employer Identification No.)

1180 Avenue of the Americas
New York, New York 10036

(Address of principal executive offices)
(Zip code)

212-899-5000

(Registrant's telephone number, including area code)

(Former name, former address and former fiscal year,
if changed since last report)

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days.

Yes [X] No [ ]

Indicate the number of shares outstanding of each of the issuer's classes of common stock, as of the latest practicable date.

Common Stock, $.001 par value	23,145,104 shares
(Class)	(Outstanding as of November 6, 1998)

CD RADIO INC.
(A Development Stage Enterprise)

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Part II

Other Information

Item 6. Exhibits and Reports on Form 8-K

(a) See the Exhibit Index for a list of exhibits filed herewith.

(b) The Company filed a Current Report on Form 8-K, dated May 28, 1998, describing the enhancement of its broadcast system as a result of the addition of a third in-orbit satellite.

SIGNATURES

Pursuant to the requirements of the Securities and Exchange Act of 1934, the registrant has duly caused this report to be signed on its behalf by the undersigned thereunto duly authorized.

CD RADIO INC.

By: /s/ John T. McClain

John T. McClain
Vice President and Controller
(Chief Accounting Officer)

November 18, 1998

EXHIBITS

Exhibit	Description
3.1	Amended and Restated Certificate of Incorporation (incorporated by reference to Exhibit 3.1 to the Company's Registration Statement on Form S-1 (File No. 33-74782) (the "S-1 Registration Statement")).
3.2	Amended and Restated By-Laws (incorporated by reference to Exhibit 3.2 to the S-1 Registration Statement).
3.3	Certificate of Designations of 5% Delayed Convertible Preferred Stock (incorporated by reference to Exhibit 10.24 to the Company's Form 10-K/A for the year ended December 31, 1996 (the "1996 Form 10-K")).
3.4	Form of Certificate of Designations of Series B Preferred Stock (incorporated by reference to Exhibit A to Exhibit 1 to the Company's Registration Statement on Form 8-A, filed with the Commission on October 30, 1997 (the "Form 8-A")).
3.5.1	Certificate of Designations, Preferences and Relative, Participating, Optional and Other Special Rights of 10 1/2% Series C Convertible Preferred Stock (the "Series C Certificate of Designations") (incorporated by reference to Exhibit 4.1 to the Company's Registration Statement on Form S-4 (File No. 333-34761) (the "S-4 Registration Statement")).
3.5.2	Certificate of Correction of the Series C Certificate of Designations (incorporated by reference to Exhibit 3.5.2 to the Company's Annual Report on Form 10-K for the year ended December 31, 1997 (the "1997 Form 10-K")).
3.5.3	Certificate of Increase of 10-1/2% Series C Convertible Preferred Stock (incorporated by reference to Exhibit 3.5.3 to the Company's Form 10-Q for the period ended March 31, 1998).
4.1	Form of Certificate for Shares of Common Stock (incorporated by reference to Exhibit 4.3 to the S-1 Registration Statement).
4.2	Form of Certificate for Shares of 10 1/2% Series C Convertible Preferred Stock (incorporated by reference to Exhibit 4.4 to the S-4 Registration Statement).
4.3	Rights Agreement, dated as of October 22, 1997, between the Company and Continental Stock Transfer & Trust Company, as Rights Agent (incorporated by reference to Exhibit 1 to the Form 8-A).
4.4	Form of Right Certificate (incorporated by reference to Exhibit B to Exhibit 1 to the Form 8-A).

Exhibit	Description
4.5	Indenture, dated as of November 26, 1997, between the Company and IBJ Schroder Bank & Trust Company, as Trustee (incorporated by reference to Exhibit 4.1 to the Company's Registration Statement on Form S-3 (File No. 333-34769) (the "Units Registration Statement")).
4.6	Form of Note (incorporated by reference to Exhibit 4.2 to the Units Registration Statement).
4.7	Pledge Agreement, dated as of November 26, 1997, between the Company, as Pledgor, and IBJ Schroder Bank & Trust Company, as Collateral Agent (incorporated by reference to Exhibit 4.5 to the Units Registration Statement).
4.8	Warrant Agreement, dated as of November 26, 1997, between the Company and IBJ Schroder Bank & Trust Company, as Warrant Agent (incorporated by reference to Exhibit 4.3 to the Units Registration Statement).

4.9	Form of Warrant (incorporated by reference to Exhibit 4.4 to the Units Registration Statement).
4.10	Form of Preferred Stock Warrant Agreement, dated as of April 9,1997, between the Company and each Warrantholder thereof (incorporated by reference to Exhibit 4.11 to the 1997 Form 10-K).
4.11	Form of Common Stock Purchase Warrant granted by the Company to Everest Capital Master Fund, L.P. and to The Ravich Revocable Trust of 1989 (incorporated by reference to Exhibit 4.12 to the 1997 Form 10-K).
10.1.1	Lease Agreement, dated October 20, 1992, between 22nd & K Street Office Building Limited Partnership and the Company (incorporated by reference to Exhibit 10.3 to the S-1 Registration Statement).
**10.1.2	Lease Agreement, dated as of March 31, 1998, between Rock-McGraw, Inc. and the Company.
10.2.1	Engagement Letter Agreement, dated November 18, 1992, between the Company and Batchelder & Partners, Inc. (incorporated by reference to Exhibit 10.4 to the S-1 Registration Statement).
10.2.2	Engagement Termination Letter Agreement, dated December 4, 1997, between the Company and Batchelder & Partners, Inc. (incorporated by reference to Exhibit 10.2.2 to the 1997 Form 10-K).
*10.3.1	Proprietary Information and Non-Competition Agreement, dated February 9, 1993, for Robert D. Briskman (incorporated by reference to Exhibit 10.8.1 to the S-1 Registration Statement).

Exhibit	Description
*10.3.2	Amendment No. 1 to Proprietary Information and Non Competition Agreement between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.8.2 to the S-1 Registration Statement.)
+10.4	Amended and Restated Contract, dated as of June 30, 1998, between the Company and Space Systems/Loral, Inc. (filed herewith).
10.5	Assignment of Technology Agreement, dated April 15, 1993, between Robert D. Briskman and the Company (incorporated by reference to Exhibit 10.10 to the S-1 Registration Statement).
*10.6.1	Amended and Restated Option Agreement between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.13 to the S-1 Registration Statement).
*10.6.2	Stock Option Agreement, dated as of October 15, 1997, between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.6.2 to the 1997 Form 10-K).
*10.7.1	Employment and Noncompetition Agreement between the Company and David Margolese (incorporated by reference to Exhibit 10.18.1 to the S-1 Registration Statement).
*10.7.2	First Amendment to Employment Agreement between the Company and David Margolese (incorporated by reference to Exhibit 10.18.2 to the S-1 Registration Statement).
*10.8.1	Employment and Noncompetition Agreement between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.19.1 to the S-1 Registration Statement).
*10.8.2	First Amendment to Employment Agreement between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.19.2 to the S-1 Registration Statement).
*10.8.3	Second Amendment to Employment Agreement between the Company and Robert D. Briskman (incorporated by reference to Exhibit 10.12.3 to the 1996 Form 10-K).
*10.9	Employment and Noncompetition Agreement, dated as of July 10, 1997, between the Company and Andrew J. Greenebaum (incorporated by reference to Exhibit 10.10 to the Company's Quarterly Report on Form 10-Q for the period ended September 30, 1997).

Exhibit	Description
*10.10	Employment and Noncompetition Agreement, dated as of April 16, 1997, between the Company and Joseph S. Capobianco (incorporated by reference to Exhibit 10.17 to the Company's Quarterly Report on Form 10-Q/A for the period ended March 31, 1997).

*10.11.1	Employment and Noncompetition Agreement, dated as of April 28, 1997, between the Company and Keno V. Thomas (incorporated by reference to Exhibit 10.18 to the Company's Quarterly Report on Form 10-Q/A for the period ended March 31, 1997).
* **10.11.2	Separation Agreement, dated as of July 6, 1998, between the Company and Keno V. Thomas.
* **10.12	Employment and Noncompetition Agreement, dated as of May 18, 1998, between the Company and Patrick L. Donnelly.
10.13	Registration Agreement, dated January 2, 1994, between the Company and M.A. Rothblatt and B.A. Rothblatt (incorporated by reference to Exhibit 10.20 to the S-1 Registration Statement).
*10.14	1994 Stock Option Plan (incorporated by reference to Exhibit 10.21 to the S-1 Registration Statement).
*10.15	Amended and Restated 1994 Directors' Nonqualified Stock Option Plan (incorporated by reference to Exhibit 10.22 to the Company's Annual Report on Form 10-K for the year ended December 31, 1995).
10.16.1	Option Agreement, dated as of October 21, 1992, between the Company and Batchelder & Partners, Inc. (incorporated by reference to Exhibit 10.24 to the S-1 Registration Statement).
**10.16.2	Form of Option Agreement, dated as of December 29, 1997, between the Company and each Optionee.
10.17	Settlement Agreement, dated as of April 1, 1994, among the Company, M.A. Rothblatt, B.A. Rothblatt and Marcor, Inc. (incorporated by reference to Exhibit 10.27 to the S-1 Registration Statement).
*10.18	1995 Stock Compensation Plan (incorporated by reference to Exhibit 10.37 to the Annual Report on Form 10-K for the year ended December 31, 1995).
10.19.1	Preferred Stock Investment Agreement dated October 23, 1996 between the Company and certain investors (incorporated by reference to Exhibit 10.24 to the 1996 Form 10-K).
10.19.2	First Amendment to Preferred Stock Investment Agreement dated March 7, 1997 between the Company and certain investors (incorporated by reference to Exhibit 10.24.1 to the 1996 Form 10-K).

Exhibit	Description
10.19.3	Second Amendment to Preferred Stock Investment Agreement dated March 14, 1997 between the Company and certain investors (incorporated by reference to Exhibit 10.24.2 to the 1996 Form 10-K).
10.20	Stock Purchase Agreement, dated as of August 5, 1997, between the Company, David Margolese and Loral Space & Communications Ltd. (incorporated by reference to Exhibit 99.1 to the Company's Current Report on Form 8-K, filed with the Commission on August 19, 1997).
**10.21	Letter, dated May 29, 1998, terminating Launch Services Agreement dated July 22, 1997 between the Company and Arianespace S.A.; Arianespace Customer Loan Agreements dated July 22, 1997 for Launches #1 and #2 between the Company and Arianespace Finance S.A.; and the Multiparty Agreements dated July 22, 1997 for Launches #1 and #2 among the Company, Arianespace S.A. and Arianespace Finance S.A.
**10.22	Credit Agreement, dated as of June 30, 1998, among the Company, the financial institutions from time to time parties thereto and Bank of America National Trust and Savings Association, as Administrative Agent.
**10.23	Pledge Agreement, dated as of June 30, 1998, made by the Company in favor of Bank of America National Trust and Savings Association, as Administrative Agent.
10.24	Summary Term Sheet/Commitment, dated June 15, 1997, among the Company and Everest Capital International, Ltd., Everest Capital Fund, L.P. and The Ravich Revocable Trust of 1989 (incorporated by reference to Exhibit 99.1 to the Company's Current Report on Form 8-K, filed with the Commission on July 8, 1997).
10.25.1	Engagement Letter Agreement, dated June 14, 1997, between the Company and Libra Investments, Inc. (incorporated by reference to Exhibit 10.26.1 to the 1997 Form 10-K).
10.25.2	Engagement Termination Letter Agreement, dated August 6, 1997, between the Company and Libra Investments, Inc. (incorporated by reference to Exhibit 10.26.1 to the 1997 Form 10-K).

Exhibit	Description
10.26	Engagement Letter Agreement dated October 8, 1997, between the Company and Merrill Lynch, Pierce, Fenner & Smith Incorporated (incorporated by reference to Exhibit 10.27 to the 1997 Form 10-K).
+10.27	Radio License Agreement, dated January 21, 1998 between the Company and Bloomberg Communications Inc. (incorporated by reference to Exhibit 10.28 to the Company's Quarterly Report on Form 10-Q for the period ended March 31, 1998).
+10.28	Agreement, dated April 24, 1998, between Lucent Technologies Inc. and the Company (filed herewith).
**27.1	Financial Data Schedule.

* This document has been identified as a management contract or compensatory plan or arrangement.

** Previously filed.

\+ Portions of these exhibits, which are incorporated by reference, have been omitted pursuant to an Application for Confidential treatment filed by the Company with the Securities and Exchange Commission pursuant to Rule 24b-2 of the Securities Exchange Act of 1934, as amended.

AMENDED AND RESTATED

CONTRACT BETWEEN

CD RADIO INC.

AND

SPACE SYSTEMS/LORAL, INC.

FOR

ON-ORBIT DELIVERY OF

CD RADIO DARS SATELLITES*

* This agreement is subject to a confidential treatment request. The confidential portions have been omitted from this Form 10-Q and have been replaced by asterisks (*). The confidential portions have been filed separately with the Commission as provided pursuant to Rule 24b-2 under the Securities Exchange Act of 1934.

TABLE OF CONTENTS

PREAMBLE

AMENDED AND RESTATED CONTRACT, dated as of June 30, 1998, between CD Radio Inc., a corporation organized and existing under the laws of the State of Delaware, having its principal place of business at 1180 Avenue of the Americas, 14th Floor, New York, New York 10036 (hereinafter referred to as the "Purchaser"), and Space Systems/Loral, Inc., a corporation organized and existing under the laws of the State of Delaware, having a place of business at 3825 Fabian Way, Palo Alto, California, 94303 (hereinafter referred to as the "Contractor").

WITNESSETH:

WHEREAS, the Purchaser and the Contractor are parties to a Contract dated as of March 2, 1993 (as amended, supplemented or otherwise modified prior to the date hereof, the "Existing Contract"), pursuant to which, among other things, the Contractor agreed to construct and deliver three (3) Satellites for use in the digital audio radio system ("DARS") being developed by the Purchaser (such system, as modified or expanded from time to time, the "CD Radio DARS System");

WHEREAS, the Purchaser and the Contractor are parties to a Memorandum of Agreement, dated as of March 27, 1998 (the "MOA"), pursuant to which the

Purchaser and the Contractor agreed to amend the Existing Contract to, among other things, provide for the construction, Launch and on-orbit, checked-out delivery of three (3) Satellites with a fourth Satellite delivered to Ground Storage for use in the CD Radio DARS System;

WHEREAS, the Contractor and the Purchaser desire to execute and deliver this Contract to (i) supersede both the Existing Contract and the MOA and (ii) provide for the construction, Launch and on-orbit, checked-out delivery of three (3) Satellites with a fourth Satellite delivered to Ground Storage for use in the CD Radio DARS System;

WHEREAS, subject to the terms and conditions of this Contract and Attachment D, the Contractor has agreed to (i) provide $50,000,000 in vendor financing for the purchaser of the Satellites for use in the CD Radio DARS System and (ii) enter into agreements relating to $115,000,000 in vendor financing for the purchase of the Launch Services to be provided to the Purchaser under this Contract; and

NOW, THEREFORE, in consideration of the mutual covenants and agreements herein contained, and other good and valuable consideration, the receipt of which is hereby acknowledged, the Purchaser and the Contractor hereby agree as follows:

Article 1.

DEFINITIONS

The following terms shall have the meanings assigned to them below:

1.1 The "Purchaser" means CD Radio Inc., a Delaware corporation, and its successors and assigns.

1.2 The "Contractor" means Space Systems/Loral, Inc.

1.3 The "Parties" means the Purchaser and the Contractor.

1.4 "Contract" means this Amended and Restated Contract, its Exhibits and Attachments plus any amendments hereto or thereto, to which the Parties agree in writing.

1.5 "Satellite" or "Spacecraft" shall mean a CD Radio DARS Satellite contemplated by and to be supplied to the Purchaser under this Contract.

1.6 "Mission Operations Support Services" shall mean the services performed by the Contractor including orbit raising of FM-1. FM-2 and FM-3 and In-Orbit Testing of such Satellites.

1.7 "Terminated Ignition" shall mean, when, for each Satellite separately of FM-1, FM-2 and FM-3, Intentional Ignition has occurred and is not followed by liftoff.

1.8 "Launch Vehicle" means one of the expendable Launch Vehicles used for the Launch of the CD Radio DARS Satellites, as described in Article 7.

1.9 "Launch Agency" means that organization which is responsible for the Launch Site and conducting the applicable Launch.

1.10 "Launch Site" means the facility used by a Launch Agency for purposes of Launching a Satellite.

1.11 "Launch Support" means those services provided by the Contractor, pursuant to the Statement of Work hereto, in support of a Launch by a Launch Agency.

1.12 "Launch" of a Satellite means Intentional Ignition.

1.13 "Launch Services Agreement" means the Contract(s) between the Contractor and the Launch Agency which provides the terms and conditions for Launching one or more Satellites which are being constructed under this Contract.

1.14 "Ground Storage" of a Satellite means a condition where the Satellite or its component parts are secured in a controlled environment for preservation on the ground.

1.15 "Effective Date of Contract" or "EDC" means March 2, 1993.

1.16 "Affiliate" with respect to any person or entity, shall mean any person or entity directly or indirectly controlling, controlled by or under common control with such person or entity.

1.17 "Intentional Ignition" means the ignition of the first stage main engine(s) of the Launch Vehicle.

1.18 "Launch Pad" shall mean the designated area at the Launch Site from which the Satellite will be Launched.

1.19 "FM" means, with respect to any Satellite, Flight Model.

1.20 "Bank of America Credit Agreement" shall mean that certain $115,000,000 Credit Agreement, dated as of June 30, 1998, among the Purchaser, the banks and financial institutions from time to time parties thereto and Bank of America National Trust and Savings Association, as administrative agent and as a bank thereunder, as amended, supplemented or otherwise modified from time to time in accordance with the terms thereof.

1.21 "Consolidated Net Worth" shall mean, at a particular date, all amounts which would be included under stockholders' equity on a consolidated balance sheet of the Purchaser and its subsidiaries determined on a consolidated basis in accordance with generally accepted accounting practices (GAAP) as at such date, plus (i) preferred stock issued by the Purchaser whether or not included in stockholders' equity and (ii) all accrued and unpaid dividends on preferred stock issued by the Purchaser.

1.22 "Data and Documentation" means the information to be provided by the Contractor in accordance with Exhibit A, Annex 2, Deliverable Document List.

1.23 "Price" shall have the meaning specified in Article 4 of this Contract, as reduced or increased from time to time in accordance with the terms of this Contract.

1.24 "LIBOR" shall mean the rate of interest per annum determined by Bank of America National Trust and Savings Association to be the arithmetic mean (rounded downwards to the nearest 1/16th of 1%) of the rates of interest per annum at which dollar deposits in the amount of $10,000,000, and having a maturity of 360 days, would be offered to major banks in the London interbank market at their request at approximately 11:00 a.m. (London time) two (2) business days prior to the applicable date.

1.25 "In-Orbit Check Out Amount" shall mean payments numbered 20B, 21E and 22E for FM's 1, 2 and 3, respectively, (E.G., milestones entitled "Complete IOT") as shown on Attachment A to this Contract.

1.26 "On-Orbit/Checked Out" shall mean a Satellite that is placed in an orbital location as defined in Exhibit B, Section 1, (I.E., on-orbit)and which has been tested in accordance with Exhibit D, Test Plan, to validate the Satellite's performance as specified in Exhibit B.

1.27 "Insurance Management Support Services" shall mean the technical assistance provided by the Contractor to the Purchaser in support of the procurement of insurance for the Satellites.

1.28 "Satellite Failure" means (i) a Satellite that has a service life that, at any point in time, is predicted to be less than six (6) years, including the number of years that have already occurred since the date of completion of in-orbit testing or (ii) a Satellite that, at any point in time, has fewer than fifty percent 50% of its EIRP specified in Exhibit B.

1.29 "Launch Failure" means: (a) that the Satellite is destroyed or lost during the period extending from Intentional Ignition to the instant when the Satellite is intended to separate from the Launch Vehicle, or if such Satellite does not separate from the Launch Vehicle; or (b) the operational capacity or nominal lifetime of the Satellite is expected to be reduced by more than 50% and it is determined from the flight data that the Launch Vehicle performed in a manner that damaged the Satellite which caused the reduction in capacity or lifetime.

1.30 "In-Orbit Testing" or "IOT" shall have the meaning described in Exhibit A, Statement of Work.

1.31 "Late Delivery Penalty Period" means the period ending on the day that is ninety (90) days after July 31, 2000 for FM's 1, 2, and 3 and after September 30, 2000 for FM-4.

Article 2.

SCOPE OF WORK

2.1 Work Effort. The Contractor shall provide the necessary personnel, material, services, and facilities, to manufacture, test and deliver On-Orbit/Checked Out or to Ground Storage as specified in Sub-Article 3.3, four (4) complete Spacecraft in accordance with the Satellite Performance Specification, Exhibit B to this Contract, and perform the services described in Exhibit A, Statement of Work, (except those items of hardware and services listed as "optional," unless such options are exercised by the Purchaser in accordance with the terms of this Contract), to the extent specified in this

Contract, and to perform the work required hereunder in accordance with the Exhibits listed below, which are attached hereto and made a part hereof by reference:

2.1.1 Exhibit A - Statement of Work (SOW) Revision 5, dated 21 July 1998, SS/L-TP93002-02

2.1.2 Exhibit B - Satellite Performance Specification, Revision 9, dated 21 July 1998, SS/L-TP93002-03

2.1.3 Exhibit C - Product Assurance Program Plan, Revision 2, dated 14 January 1997, SS/L-TP93002-04

2.1.4 Exhibit D - Test Plan, Revision 3C, dated 21 July 1998, SS/L-TP93002-05

2.1.1 Exhibit E - Dynamic Simulator Specification dated 21 July 1998, SS/L-TP93002-06

The Contractor acknowledges that the Test Plan, Exhibit D, which is attached to this Contract has not yet been modified to reflect, among other things, the modifications that the Contractor and the Purchaser agree are required as a result of the changes in the Statement of Work, Exhibit B, and the on-orbit delivery required by this Contract. The Contractor and the Purchaser agree to negotiate in good-faith a mutually acceptable revision of such Exhibit D. The Contractor agrees that, notwithstanding anything to the contrary contained in this Contract, the Purchaser shall not be required to pay a $4,000,000 portion of payment 17A listed on Attachment A to this Contract until such time as a revision to Exhibit D has been (i) delivered to the Purchaser, (ii) agreed upon by the Purchaser and the Contractor and (iii) incorporated into this Contract by a written amendment to this Contract executed by both the Purchaser and the Contractor.

Article 3.

DELIVERABLE ITEMS AND DELIVERY SCHEDULE

3.1 Satellite Delivery. Each of the Satellites to be delivered On-Orbit/Checked Out shall be delivered in accordance with the provisions of Sub-Article 3.3 below and Exhibit A, with such delivery being deemed to have occurred upon completion of In Orbit Testing of the applicable Satellite which is conducted to verify that the performance of the Satellite has not degraded during Launch. For a Satellite delivered into Ground Storage pursuant to Sub-Article 3.3 or Article 35, delivery shall be deemed to have occurred when the Satellite arrives at the designated Ground Storage site.

3.2 Delivery of Services. Delivery of services shall be deemed to have occurred when such services have been completed in accordance with the requirements of Exhibit A.

3.3 Deliverable Items. The goods and services to be delivered and the corresponding delivery schedule under this Contract are as follows:

Item	Description	Delivery Schedule	Place of Delivery
1	First Satellite (FM-1)	January 30, 2000, On-Orbit/Checked Out	per Exhibit B, Section 1
2	Second Satellite (FM-2)	February 28, 2000, On-Orbit/Checked Out	per Exhibit B, Section 1
3	Third Satellite (FM-3)	March 31, 2000, On-Orbit/Checked Out	per Exhibit B, Section 1
4	Fourth Satellite (FM-4)	May 31, 2000	Purchaser designated CONUS Ground Storage site
5-7	Launch Services for FM-1, FM-2 and FM-3 in accordance with the terms of Article 7	November 1999 (FM-1) December 1999 (FM-2) January 2000 (FM-3)	Launch Site

Item	Description	Delivery Schedule	Place of Delivery
8	Optional Satellite	Per Sub-Article 14.2	Purchaser designated CONUS Ground Storage site
9	Dynamic Simulator (Qty 1)	September 1, 1999	Purchaser CONUS TT&C facility

10	Mission Operations Support Services FM-1, FM-2 and FM-3	Per Exhibit A	Per Exhibit A
11	Insurance Management Support Services for FM-1, FM-2 and FM-3	As Required	N/A
12	Data and Documentation	Per Exhibit A	Per Exhibit A
13	Training	Per Exhibit A	Palo Alto, CA New York, NY
14	Insurance Option	Per Article 16	N/A

3.4 Late Delivery Penalties. If all of FM-1, FM-2 and FM-3 Satellites (including applicable Launch Services and one (1) dynamic simulator) are not delivered On-Orbit/Checked Out by 31 July 2000 the Price shall, unless such delays are excusable within the meaning of Article 18 - FORCE MAJEURE, be reduced by Forty-Five-Thousand dollars ($45,000) per day for each day of delay starting on August 1, 2000 for up to eighty-nine (89) days thereafter with a maximum Price reduction of Four-Million-Fifty-Thousand dollars ($4,050,000).

If FM-4 is not delivered to Ground Storage by 30 September 2000, then the Price shall, unless such delay is excusable within the meaning of Article 18 FORCE MAJEURE, be reduced by Fifteen-Thousand dollars ($15,000) per day for each day of delay starting on October 1, 2000 for up to eighty-nine (89) days thereafter with a maximum Price reduction of One-Million-Three-Hundred-Fifty-Thousand dollars ($1,350,000).

There shall be no other remedies to the Purchaser (including any default remedy) for late delivery, or for failure to prosecute the work as required to achieve delivery by dates earlier than those set forth in this Article 3.4, or through the applicable ninety (90) day penalty period.

3.5 Payment of Late Delivery Penalties. Any late delivery penalties incurred by the Contractor for one or more Satellites shall be paid by the Contractor at the time of delivery of FM-1, FM-2 and FM-3 or FM-4, as the case may be. The Contractor shall wire transfer the amount of the late delivery penalties to the bank specified by the Purchaser.

3.6 Limit of Liability. EXCEPT AS OTHERWISE SPECIFICALLY PROVIDED HEREIN, THE CONTRACTOR SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR FOR LOST REVENUES OR PROFITS DUE TO LATE DELIVERY OF ANY ITEMS, INCLUDING BUT NOT LIMITED TO THE SATELLITES REQUIRED TO BE DELIVERED UNDER THIS CONTRACT.

3.7 Early Delivery Incentives. In the event that FM-1, FM-2 and FM-3 are all delivered On-Orbit/Checked Out before March 31, 2000, an early delivery incentive shall be paid to the Contractor at a rate of $45,000 per day from the date delivery of all three Satellites occurs On-Orbit/Checked Out through March 31, 2000 or a 90 day period, whichever occurs first.

In the event that FM-4 is delivered to Ground Storage before May 31, 2000, an early delivery incentive shall be paid to the Contractor at a rate of $15,000 per day from the date delivery occurs to Ground Storage through May 31, 2000 or a 90 day period, whichever occurs first.

3.8 Payment of Early Delivery Incentives. Any early delivery incentive earned by the Contractor for FM-1, FM-2, and FM-3 shall be paid to the Contractor by the Purchaser at the time of delivery, On-Orbit/Checked Out, of such Satellites.

3.9 Earned Delivery Incentives for a Stored Satellite. Any early delivery incentive earned for FM-4 shall be paid to the Contractor by the Purchaser at the time FM-4 is delivered to Ground Storage.

Article 4.

PRICE

The price to be paid by the Purchaser to the Contractor for performance of its obligations under this Contract is Four-Hundred-Thirty-Eight-Million-Forty- Thousand Dollars ($438,040,000) plus the price of the Launch Services provided by the Contractor in accordance with Article 7 (the "Price").

The Price does not include any of the options available to the Purchaser under the terms of this Contract. In the event that the Contractor receives a contract from one or more customers, other than the Purchaser, for a

Satellite procurement intended to provide direct audio radio service in the United States of America, then the Purchaser shall receive as a refund a percentage of the non-recurring effort charged to the Purchaser in the Price. The calculation of the refund shall be based on the amount of non-recurring effort that is common to the Programs. This non-recurring Price shall be divided between the Programs. Any portion of the non-recurring Price that is unique to the CD Radio DARS System Satellites shall not be included in the calculation of the refund.

The itemization of the Price is as follows:

Line Item	Description	Amount
1.	FM-1 delivered On-Orbit/Checked Out (Effort includes Launch Support, Insurance Management Support, Data and Documentation, Training, and Mission Operations Support Services through In-Orbit Testing as defined in Exhibit A)	$116,014,000
2.	FM-2 delivered On-Orbit/Checked Out (Effort includes Launch Support, Insurance Management Support, Data and Documentation, Training, and Mission Operations Support Services through In-Orbit Testing as defined in Exhibit A)	$116,013,000
3.	FM-3 delivered On-Orbit/Checked Out (Effort includes Launch Support, Insurance Management Support, Data and Documentation, Training, and Mission Operations Support Services through In-Orbit Testing as defined in Exhibit A)	$116,013,000
4.	FM-4 delivered to Ground Storage	$ 90,000,000

Line Item	Description	Amount
5.	*Launch Service for FM-1	$(*)
6.	*Launch Service for FM-2	$(*)
7.	*Launch Service for FM-3	$(*)
8.	Dynamic Simulator (Qty 1)	Not Separately Priced

*Launch Services to be provided and prices determined in accordance with the terms of Article 7.

Article 5.

PAYMENTS

5.1 General.

5.1.1 Payments by the Purchaser to the Contractor of the Price shall be in accordance with the applicable Payment Plan provided in Attachment A.

5.1.2 Notwithstanding anything in this Contract or otherwise to the contrary (including the actual timing of payments required under the applicable Payment Plan), on the thirtieth (30th) day following the date upon which the unpaid principal amount of the "Loans" (as such term is defined in the Bank of America Credit Agreement) become immediately due and payable(the "Bank of America Credit Agreement Maturity Date"), whether at maturity, upon acceleration, or otherwise, the Purchaser will pay the Contractor Thirty-One-Million-Six-Hundred-Thousand dollars ($31,600,000). Such payment shall be applied by the Contractor to the final payments due under the Payment Plan provided in Attachment A for FM's 1, 2 and 3. The Purchaser shall provide the Contractor prompt written notice of the occurrence of the Bank of America Credit Agreement Maturity Date, but the failure to provide such notice shall not prevent the operation of the provisions of this Sub-Article 5.1.2.

5.1.3 So long as the Support Agreement (as such term is defined in the Bank of America Credit Agreement) is in full force and effect (including at all times from and after the purchase, if any, of the Term Loans (as such term is defined in the Support Agreement) by Loral Space & Communications Ltd. ("Loral"), a Bermuda company, in accordance with Section 2 or Section 3 of the Support Agreement), and Loral is not in default of its obligations under Section 2 of the Support Agreement, the Purchaser agrees that it shall (i) maintain (a) prior to

December 31, 1998, a Consolidated Net Worth of at least One-Hundred-Twenty-Five Million dollars ($125,000,000); and (b) from and after December 31, 1998, a Consolidated Net Worth of at least Seventy-Five Million dollars ($75,000,000), and (ii) it shall maintain committed financing or unrestricted cash and cash equivalents sufficient for the Purchaser to pay its obligations (including, but not limited to, its obligations under this Contract) as they become due.

5.1.4 So long as the Support Agreement is in full force and

effect and Loral is not in default of its obligations under Section 2 of the Support Agreement, the Purchaser shall not, without the prior written consent of Loral (i) amend or modify the Bank of America Credit Agreement or (ii) cause, or suffer to occur, the release of any collateral securing the obligations of the Purchaser under the Bank of America Credit Agreement. Within forty-five (45) days after the end of each calendar quarter, the Purchaser shall deliver to the Contractor a certificate signed by the Purchaser's Chief Financial Officer, Treasurer, or Controller, or any other officer having substantially the same authority and responsibility, as to the compliance by the Purchaser with the covenants contained in Sub-Article 5.1.3.

5.2 Escalation. The prices, for options in this Contract shall be escalated in accordance with the formula provided below from May 1998 to the date an option is exercised when the Bureau of Labor Statistics ("BLS") data, as required, is available.

Adjustment = 100% Price x Labor E/Labor B

where

Labor B = BLS 3721 (Average aircraft hourly earnings, excluding lump sum payments, for May 1998)

Labor E = BLS 3721 (Average aircraft hourly earnings, excluding lump sum payments, for the month in which an option is exercised.)

5.3 Payment Conditions. All time payments by the Purchaser shall be due in accordance with the Program Payment Plan, Attachment A hereto. The Contractor shall submit an invoice for the applicable amount thirty (30) days prior to the payment due date. For any invoice for payment which is subject to the completion of a milestone, the Contractor shall provide evidence, in the form of Attachment B, Milestone Achievement Certification, of the completion of such item to the Purchaser. The Purchaser shall, within five (5) business days of its receipt of such certification, notify the Contractor of either (i) its approval, which approval shall not be unreasonably withheld, by signing and returning the Milestone Achievement

Certification or (ii) its rejection of such certification with notification to the Contractor of the area(s) not considered by the Purchaser to be acceptable. In the event the Contractor does not receive notification in writing from the Purchaser within five (5) business days, then such milestone event completion certificate shall be deemed to have been approved. Milestone payments shall be due thirty (30) days after the Contractor provides an invoice accompanied by such certification, executed by both the Purchaser and the Contractor. In the event that the Purchaser does not make any payment required to be made under this Contract by the said due date, the Purchaser shall be liable to pay the Contractor interest at the rate of LIBOR + 2% per annum on the unpaid balance until such time as payment is made by the Purchaser (without prejudice to the Contractor's other rights and remedies for such late payment). All payments to the Contractor from the Purchaser shall be in United States Dollars and shall be made by electronic funds transfer (EFT) to the following account:

BANK OF AMERICA, NT & SA
SPACE SYSTEMS/LORAL
ACCOUNT NO. 75-69165
CHICAGO, ILLINOIS
ABA #071-000-039

or other such accounts as the Contractor may specify from time to time in written notices to the Purchaser.

5.4 Payments Associated with Options. In the event that the Purchaser exercises any of the options provided for under this Contract, then the Purchaser shall make payments for such option(s) in accordance with the respective Payment Plans which are a subset of Attachment A hereto.

5.5 Deferral of Payment. The Contractor agrees that it will defer a total amount of Fifty-Million dollars ($50,000,000) as reflected in the Payment Plan provided in Attachment A for FM's 1,2 and 3 and the Purchaser shall make deferred payments on the specified dates, also provided in the attached Payment Plan. These deferred schedule payments are reflected in payments numbered 6B, 8B, 10A, 12B, 13C, and 16 of the Payment Plan for FM's 1, 2, and 3. The Purchaser shall pay such deferred payments as noted in payments numbered 24, 25A, 25B, 26, 27A, and 27B of the Payment Plan for FM's 1, 2, and 3.

However, in the event of a Satellite Failure or Launch Failure, the Purchaser shall pay the full deferred amount for that Satellite no later than one hundred twenty (120) days after the date of the Satellite Failure or Launch Failure, as the case may be.

If the Purchaser elects to exercise the Ground Storage option under Article 35 for FM's 1, 2, or 3, the Purchaser shall pay the full deferred amount

for that Satellite within sixty (60) days of the option exercise date and all affected Articles shall be mutually amended as required (E.G., delay penalties and incentives).

The Purchaser and the Contractor agree to negotiate in good-faith an agreement regarding the terms and conditions of such deferred payments. Such agreement shall contain the principal terms and conditions set forth on Attachment D and no other principal terms and conditions.

Article 6.

PURCHASER FURNISHED ITEMS

6.1 Facilities for IOT. The Purchaser shall make available to the Contractor the use of the Purchaser's Satellite control facilities for the purposes of In-Orbit Testing of the Satellites.

6.2 Spacecraft Monthly Reports. The Purchaser shall provide to the Contractor, no less frequently than monthly during the on-orbit life of each Satellite, an informal letter report which shall describe the general health and operating status of the Satellites and specifically identify any defined anomalies. For the purpose of this Article, a Satellite anomaly means any occurrence in-orbit that was not anticipated in the Satellite Orbital Operation Handbook (SOOH) delivered to the Purchaser pursuant to Annex 2 of Exhibit A. In the event that a Satellite anomaly is encountered, the Purchaser shall provide and/or give access to such data as the Contractor may require for investigation and/or correction of such anomaly. Further, the Purchaser shall grant such reasonable access to ground stations and the Satellites as the Contractor might require for an investigation of such anomaly. The Contractor shall use its best efforts to understand the anomaly.

6.3 Purchaser Delays. If the Contractor is delayed due to failure of the Purchaser to perform its obligations under this Article, the Contractor shall notify the Purchaser of such delay and failure. If the Purchaser fails to cure such failure within thirty (30) days thereafter, the Contractor shall have the option to perform such obligations on behalf of the Purchaser; if the Contractor does so, it will so notify the Purchaser and the Purchaser shall reimburse the Contractor by means of an equitable adjustment in the Price, schedule, and other affected portions of this Contract. Whether or not the Contractor elects to perform such Purchaser obligations, delays caused by the Purchaser's failure shall be subject to the provisions of Article 19 - PURCHASER DELAY OF WORK.

Article 7.

LAUNCH SERVICES

7.1 Atlas, Sea-Launch and Proton Launch Services. Subject to the provisions set forth below, the Contractor and the Purchaser agree that Launch services under this Contract shall consist of three (3) Launches ("Launch Services") and shall be provided on two (2) Proton Launch Vehicles and an Atlas IIIA Launch Vehicle. The Contractor agrees that FM-1 and FM-2 shall be Launched on Proton Launch Vehicles and, subject to the provisions set forth below, that FM-3 shall be Launched on an Atlas IIIA Launch Vehicle.

In the event that the Contractor, after consultation with the Purchaser, determines that the Atlas IIIA Launch Vehicle is not suitably optimized for Launch of FM-3 (which determination shall be made prior to August 27, 1998), then the Purchaser shall, by August 28, 1998 instruct the Contractor to substitute either a Proton Launch Vehicle (to the extent that a Proton Launch Vehicle is available), a Sea-Launch Launch Vehicle or an Atlas IIIB Launch Vehicle (to the extent that an Atlas IIIB Launch Vehicle is available) for such unsuitable Launch Vehicle. Any such substitution of Launch Vehicles shall not change the applicable Launch dates or delivery schedule contained in Sub-Article 3.3.

The price for Launch Services under this Contract shall be determined based upon which Launch Vehicle is utilized to Launch FM-1, FM-2 and FM-3. The prices for such Launch Vehicles are set forth below (and are not subject to escalation in any respect):

Proton Launch Vehicle:	For FM-1	$90,000,000
	For FM-2	$95,000,000
	For FM-3	$95,000,000
Atlas Launch Vehicle:	For FM-3	IIIA= $90,000,000; IIIB= $95,000,000
Sea-Launch Launch Vehicle:	For FM-3	$90,000,000

In the event the first Proton Launch Vehicle suffers a Launch Failure, then the Contractor shall provide to the Purchaser one (1) free reflight on a Proton Launch Vehicle. The Contractor agrees that only FM-3 shall be launched on a Sea-Launch Launch Vehicle or an Atlas IIIA or IIIB Launch Vehicle.

restriction on the title page of this Contract.

Each Launch Vehicle shall have the capability of providing an anticipated mission life per Satellite of fifteen (15) years subject to optimization to be provided at the system Critical Design Review per Attachment A, but in no event to be less than twelve (12) years. On or before August 3, 1998, the Contractor shall inform the Purchaser, in writing, whether a Sea-Launch Launch Vehicle which may be selected by the Purchaser can be replaced by an additional Proton Launch Vehicle. In the event a Launch Failure occurs in the industry that causes a postponement of a scheduled Launch, the Contractor will work with the Purchaser and its Launch Agencies to obtain the earliest possible Launch date for the affected Satellite.

7.2 Ariane Launch Vehicles. The Contractor shall use reasonable best efforts, provided they entail no net cost or liability to the Contractor and the Purchaser, to modify its Multiple Launch Service Agreement ("MLSA") with Arianespace S.A. ("Arianespace") to add the two (2) Ariane launchers which were previously under contract between the Purchaser and Arianespace. In this connection, the Contractor shall use reasonable best efforts, provided they entail no net cost nor liability to the Contractor and the Purchaser, to secure Arianespace's agreement to reimburse the Purchaser, fully or partially, for all amounts paid under the Purchaser/Arianespace agreement. Such efforts will be made to secure the reimbursement prior to March 31, 2000 although no assurances can be made. The Contractor agrees to include the Purchaser in (or at least to consult on a regular basis with the Purchaser regarding) the Arianespace negotiations that directly affect the Purchaser's interests. Upon reaching successful agreement with Arianespace, the Contractor will inform the Purchaser of the terms of the agreement and promptly pay over to the Purchaser any reimbursement amounts paid by Arianespace in connection with the Purchaser/Arianespace agreement.

7.3 Launch Vehicle Financing. The Contractor agrees that upon execution of this Contract it shall either: (i) provide the Purchaser with a $115,000,000 vendor financing facility on terms satisfactory to the Contractor and the Purchaser, the proceeds of which shall be used to finance the purchase of Launch Services under this Contract; or (ii) enter into the Support Agreement (to be agreed to and defined in the Bank of America Credit Agreement).

Article 8.

INSPECTION, INTERIM AND FINAL ACCEPTANCE

8.1 Inspections and Testing of Satellites. The Satellites shall be subjected to inspection and acceptance testing in accordance with Exhibit A, Statement of Work, Exhibit C, Product Assurance Plan and Exhibit D, Test Plan. The Purchaser shall have the right to conduct inspections of the Satellites and witness acceptance

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testing in accordance with the paragraph below, and to examine the test data resulting from such tests. The Contractor will give reasonable advance notice to the Purchaser, when practicable, as to the time such tests will be conducted and the nature of the test. Failure of the Purchaser to witness the tests shall not prevent the tests from proceeding.

8.2 Interim Acceptance of the Satellites. The Satellite(s) will be inspected and subject to Interim Acceptance by the Purchaser at the Contractor's Palo Alto facility. Upon completion of the Purchaser's inspection of the Satellites and upon satisfactory completion of the acceptance testing by the Contractor, the Purchaser shall provide written notice to the Contractor of its Interim Acceptance of a Satellite. This written Interim Acceptance shall be provided at the Satellite Pre-shipment Review, to be held in Palo Alto, prior to the shipment of the Satellites to the Launch Site for FM-1, FM-2 and FM-3 or to Ground Storage for FM-4.

8.3 Final Acceptance of FM-1, 2 and 3 Satellites. When each of FM-1, FM-2 and FM-3 arrive at the Launch Site, inspection and verification testing will be performed by the Contractor to make sure that no damage occurred to the Satellites during shipment to the Launch Site. The Contractor shall then conduct the Satellite Launch Readiness Review in accordance with Exhibit A, Statement of Work. Final Acceptance of a Satellite shall be deemed to occur upon delivery On-Orbit/Checked Out. The Parties sole rights and remedies in the event of Final Acceptance based on Satisfactory; Less Than Satisfactory Operation, or Satellite Failure, shall be as set forth in Article 12, In-Orbit Check-Out.

8.4 Final Acceptance of the Fourth Satellite. Final Acceptance of FM-4 shall be deemed to occur only upon delivery of such Satellite to the Purchaser's designated CONUS Ground Storage facility.

Article 9.

CIP POINT, TITLE, AND RISK OF LOSS

9.1 Title and Risk of Loss. The title for FM-1, FM-2 and FM-3 shall pass to the Purchaser at the time of delivery of such Satellite On-Orbit/Checked Out or, in the case of a Satellite delivered for Ground Storage, in accordance with the requirements of Article 35 hereof. Risk of loss and/or damage for FM-1, FM-2 and FM-3 shall pass to the Purchaser at the time of Launch of such Satellite or, in the case of a Satellite delivered for Ground Storage, in

accordance with the requirements of Article 35 hereof. Title and risk of loss and/or damage for FM-4 shall pass to the Purchaser upon delivery of the Satellite to the Purchaser designated CONUS Ground Storage site. Neither the Contractor nor any of its subcontractors or suppliers at any tier shall be liable to the Purchaser or its agents, representatives, or customers

(including insurers of Satellite(s)) for loss of or damage to a Satellite after Launch (including if the Contractor furnishes post-Launch mission or operational support, if any), regardless of the cause or theory. The Contractor's sole responsibility in the event of such loss or damage arising from or related to the provision of such support shall be as set forth in Article 25. The Purchaser agrees to indemnify and hold harmless the Contractor for all costs, expenses and losses of the Contractor that result from claims or litigation based upon the Contractor's alleged responsibility, or liability, or the alleged responsibility of the Contractor's subcontractors or suppliers for loss of, or damage to, the Satellites occurring after Launch, regardless of the cause or theory.

9.2 CIP Point. The Contractor will provide Carriage and Insurance Paid (CIP) to the applicable Launch Pad for FM-1, FM-2 and FM-3 and to the applicable Purchaser designated CONUS Ground Storage site for FM-4.

9.3 Terminated Ignition Contingency Support. In the event of the occurrence of a Terminated Ignition of the Launch Vehicle used for the Launch of the FM-1, FM-2 or FM-3, the Parties agree that the Contractor shall immediately reacquire risk of loss of the affected Satellite and immediately commence work subsequently required to ready the Satellite for a Launch Vehicle relaunch (including, as applicable, demating and defueling of Satellite, procurement of applicable insurance(s), the Contractor taking re-possession of the Satellite upon its removal from the Launch Vehicle, storage, shipping of Satellite back to Palo Alto, refurbishing, retesting, re-shipping, and re-initiation and performance of a subsequent Launch, and any other related effort). It is agreed by the Parties that such support shall be provided at the Purchaser's expense and shall be subject to an equitable adjustment to this Contract for schedule and the price of such work as mutually agreed to by the Parties. Equitable adjustment for such work and all affected terms of this Contract, its Exhibits and Schedule(s), as applicable, shall be negotiated within thirty (30) days of the Terminated Ignition or as otherwise agreed to by the Parties.

In such event where the Contractor proceeds with the Terminated Ignition contingency support as described in this Article 9.3, the application of Article 25 shall also apply.

In such event where the Contractor proceeds with the Terminated Ignition contingency support and pending final negotiation of an equitable adjustment, both as described in this Article 9.3, the Parties agree to perform their respective obligations described elsewhere in this Contract.

Article 10.

ACCESS TO WORK IN PROGRESS

10.1 Work in Progress at Contractor's Plant. For the purpose of observing the quality of the Contractor's performance of work, a pre-agreed limited number of the Purchaser's personnel (including its consultants who must be approved in advance by the Contractor) shall be allowed to observe, on a non-interference basis, work being performed at the subsystem level and above for the Satellites, at the Contractor's plant. Such observation shall occur during normal working hours that are reasonable under the circumstances. The Contractor shall provide office space and access to telephone, copy and fax machine services for the Purchaser's personnel, not to exceed four (4), at the Contractor's facility.

10.2 Work in Progress at Subcontractor's Plants. To the extent permitted by the Contractor's major subcontractors, and any U.S. Government restrictions, the Contractor shall allow the Purchaser access to work being performed pursuant to this Contract in subcontractors' plants for the purpose of observing the quality of subcontractor's performance of work, subject to the right of the Contractor to accompany the Purchaser on any visit to a subcontractor's plant. The Contractor will exert its best efforts in subcontracting to obtain permission for such access to subcontractors' facilities.

Article 11.

TAXES AND DUTIES

11.1 U.S. Taxes (Excluding Sales Taxes). Tariffs, duties, taxes (except sales taxes) or other charges levied by any taxing authority within the United States of America on the goods, equipment, materials or effort covered by this Contract shall be paid by the Contractor.

11.2 U.S. Sales Taxes. The Purchaser shall be responsible for the payment of any sales taxes levied against the effort under this Contract by any

taxing authority within the United States.

11.3 Foreign Taxes. The Contractor shall be responsible for all foreign taxes (including sales taxes, if any) on the goods, equipment, materials or effort covered by this Contract, including those associated with subcontract work.

11.4 Contractor Payment of Taxes. In the event that the Contractor is required to pay or withhold any sales tax imposed by any taxing authority within the

United States in connection with this Contract, which is the responsibility of the Purchaser under the terms of this Contract, and the Contractor pays such sales tax for the Purchaser, the Price shall be increased by an amount to account for such sales tax and the amount shall be invoiced by the Contractor as an obligation that is immediately due and payable by the Purchaser.

11.5 Survival. The provisions of this Article shall survive the expiration, completion, or termination of this Contract.

Article 12.

IN-ORBIT CHECK-OUT FOR FM-1, FM-2 and FM-3

12.1 In-Orbit Check-Out Amounts. Included in the Price, is an In-Orbit Check Out Amount for the In-Orbit Check-Out of FM-1, FM-2 and FM-3. Upon the completion of the In-Orbit Testing of each Satellite, the Contractor shall be entitled to payment of the applicable In-Orbit Check Out Amount in accordance with the following:

(a) Satisfactory Operation. Following Launch, successful injection and In-Orbit Testing of a Satellite, and verification that the Spacecraft meets the requirements of Article 13 - SATISFACTORY OPERATION, the Contractor shall be entitled to payment of the full amount of the In-Orbit Check-Out Amount applicable to such Satellite, 30 days from completion of the IOT Summary Review.

(b) Less than Satisfactory Operation. In the event that the In-Orbit Testing of a Satellite shows that the Satellite does not meet all the requirements of Article 13 - SATISFACTORY OPERATION, the Parties shall negotiate a equitable reduction in the In-Orbit Check-Out Amount to be paid to the Contractor, taking into account, as a primary consideration, the impact of such out-of-spec condition(s) on the operational capability of the Satellite and any consequent reduction in revenue from the Satellite. If at completion of In-Orbit Testing of a Satellite it is determined that such Satellite has a service life that is predicted to be less than seven and one-half (7 1/2) years due to the Contractor's fault or negligence then the Purchaser's sole remedy, and Contractor's sole liability, shall be forfeiture of the In-Orbit Check Out Amount for the applicable Satellite.

(c) Satellite Failure. In the event that there is a Satellite Failure of FM-1, FM-2 or FM-3 prior to delivery, On-Orbit/ Checked Out, due to reasons of a Launch Failure or otherwise not due to the Contractor's fault or negligence, the Contractor shall be paid the full amount of the applicable In-Orbit Check-Out Amount by the Purchaser thirty (30) days after submission of an invoice for

such payment. In the event of a Satellite Failure due to the Contractor's fault or negligence or which does not result from Launch Failure, the Purchaser's sole remedy, and Contractor's sole liability, shall be forfeiture of the In-Orbit Check Out Amount for the applicable Satellite.

In the event there is a Satellite Failure of FM-1, FM-2 or FM-3, due to the Contractor's fault or negligence, prior to delivery of any such Satellite On-Orbit/Checked Out, then the Purchaser shall not be required to pay any In-Orbit Check Out Amount in connection with the On-Orbit/Checked Out delivery of a replacement Satellite (I.E., FM-4).

Article 13.

SATISFACTORY OPERATION

For purposes of calculating the In-Orbit Check-Out Amount, the term "Satisfactory Operation" means that the applicable Satellite is in conformance with the requirements set forth in Exhibit B - Satellite Performance Specification to this Contract, taking into account tolerances for measurement accuracy; provided, however, that any failure of the applicable Satellite to meet the performance specified in said Exhibit which is capable of being corrected by switching to one redundant unit in the Satellite within 30 minutes after said failure is discovered or which does not have a material impact on Satellite performance (including broadcast capacity and useful life), shall not be deemed as causing nonconformance to said Exhibit.

Article 14.

ADDITIONAL SATELLITE OPTION

14.1 Order for Optional Satellite. The Purchaser may, at its option to be exercised by written notice delivered to the Contractor at any time on or before 1 May 2000, order the Contractor to produce and deliver CIP to a Purchaser designated CONUS Ground Storage site an additional Satellite identical to those being furnished pursuant to Article 2- SCOPE OF WORK.

14.2 Delivery of Optional Satellite. If the optional Satellite is ordered on or before 1 November 1998, then the delivery of the optional Satellite shall be six months following the delivery of FM-4 ordered hereunder. If the optional Satellite is ordered after 1 November 1998, then the delivery of this optional Satellite shall be 28 months after the option is exercised, or six months following the delivery of FM-4 ordered hereunder, whichever is later.

14.3 Option Prices. The Price for ordering an additional Satellite is Ninety-Million dollars ($90,000,000) if ordered prior to May 1, 1999 and Ninety-Four- Million-Five-Hundred-Thousand dollars ($94,500,000) if ordered on or after May 1, 1999 through May 1, 2000.

14.4 Payment Plan. A Payment Plan for an optional Satellite ordered under this Article is included in the Payment Plan, Attachment A.

14.5 Terms and Conditions. In the event that the option provided for under this Article is exercised by the Purchaser, then the terms and conditions of this Contract shall be applicable to such option (unless the Parties agree otherwise), except for the financial and delivery provisions of the Contract which will be modified to reflect the procurement of the additional optional Satellite.

Article 15.

SUCCESSFUL INJECTION

15.1 Definition. Injection of a Satellite shall be considered successful if both of the following circumstances occur:

a. No damage occurs to the Satellite which can be shown to have resulted from Launch Failure or malfunction.

b. The elements of the transfer orbit attained by the Launch Vehicle and Launch Vehicle orientation at the time of separation of the Satellite from the Launch Vehicle are within the 3-sigma limits of the Launch Vehicle performance established by the Contractor.

15.2 Unsuccessful Injection. If the transfer orbit attained by the Launch Vehicle or Launch Vehicle orientation at the time of separation of the Satellite from the Launch Vehicle are outside the 3sigma limits, the Satellite injection shall be considered unsuccessful. However, the Contractor shall use its best efforts to utilize the propulsion capabilities of the Satellite to achieve a successful final orbit. Notwithstanding achievement of a successful final orbit, this situation shall be treated as an "Unsuccessful Injection." Payment of the In-Orbit Check Out Amount for the applicable Satellite shall be made and the Purchaser shall then have the right to use said Satellite for any purpose without incurring any obligation to the Contractor (subject to the terms of the Purchaser's salvage provision of any applicable insurance policy).

Article 16.

INSURANCE OPTION

16.1 Exercise of Option. The Purchaser may, at its option, to be exercised by written notice delivered to the Contractor by March 31, 1999 for FM-1, FM-2 or FM-3 order the Contractor to procure Launch insurance to cover the risk of loss to the applicable Satellite for the period of time from Launch (as defined in this Contract) through a period after Launch which shall be defined by the Purchaser at the time of option exercise.

16.2 Price and Payment Terms. Upon written receipt by the Contractor of the Purchaser's election to exercise this option, the Contractor shall provide the Purchaser with the price and payment terms for this option within thirty (30) days. If the Purchaser accepts the Contractor's price and payment terms, then the exercise of this option shall be subsequently effected through an amendment to this Contract.

16.3 Risk of Loss and Title. Subsequent to agreement by the Parties on the price and applicable terms for this option, the Parties agree that risk of loss of the effected Satellite(s) shall pass at the end of the period covered by this insurance option.

16.4 Terms and Conditions. In the event that the option provided for

under this Article 16 is procured by the Purchaser, (i) the remaining terms and conditions of this Contract, as applicable, and, as modified in this Article 16, shall apply, and (ii) the Purchaser and the Contractor agree to incorporate appropriate language required to support this effort (E.G., applicable insurance related definitions and language).

Article 17.

U.S. GOVERNMENT LICENSES FOR FM-1, FM-2 OR FM-3

17.1 U.S. Government License. The Contractor shall have the responsibility to obtain export licenses as required for delivery and Launch of FM-1, FM-2 and FM-3. The Purchaser agrees to use its best efforts to assist the Contractor in such efforts. The Contractor shall have no liability for costs, damages or expenses incurred by the Purchaser for any reason whatsoever, resulting from or in connection with any decision on the part of the U.S. Government with regard to the issuance of a license, or refusal to issue a license for export or Launch on a non-U.S. Launch

Vehicle. Both Parties agree to abide by the provisions of any license issued by the U.S. Government.

17.2 Purchaser's Documentation Required for License Application. The Purchaser agrees to provide the Contractor with the Purchaser's data or documentation, as may be required for submitting any license request.

Article 18.

FORCE MAJEURE

It is recognized by the Parties that a Force Majeure event may delay the performance of the work on the Program or cause non-performance of this Contract by the Contractor, provided however that the Contractor shall use its best efforts to avoid or minimize the effects of such late delivery, delay or non-performance. Such excusable delay shall not be a default hereunder or a ground for termination hereof.

18.1 Definition. Force Majeure shall include any event beyond the reasonable control of the Contractor and its subcontractors and shall include, but will not be limited to, acts of God, acts of a public enemy, acts of any Government in its sovereign capacity, war and warlike events, unusually severe weather, fire, mud slides, earthquakes, floods, epidemics, quarantine restrictions, sabotage, riots and embargoes; which in every case, are beyond the reasonable control and without the fault or negligence of the Contractor and its subcontractors. Upon the occurrence of Force Majeure, an equitable adjustment shall be negotiated in the schedule and other affected portions of this Contract. In addition , failure to deliver the Launch Services required by this Contract due to causes beyond the Contractor's control (including prior failures of the designated Launch Vehicle) will be an excusable delay under this Article 18.

18.2 Delayed Delivery. Accordingly, the Contractor shall not be responsible for the late delivery, delay of final completion or non-performance of its contractual obligations due to Force Majeure events to the extent such events affect the delivery, completion or non-performance under this Contract.

18.3 Notification. The Contractor shall advise the Purchaser in writing as soon as possible after the Contractor has learned of a delay or potential delay but not later than five (5) days after the onset, and again at the termination, of a Force Majeure event.

Article 19.

PURCHASER'S DELAY OF WORK

If the performance of all or any part of the work required by this Contract is delayed or interrupted by (1) any act of the Purchaser in the administration of this Contract, or (2) by any acts of the Purchaser which are not expressly or impliedly authorized by this Contract, or (3) by the Purchaser's failure to perform its contractual obligations within the time specified in this Contract, or within a reasonable time if no time is specified, then this Contract shall be equitably adjusted in the Price, performance requirements, schedule, and/or any other affected terms of this Contract. Such delay of work does not include that caused by a Force Majeure event.

Article 20.

RIGHTS IN DATA

The Contractor shall retain all rights, title and interest in any Contractor data, invention, discovery or improvement utilized or developed by the Contractor during the performance of this Contract.

20.1 Deliverable Data. The Purchaser's officers, employees, consultants, representatives and agents shall have the perpetual, paid-up, royalty-free, world-wide, nonexclusive right to use the deliverable Data and Documentation for the purpose of establishing, operating, and maintaining the CD Radio DARS System and for no other purpose. The Purchaser's officers, employees, consultants, representatives, and agents shall not disclose such Data and Documentation (or any other data obtained by Purchaser under this Contract) to other companies, organizations or persons without the express written consent of the Contractor.

20.2 Other Data. All other Contractor data, or data of its subcontractors, to which the Purchaser may have access to in the course of the Contractor's performance of this Contract shall remain the property of the Contractor or its subcontractors and shall not be duplicated, used, or disclosed to persons other than the Purchaser's officers, employees, consultants, representatives or agents and shall be used solely to assist the Purchaser in establishing, operating and maintaining the CD Radio DARS System including Satellite/ground equipment interface. This data may only be provided to third parties with the prior written approval of the Contractor, and, if applicable, Contractor's subcontractors, in each case which consent will not be unreasonably withheld or delayed. Nothing contained in this Article shall require the Contractor to provide any data beyond that set forth in Exhibit A.

20.3 Purchaser's Data. The Contractor and its officers, employees, consultants, subcontractors and representatives shall not disclose any data or information obtained from the Purchaser and its officers, employees, consultants or representatives during the performance of its obligations under this Contract to other companies, organizations or persons without the express written consent of the Purchaser.

20.4 Confidentiality. The confidentiality obligations imposed on the Contractor and Purchaser under this Article 20 with regard to data provided under this Contract shall survive the termination, for whatever reason, of this Contract, in accordance with the requirements of Attachment C, Non-Disclosure Agreement.

Article 21.

PATENT INDEMNITY

21.1 The Contractor, at its own expense, shall defend, indemnify and hold the Purchaser harmless against any claim or suit against the Purchaser based on an allegation that the manufacture of any item in the performance of this Contract, or the normal intended use, lease or sale of any item delivered or to be delivered under this Contract, infringes any U.S. letters patent, copyrights or trade secrets, and shall pay any royalties and other costs of the settlement of such claim or suit and the costs and damages finally awarded, including reasonable attorney fees as the result of any suit, provided that the Purchaser promptly notifies the Contractor in writing of any such claim or suit and gives the Contractor authority and such assistance and information as is reasonably available to the Purchaser for the defense of such claim or suit.

21.2 If the manufacture of any item in the performance of this Contract, or the normal intended use, lease or sale of any item delivered under this Contract, is enjoined as a result of a suit based on such claim of infringement, the Contractor shall resolve the matter by negotiating a license or other agreement so that the injunction no longer pertains; otherwise, the Contractor shall be liable to the Purchaser for the Purchaser's additional costs and damages arising as a result of such injunction, subject to the limitation set forth in Sub-Article 21.6 provided that the conditions of Sub-Article 21.3 herein do not apply.

21.3 The indemnity provided under this Article shall not apply to the Contractor's delivery of normally non-infringing items and their intended use which are rendered infringing by the Purchaser's modification of said items or by a combination of said items with items not provided by the Contractor under this Contract.

21.4 The indemnity provided under this Article does not extend to any infringement resulting from a change in method of manufacture of an item to be delivered, ordered by the Purchaser pursuant to Article 27 - CHANGES, or the stipulation by the Purchaser of the specific design of an item to be delivered if infringement would not have occurred but for compliance with such change or design.

21.5 The indemnity provided under this Article does not extend to any claim that the placement of any Satellite in any orbit other than geostationary(E.G., a highly inclined geosynchronous orbit) directed or stipulated by the Purchaser infringes the intellectual property rights of any third party.

21.6 In no event shall the Contractor's total liability for patent infringement as specified in this Article 21 (including the occurrence of

injunction per Sub-Article 21.2) exceed 160% of the price of the affected Satellite(s).

Article 22.

INDEMNITY - PERSONAL INJURY/PROPERTY DAMAGE

22.1 Contractor Indemnification of the Purchaser. The Contractor shall indemnify and hold harmless the Purchaser, its officers, directors, employees, consultants, representatives and agents from any loss, damage (not including any lost profits or consequential damages), claims, liability, and causes of action for injury or death of any third party, or for damage to, or destruction of, third party property (excluding any Satellite provided under this Contract following the Launch of such Satellite) arising out of negligent acts or omissions by the Contractor, its officers, directors, employees, consultants, representatives, agents or subcontractors in connection with, or relating to, the manufacture, testing, and delivery of a Satellite occurring at or before the Launch or, if delivered to Ground Storage, delivery to Ground Storage, of the last Satellite ordered under this Contract, except to the extent such loss, damage, claims, liabilities or causes of action arise from the fault or negligence on the part of the Purchaser, its officers, directors, employees, consultants, representatives, agents or subcontractors. The Contractor's responsibility with respect to items delivered hereunder shall be solely governed by the provisions of Article 25, WARRANTY.

22.2 Purchaser Indemnification of Contractor. The Purchaser shall indemnify and hold harmless the Contractor, its officers, directors, employees, consultants, representatives and agents from any loss, damage (not including any lost profits or consequential damages), claims, liability, and causes of action for injury or death of any third party, or for damage to or destruction of third party property arising out of negligent acts or omissions by the Purchaser, its officers, directors, employees,

consultants, representatives, agents, or subcontractors occurring at or before the Launch (or, if delivered to Ground Storage, delivery to Ground Storage) of the last Satellite ordered under this Contract, except to the extent such loss, damage, claims, liabilities or causes of action, arises from the fault or negligence on the part of the Contractor, its officers, directors, employees, consultants, representatives, agents, or subcontractors.

22.3 Property Damage Insurance. The Contractor certifies it has all-risk property insurance and will maintain such policy through completion of this Contract. The Contractor will use best efforts to include the Purchaser as a named beneficiary, at no additional cost to Contractor, under any indemnities or insurance provided by a Launch Agency against claims by third parties for bodily or property damage resulting from a Launch.

Article 23.

RESERVED

Article 24.

DEFAULT

24.1 Failure to Perform by the Contractor. Subject to the expiration of the Late Delivery Penalty Periods provided in Article 3.4, if the Contractor (1) fails to deliver the deliverable items or perform the work under the Contract within the time specified herein, or any approved extension thereof, or (2) fails to prosecute the work so as to endanger performance of this Contract, or (3) fails to perform any of the other material provisions of this Contract, and in each case does not cure such failure within 30 days (or such longer period as authorized by the Purchaser) after receipt from the Purchaser of written notice of such failure, then the Purchaser, at its option, may terminate this Contract in whole or in part by written notice of default. Upon termination for default, the Contractor shall be reimbursed for the terminated work as follows: (1) at price for delivered items for which a line item price exists and (2) at cost incurred for (a) completed items-not delivered, for which no line item price exists, (b) partially completed items/services, or work-in-process, and (c) completed items delivered, for which no line item price exists. If this Contract is terminated by the Purchaser as a result of a default, then the Contractor shall promptly refund to the Purchaser all amounts paid by the Purchaser on account of unfurnished Launch Services which are required to be arranged by the Contractor under this Contract,

subject to the rights of the banks under the Bank of America Credit Agreement to the extent such refund constitutes the Bank's collateral.

24.2 Payment for Completed and Incomplete Items. To the extent that this Contract is terminated under Sub-Article 24.1, the Purchaser may require that all partially completed items be delivered by the Contractor, excluding unfurnished Launch Services, and that the Contractor pay to the Purchaser all costs reasonably incurred by the Purchaser in having the work prosecuted to

completion, by contract or otherwise, by a responsible contractor in a reasonable time period following termination for default; provided that Contractor's liability for such additional costs shall not exceed 60% of the applicable Satellite price.

24.3 LIMITATION OF CONTRACTOR'S LIABILITY. IF THE CONTRACTOR FAILS TO MEET ITS OBLIGATIONS TO PERFORM THE WORK UNDER THIS CONTRACT THE REMEDIES SET FORTH IN THIS Article AND IN Article 25 - WARRANTY (only for those items completed and delivered to the Purchaser under this Contract), AND IN Sub-Article 3.4 - LATE DELIVERY PENALTIES, IF INCURRED, SHALL BE THE SOLE COMPENSATION TO WHICH THE PURCHASER IS ENTITLED AND ARE IN LIEU OF ANY PENALTY, AND THE CONTRACTOR SHALL HAVE NO LIABILITY FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR FOR LOST REVENUES OR PROFITS.

24.4 Contractor Termination.

24.4.1 The Contractor may terminate this Contract for the Purchaser's failure to comply with any material provision of this Contract; provided, that the right of the Contractor to terminate this Contract upon breach by the Purchaser of any of its covenants and agreements set forth in Sub-Articles 5.1.2 through 5.1.4 hereof shall be governed by Sub-Article 24.4.2 below. Such termination, under this Sub-Article 24.4.1, will become effective should the Purchaser fail to correct such nonperformance within thirty (30) days of receipt of notice in writing from the Contractor.

24.4.2 (i) The Contractor may immediately terminate this Contract upon the occurrence of an "Event of Default" (as such term is defined in the Bank of America Credit Agreement) under the Bank of America Credit Agreement. Any such termination under this Article 24.4.2 shall become effective upon delivery to the Purchaser of notice of such termination in writing from the Contractor.

(ii) The Contractor may immediately terminate this Contract upon a breach by the Purchaser of any of its covenants and agreements

contained in Sub-Article 5.1.4, such termination to become effective upon delivery to the Purchaser of notice of such termination in writing from the Contractor.

(iii) The Contractor may terminate this Contract upon a breach by the Purchaser of any of its covenants and agreements contained in Sub-Article 5.1.3. Such termination shall only become effective should the Purchaser fail to correct such non-performance within thirty (30) days of receipt of notice of such termination in writing from the Contractor.

(iv) So long as the Support Agreement (as such term is defined in the Bank of America Credit Agreement) is in full force and effect (including at all times from and after the purchase, if any, of the Term Loans (as such term is defined in the Support Agreement), and Loral is not in default of its obligations under Section 2 of the Support Agreement, the Contractor may immediately terminate this Contract upon a breach by the Purchaser of any of its covenants and agreements contained in Sub-Article 5.1.2, such termination to become effective upon delivery to the Purchaser of notice of such termination in writing from the Contractor. At all other times the Contractor may terminate this Contract upon a breach by the Purchaser of any of its covenants and agreements contained in Sub-Article 5.1.2, but such termination shall only become effective should the Purchaser fail to correct such non-performance within thirty (30) days of receipt of notice of such termination in writing from the Contractor.

24.4.3 In the event of termination of this Contract by the Contractor under this Sub-Article 24.4, the Contractor shall be paid the following:

a. Actual costs incurred by the Contractor for items completed prior to the termination and accepted before or after termination but not previously invoiced and paid for by the Purchaser for which a line item price exists,

b. Actual costs incurred by the Contractor in performance of work on terminated items not accepted under subparagraph (a) above,

c. Actual costs incurred by the Contractor in completing the termination process,

d. Actual costs incurred in settling claims of subcontractors and other suppliers and vendors in connection with the termination (the Contractor agrees to use its best efforts to settle with any such subcontractors, suppliers and vendors at the lowest possible cost), and

e. All damages that the Contractor is entitled to

under the uniform commercial code of the State of New York.

The Contractor's termination claim under Sub-Article 24.4 (a) through (d) shall be forwarded to the Purchaser within ninety (90) days of the Contractor's notice of termination to the Purchaser. The Purchaser may require at its expense that the Contractor's claim for the above costs be verified by an independent party. Such verification would exclude Contractor's Proprietary Data.

24.5 Residual Inventory and Unfurnished Launch Services. Following the submission of the Contractor's termination claim to the Purchaser, the Contractor shall dispose of the residual inventory and unfurnished Launch Services using its best efforts to purchase or sell any parts, components, boxes, Launch Service(s) or subsystems originally bought or manufactured for this Contract on the best terms possible in the circumstances, subject to the rights of any other person in and to this Contract (including, but not limited to, the rights of any party holding a lien on or security interest in this Contract as collateral for obligations owed to such person by any party hereto). In the event the amount of the Contractor's termination claim exceeds the amounts paid to the Contractor to the date of termination, the Contractor shall apply the amounts received from the disposal of the Contract inventory or reassigned Launch Service(s), less reasonable selling or reassignment expenses, to the termination claim. In the event that payments to the Contractor by the Purchaser to the date of termination, plus the amount received from the disposal of such inventory, is in excess of the Contractor's termination claim, then the amount of that excess shall be retained by the Contractor as an offset against lost profits or other damages due to the Contractor under Sub-Article 24.4.1 (e). At the conclusion of the Contractor's claim for lost profits and damages allowed under Sub-Article 24.4.1 (e), any excess shall be promptly refunded to the Purchaser. In the event that the amount paid to the Contractor to the date of termination, plus the amount received by the Contractor from the liquidation of such inventory and unfurnished Launch Services, if any, is insufficient to cover the amount of the Contractor's termination claim, then the Contractor shall have the right to proceed against the Purchaser for the amount of such excess.

24.6 LIMITATION OF THE PURCHASER'S LIABILITY. THE RIGHTS AND REMEDIES SET FORTH IN THIS Article SHALL BE THE SOLE REMEDIES TO WHICH THE CONTRACTOR IS ENTITLED IF THE PURCHASER FAILS TO MEET OR PERFORM ITS OBLIGATIONS UNDER THIS CONTRACT. THE PURCHASER SHALL HAVE NO LIABILITY FOR CONSEQUENTIAL DAMAGES.

Article 25.

WARRANTY

The Contractor warrants that (i) for FM-1, FM-2 and FM-3, from Interim Acceptance pursuant to Article 8.2 up to Launch or (ii) for FM-4 for a period extending two (2) years starting from Interim Acceptance pursuant to Article 8.2, each Satellite is in accordance with the applicable specification and other requirements of this Contract, and is free from defects in materials and workmanship. This warranty is subject to the following provisions with respect to such Satellite(s).

25.1 Unlaunched Satellite(s). During the warranty period, either party may give notice to the other of a defect. The Contractor's sole responsibility under this warranty shall be either to repair or replace any component which is discovered during the warranty period to be defective in material or workmanship, and to retest the repaired or replaced component as is determined appropriate action by the Parties, in order to place the Satellite in a suitable condition for Launch. This warranty shall continue for the duration of the applicable warranty period as stated in this Article 25.

The remedy under this Sub-Article 25.1 shall not apply if adjustment, repair or parts replacement is required because of accident, unusual physical or electrical stress, negligence, misuse, failure of environmental control prescribed in operations and maintenance manuals, repair or alterations by the Purchaser, its officers, directors, employees, consultants, representatives, agents or subcontractors, or causes other than ordinary use. If the defect is not covered by this warranty, the Purchaser shall pay the Contractor the cost of repairs or replacement, the transportation charges and a reasonable profit. Such repair cost shall be invoiced to the Purchaser pursuant to the provisions of Article 5. The remedy stated in this Sub-Article 25.1 is the Purchaser's exclusive remedy for the Contractor's nonconformance with the warranties set forth in this Article.

25.2 Transportation Charges. Transportation charges for the repaired or replaced item shall be at the Contractor's expense only if the Contractor is found responsible under the terms of this warranty. The Purchaser shall notify the Contractor in writing of any such defect, relevant information with respect thereto, and of the intended return of the item sufficiently in advance of the intended shipment date to arrange shipment should the Contractor so desire.

25.3 Launched Satellite. This warranty shall not apply to a Satellite after its Launch.

25.4 Limit of Liability. NOTWITHSTANDING ANY OTHER PROVISIONS OF THIS CONTRACT TO THE CONTRARY, THIS WARRANTY IS

IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHETHER ARISING FROM LAW, CUSTOM OR CONDUCT, AND THE RIGHTS AND REMEDIES PROVIDED HEREIN ARE EXCLUSIVE AND IN LIEU OF ANY OTHER RIGHTS OR REMEDIES RELATED TO THE DESIGN, MANUFACTURE, MATERIALS, WORKMANSHIP, OR CONFORMANCE TO SPECIFICATION REQUIREMENTS OF THE SATELLITE(S) AND ASSOCIATED ITEMS AS ARE SET FORTH IN EXHIBITS A THROUGH E HERETO, (EXCEPT FOR RIGHTS AND REMEDIES ARISING UNDER Article 8, "INSPECTION AND ACCEPTANCE", Article 12, "IN-ORBIT CHECK-OUT" AND Article 24, "DEFAULT"). IN NO EVENT SHALL THE CONTRACTOR BE LIABLE FOR ANY INDIRECT, SPECIAL, EXEMPLARY, INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR FOR LOST REVENUES OR PROFITS.

Article 26.

DISPUTES AND ARBITRATION

Any disputes which may arise between the Parties with respect to performance of obligations or interpretation of this Contract, which cannot be settled by negotiation between the Parties themselves, shall upon application of either of the Parties be submitted for settlement by arbitration by the American Arbitration Association in New York, New York, in accordance with the rules of commercial arbitration of the American Arbitration Association using three arbitrators, whose decision and award shall be final and binding on the Parties and be enforceable by any Court of competent jurisdiction. In resolving any dispute, the arbitrators shall apply the laws of the State of New York with respect to all matters, including the interpretation of the terms and conditions of this Contract. Of the three arbitrators in the case, one shall be appointed by the Purchaser, one shall be appointed by the Contractor and the third shall be appointed by the agreement of both Parties. In the event that the Parties cannot agree on the third arbitrator, then the third arbitrator shall be appointed by the President of the American Arbitration Association. Each Party shall bear the costs of preparing and presenting its own case, unless the arbitrators' award shall provide otherwise.

A party may, pending resolution of a dispute in an arbitration proceeding brought under this Article 26, nevertheless seek specific performance in any court having jurisdiction therefor, of the obligations, undertakings, agreements and covenants of the other party pursuant to this Contract.

Article 27.

CHANGES

27.1 Changes in Scope of Work. Purchaser-desired changes to the Scope of Work may be implemented provided the Parties agree in advance upon a mutually satisfactory Contract adjustment regarding Price, schedule, and other provisions of this Contract affected by such changes. Any such change shall become effective only upon the execution by the Parties of an amendment to this Contract incorporating such changes and the resulting adjustment. The Contractor shall have no obligation to proceed with the Purchaser-desired changes prior to the execution of such an amendment or receipt of a funded Authorization to Proceed (ATP) wherein the Purchaser assumes the cost of the Contractor's performance on the desired change.

Article 28.

MISCELLANEOUS PROVISIONS

28.1 Applicable Law. This Contract shall be construed and interpreted and the rights of the Parties shall be determined, in all respects, according to the laws of the State of New York (USA), without regard to any principles of conflicts of law that would result in a choice of law other than New York.

28.2 Amendments and Supplements. This Contract may be amended or supplemented by additional written Agreements, Articles or Certificates, as may be determined by the Parties from time to time to be necessary, appropriate or desirable to further the purpose hereof, to clarify the intention of the Parties, or to add to or modify the covenants, terms or conditions hereof or thereof.

28.3 Headings. The headings in this Contract are for convenience only and shall not be considered a part of, or affect, the construction or interpretation of any provisions of this Contract.

28.4 Counterparts. This Contract may be executed in two or more counterparts, each of which shall be an original, but all of which together shall constitute one and the same document.

28.5 Severability. In the event any one or more of the provisions of this Contract shall, for any reason, be held to be invalid or unenforceable, the remaining provisions of this Contract shall be unimpaired, and the invalid or unenforceable provisions shall be replaced, if possible, by a mutually acceptable

provision which, being valid and enforceable, comes nearest to the intention of the Parties.

28.6 LIMITATION OF LIABILITY. THE CONTRACTOR SHALL NOT BE LIABLE DIRECTLY OR INDIRECTLY TO THE PURCHASER, TO THE PURCHASER'S OFFICERS, DIRECTORS, EMPLOYEES, AGENTS OR CUSTOMERS, OR TO PERMITTED ASSIGNEES OR SUCCESSOR OWNERS OF THE SATELLITE(S) FOR ANY AMOUNTS REPRESENTING LOSS OF PROFITS, LOSS OF BUSINESS, OR INDIRECT, SPECIAL, EXEMPLARY, CONSEQUENTIAL OR PUNITIVE DAMAGES ARISING FROM THE PERFORMANCE OR NONPERFORMANCE OF THIS CONTRACT OR ANY ACTS OR OMISSIONS ASSOCIATED THEREWITH OR RELATED TO THE USE OF ANY ITEMS OR SERVICES FURNISHED HEREUNDER, WHETHER THE BASIS OF THE LIABILITY IS BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), STATUTES OR ANY OTHER LEGAL THEORY. IN NO EVENT SHALL THE CONTRACTOR'S TOTAL LIABILITY UNDER OR IN CONNECTION WITH THIS CONTRACT EXCEED THE CONTRACT PRICE.

28.7 Alenia. The Contractor has teamed with Alenia Spazio in the execution of this program. The Parties agree that the previous sentence does not create a contractual liability or relationship between the Purchaser and Alenia Spazio under this Contract.

28.8 No Third Party Beneficiaries. Nothing contained in this Contract, express or implied, is intended to or shall confer upon anyone other the parties hereto (and their permitted successors and assigns) any right, benefit or remedy of any nature whatsoever under or by reason of this Contract.

Article 29.

RESERVED

Article 30.

INTER-PARTY WAIVER OF LIABILITY

Notwithstanding any indemnification provisions set forth in this Contract, the Purchaser agrees, on behalf of itself and its officers, directors,

employees, consultants, representatives, agents, subcontractors, insurers, and customers, to sign and agree to the no-fault, no-subrogation, inter-party waiver of liability provisions set forth in any Launch Services Agreement prior to entering on the Launch Site.

Article 31.

AUTHORITY OF THE PURCHASER'S REPRESENTATIVE

No request, notice, authorization, direction or order received by the Contractor and issued either pursuant to an Article of this Contract, to a provision of any document incorporated in this Contract by reference, or otherwise, shall be binding upon either the Contractor or the Purchaser, unless issued or confirmed in writing by the Chief Executive Officer of the Purchaser or by his authorized representative. Designations of authorized representatives (1) shall be in writing, signed by the Chief Executive Officer of the Purchaser, and (2) shall define the scope and limitations of the authorized representatives' authorities. A copy of each such designation and of each modification or cancellation thereof, shall be furnished to the Contractor. The Contractor shall immediately notify, in writing, the Chief Executive Officer of the Purchaser or his authorized representative whenever a request, notice, authorization, direction, or order has been received from a representative of the Purchaser other than the Chief Executive Officer of the Purchaser or his authorized representative, which, but for the lack of authorization on the part of the issuing Purchaser's representative, would effect a change within the meaning of Article 27 - CHANGES, or an increase in the Price or amounts allotted to this Contract, or which but for such lack of authorization, would otherwise be the basis for the modification of the Contract Statement of Work, delivery or performance schedule, Price, or any other terms and conditions of this Contract.

Article 32.

PUBLIC RELEASE OF INFORMATION

32.1 Within a reasonable time prior to the issuance of news releases, articles, brochures, advertisements, prepared speeches, and other information releases concerning the work performed hereunder by the Contractor, a subcontractor or any employee or a consultant of either, the Contractor shall obtain the written approval of the Purchaser concerning the content and timing of such releases. Approval will not be unreasonably delayed or denied.

32.2 The Purchaser may issue news releases, articles, brochures,

advertisements, prepared speeches, or other information concerning the CD Radio DARS System or the products and services to be provided under this Contract without the express consent of the Contractor; provided that to the extent such information relates to (i) any financing of the Purchaser which is being arranged with the assistance of credit support from the Contractor or its Affiliates or (ii) the Contractor in any other capacity besides manufacturer, then such information shall only be released for use with the prior written approval of the Contractor.

Article 33.

FUNCTIONS NOT THE RESPONSIBILITY OF THE CONTRACTOR

33.1 Radio Frequencies. The Contractor is not responsible for radio frequencies coordination, or the preparation of filings with the Federal Communications Commission or the International Telecommunications Union/Radio Communication Bureau registration. The Contractor shall provide technical support, when needed, to assist the Purchaser in making the above filings.

33.2 General. The Contractor shall not be responsible for any undertakings not expressly and specifically set forth in this Contract as being the assigned responsibility of the Contractor.

Article 34.

RESERVED

Article 35.

SATELLITE GROUND STORAGE OPTION

35.1 Notification. The Purchaser may, at its option to be exercised no later than September 1, 1999 (for FM-1, FM-2 or FM-3) order the Contractor to store a Satellite for a period of up to two (2) years after Interim Acceptance of the Satellite. In the case of FM-4, the Purchaser may, also at its option to be exercised no later than three (3) months prior to Satellite Pre-Shipment Review as defined in Exhibit A, order the Contractor to provide Ground Storage for the Satellite up to two (2) years after Final Acceptance of such Satellite.

35.2 Storage Location. Such Ground Storage shall be performed at a Contractor controlled facility and shall be conducted in accordance with the Satellite Storage Plan described in Section 8 of Exhibit D, Program Test Plan.

35.3 Storage and Verification Testing Prices. The storage price for a Satellite at the Contractor's Ground Storage facility is $30,000 per month of storage. Upon removal of a Satellite from Ground Storage, verification testing shall be conducted. The price of such verification tests shall be $122,000, if the Satellite storage was for six (6) months or less, or, $1,075,000, if the Satellite storage was greater than six (6) months through twenty-four (24) months after exercise of this option.

For a Satellite stored for two (2) years, the Purchaser shall notify the Contractor of its desire to have such Satellite refurbished or to continue Ground Storage of a Satellite for up to an additional twelve (12) months beyond the period specified in Article 35.1. Within ninety (90) days after the Contractor's receipt of the Purchaser's notice electing refurbishment or continued Ground Storage, the Contractor shall provide the Purchaser with (i) a plan for refurbishment and retesting to recertify the Satellite as Launchworthy or (ii) a plan for continued Ground Storage, in either case together with proposed adjustments to applicable provisions.

35.4 Payments. Any monthly storage charge referred to in Sub-Article 35.3 shall be paid commencing thirty (30) days from the date the Satellite is stored and continuing each month until the Purchaser directs the Contractor to remove the Satellite from storage, conduct the verification tests and ship the Satellite to the Launch Site. Payment for the verification testing shall be made 30 days after the Contractor issues an invoice for such testing. Payments shall be made by wire transfer as set forth in Article 5 - PAYMENTS.

35.5 Title and Risk of Loss. Title and risk of Loss to a Satellite delivered for Ground Storage shall remain with the Contractor at the Storage Site and notwithstanding the provisions of Article 9 - CIP POINT, TITLE, AND RISK OF LOSS and/or Article 25, WARRANTY, the Contractor shall assume full responsibility for any loss or damage to the Satellite during storage and transportation to the Launch Site and while the Satellite is at the Launch Site up to the time of Launch. If the Contractor's insurance rates covering the Satellite during transportation to the Launch Site and at the Launch Site are increased, through no fault of the Contractor, above the rates that prevailed at the time of Purchaser's exercise of this Ground Storage option, the additional cost shall be an amount that is due and payable to the Contractor from the Purchaser. It shall be incumbent upon the Contractor to minimize the additional cost for insurance, if any, that the Purchaser is obligated to pay under the terms of this Sub-Article. In the event of a decrease in the price of such insurance, the Contractor shall refund to the Purchaser the amount of the decrease.

35.6 Launch Services for a Stored Satellite. In the event that the Purchaser exercises the option to store a Spacecraft, and subsequent to a period of storage directs the Contractor to prepare the Spacecraft for Launch, then the Contract shall be equitably adjusted to cover the increase in the cost of providing Launch Services and mission operations support, if any, and any additional costs associated with extended mission support costs, if this option is exercised, and if such additional costs are incurred.

35.7 Escalation. The Prices quoted in this Article for the storage of a Satellite shall be escalated in accordance with the formula in Article 5, from the Effective Date of Contract to the option exercise date.

35.8 Storage at the Contractor's Site. In the event that the Purchaser directs the Contractor to deliver one or more Satellites for Ground Storage in accordance with this Article 35, then the Purchaser shall pay the Contractor interest on the scheduled payment amounts that would have been paid based on the scheduled payment date or the then projected Milestone completion date, whichever is later, had the Purchaser not directed Ground Storage at the rate of LIBOR + 2% for the period of storage, for the period of shipment of the Satellite to the Launch Site for a rescheduled Launch and for the period of up to the Launch of the Satellite. Such interest shall be paid on a monthly basis in accordance with the requirements of Article 5 - PAYMENTS.

35.9 Delivery of the Satellite to a Location Named by the Purchaser. In the event that the Purchaser directs the Contractor to deliver a Satellite to a location other than one controlled and operated by the Contractor, then the Purchaser shall pay to the Contractor the In-Orbit Check Out Amount applicable to such Satellite or, for FM-4, any amount that otherwise would have been due at delivery. The Contractor shall then have no further obligation to the Purchaser with regard to this payment and title and risk of loss to the Spacecraft shall pass to the Purchaser at the time of such delivery.

35.10 Other Costs. If the Contractor is required to pay any other costs (E.G., taxes, duties, transportation) for a Satellite directed to be stored in Ground Storage pursuant to this Article 35, which would not have been incurred had the Satellite been delivered as otherwise contemplated by this Contract, the Purchaser shall reimburse the Contractor for such taxes within thirty (30) days after receipt of invoice and appropriate documentation.

35.11 Maximum Storage Period. In no event shall a Satellite procured hereunder remain in storage at a location owned and operated by the Contractor for a period in excess of two (2) years from the date of Interim Acceptance of such Satellite by the Purchaser. At the conclusion of the storage period provided for hereunder, the

Use or disclosure of the data contained on this page is subject to the restriction on the title page of this Contract.

Purchaser shall direct the Contractor to deliver the Satellite to a location designated by the Purchaser. At the time the Contractor receives direction as to the delivery of such Satellite from storage, the Purchaser shall pay the Contractor the In-Orbit Check Out Amount for the applicable Satellite(s) or, for FM-4, any amount that otherwise would have been due at delivery.

Article 36.

NOTICES

Any notices or correspondence required or desired to be given or made hereunder shall be in writing and shall be effective when delivered to an authorized recipient party at the address indicated below:

PURCHASER:
CD Radio Inc.
1180 Avenue of the Americas, 14th Floor
New York, New York 10036
Phone: (212) 899-5031
Fax: (212) 899-5050

Attention: General Counsel
Phone: (212) 899-5031
Fax: (212) 899-5050

and

CD Radio Inc.
2175 K Street, NW
Washington, CD 20037

Attention: Rob Briskman
Phone: (202) 296-6192
Fax: (202) 296-6265

CONTRACTOR:
Space Systems/LORAL, Inc.
3825 Fabian Way
Palo Alto, California 943034697

Attention: John Dietzel (M/S G-82)
Phone: (650) 852-7370

FAX: (650) 852-4807

with Copy to: Brian Saleh, Executive Director

M/S: G-44
Phone: (650) 852-4502
FAX: (650) 852-6686

Either party may change the above notice addresses by giving written notice to the other party of said change.

Article 37.

ASSIGNMENT

37.1 This Contract may not be assigned other than to an Affiliate, either in whole or in part, by either party without the express written approval of the other party (which approval shall not be unreasonably withheld or delayed); provided however, this clause does not restrict the Contractor from utilizing subsidiaries or other divisions of its company to manufacture subsystems or components of the Satellite(s) or other hardware; and provided that either party may assign security interests in its rights hereunder to its lenders which provide financing for the performance by such party under this Contract. It is expressly understood that Article 7 of this Contract shall separately be pledged by Purchaser to secure its obligations under the Bank of America Credit Agreement, and Contractor agrees that Article 7, and the rights of the Purchaser under this Contract in connection therewith, may be so pledged. Contractor agrees that, in the event of a foreclosure of the security interests securing the obligations of Purchaser under the Bank of America Credit Agreement, Contractor shall provide the services set forth in Article 7 to the holder of security interests or its assignee with respect to other satellites.

37.2 Notwithstanding the above, in the event either party is sold to or merged into another company, its responsibilities under this Contract shall not be altered, and the successor shall remain liable for performance of this Contract.

Article 38.

RESERVED

Article 39.

RESERVED

Article 40.

RESERVED

Article 41.

SUPPORT FOR INVESTIGATION OF SATELLITE ANOMALIES

In the event that a Launched Satellite experiences anomalies during its operational life, the Contractor will provide reasonable support by qualified personnel to investigate said anomalies from Palo Alto, CA. The Contractor shall use its best efforts to identify the cause of the anomaly, to propose procedures to correct such anomaly, if feasible, and to provide operational procedures to avoid such an anomaly from occurring again. The above effort shall be provided on the verbal request of the Purchaser which shall be confirmed in writing within 24 hours of the time of the verbal request.

Article 42.

INSURANCE

42.1 The Purchaser agrees to obtain any insurer's written agreement to waive all rights of subrogation against the Contractor and against the Contractor's subcontractors and suppliers at any tier. The Purchaser agrees to indemnify and hold the Contractor harmless from and against all costs, expenses or losses of the Contractor directly or indirectly resulting from any subrogation action brought by the Satellite insurers.

42.2 The Contractor agrees to provide the Purchaser with quotes to obtain insurance for FM-1, FM-2, and FM-3 applicable from Launch and orbit raising through placement of the Satellites in their orbit locations and, at the request of the Purchaser, to purchase such insurance at the quoted price. In the event the Contractor fails to secure for the Purchaser full reimbursement of the amounts paid to Arianespace by the Purchaser in accordance with Article 7, then the Contractor shall provide the Purchaser with quotes to obtain insurance for the Satellites applicable from Launch and orbit raising through placement of the

Satellites in their orbit locations and, if requested

by the Purchaser, purchase such insurance at a price equal to the cost (inclusive of brokerage costs, if any) of such insurance to the Contractor without commission or mark-up by the Contractor or the payment of any additional fees or expenses by the Purchaser.

Article 43.

MISSION OPERATIONS SUPPORT

The Mission Operations Support Services to be provided by the Contractor under this Contract is as provided for in Exhibit A, Statement of Work. The Contractor shall not be liable to the Purchaser or any third party for loss of, or damage to the Satellite(s) resulting from any Contractor acts in furnishing services to the Purchaser (including any act or failure to act alleged to be negligent in any degree). The Purchaser agrees to indemnify and hold the Contractor harmless from and against all costs, expenses and losses resulting from any claim or litigation directly or indirectly premised on loss of or damage to any Satellite after Launch.

Article 44.

DARS LICENSE

It is agreed between the Parties that if the Purchaser (or its successor) cannot enter the DARS business due to actions of the U.S. Government which deny the Purchaser the license to enter into the DARS business and such denial is due to circumstances beyond the Purchaser's control, this Contract shall terminate upon receipt of written notification by the Purchaser to the Contractor of such condition accompanied by appropriate documentation from the regulatory agency.

In the event of termination under this Article, the Purchaser shall pay the Contractor within thirty (30) days of invoice (1)_the Contractor's incurred costs for all work performed prior to termination, (2)_the termination related costs including those resulting from termination of subcontractor or vendor contracts, plus (3)_a reasonable profit on the costs of (1) and (2) above less any payments made by the Purchaser on this Contract prior to termination.

Upon termination of this Contract under the terms of this Article, the rights, obligations and liabilities of the Parties with respect to this entire Contract shall thereupon terminate (unless the Parties have expressly agreed otherwise, and except for articles that by their nature are intended to be applicable following such termination

under this Article), and the Contractor shall not be obligated to deliver any additional items under this Contract.

This Article shall become null and void once the DARS license issued to the Purchaser (or to any successor entity) is no longer subject to reconsideration by the U.S. Government.

Article 45.

STANDARD OF CONDUCT

Both Parties agree that all their actions in carrying out the provisions of this Contract shall be in compliance with applicable laws and regulations, and neither party will pay or accept bribes, kickbacks, or other illegal payments, or engage in unlawful conduct.

Article 46.

ORDER OF PRECEDENCE

In the event of conflict between this Contract, its Exhibits and the Annexes thereto, the following order of decreasing precedence shall follow:

1. Contract (excluding Exhibits)
2. Exhibit A
3. Exhibit B
4. Exhibit C
5. Exhibit D
6. Exhibit E

IN WITNESS THEREOF, the Parties have executed this Contract as of the date set forth below:

SPACE SYSTEMS/LORAL, INC.

SIGNATURE:

NAME: C. Patrick DeWitt

TITLE: Executive Vice President, Business

DATE: July 28, 1998

CD RADIO INC.

SIGNATURE:

NAME: Andrew J. Greenbaum

TITLE: Executive Vice President and Chief Financial Officer

DATE: July 28, 1998

ATTACHMENT A

CD RADIO PROGRAM

PAYMENT PLAN FOR FM-1, FM-2, FM-3 AND FM-4

(EXCLUDING LAUNCH VEHICLES)

($ IN MILLIONS)

<TABLE>
<CAPTION>

DUE DATE	PAYMENT NUMBER	PAYMENT AMOUNT	DEFERRAL AMOUNT	MILESTONE
<S>	<C>	<C>	<C>	<C>
	1	$0.100		Effective Date of Contract
11-Apr-97	2	6.500		Headstart Schedule Payment
11-Sep-97	3	24.650		Schedule Payment
11-Dec-97	4	18.150		Conduct System PDR
11-Mar-98	5B**	6.618		Start Third Satellite
11-Mar-98	5A**	13.859		Complete Baseline Program CDR
11-Mar-98	5D**	4.619		Schedule Payment
28-May-98	5C	5.000		Additional Spacecraft & Revised SOW and Perf Spec
11-Jun-98	6A**	3.925		Schedule Payment
11-Jun-98	6B*	8.297	10.180	Deliver Preliminary CIL (Config I.D. List)
11-Jul-98	7	5.345		Schedule Payment
11-Sep-98	8A	8.925		Schedule Payment
11-Sep-98	8B*	8.348	10.180	Complete Comm Panel Design (FM - 1)
11-Oct-98	9A	7.994		Schedule Payment
11-Nov-98	9B	6.500		Start FM - 4
11-Dec-98	10A*	8.349	10.180	Complete FM-1 Central Cylinder
11-Dec-98	10B	8.925		Conduct System CDR
11-Jan-99	11A	9.163		Schedule Payment
11-Feb-99	11B	5.100		Schedule Payment
11-Mar-99	12A	18.529		Submit Satellite Orbital Operations Hdbk, Vol. 1
11-Mar-99	12B*	2.438	6.487	Schedule Payment
11-Apr-99	13A	10.282		Deliver FM - 1 DTWTA's
11-May-99	13B	6.400		Start FM - 1 Bus Integration
11-Jun-99	13C*	2.438	6.487	Schedule Payment

</TABLE>

<TABLE>
<CAPTION>

DUE DATE	PAYMENT NUMBER	PAYMENT AMOUNT	DEFERRAL AMOUNT	MILESTONE
<S>	<C>	<C>	<C>	<C>
11-Jul-99	14	21.888		Schedule Payment
11-Aug-99	15	8.800		Start FM - 1 Reference Performance Tests
11-Sep-99	16*	2.439	6.486	FM - 1 "S" Band Antenna Delivered
11-Oct-99	17A	8.246		Start FM - 2 Thermal Vacuum Tests
11-Nov-99	17B	4.950		FM - 1 Solar Array Delivered
11-Nov-99	17C	4.950		Submit Satellite Orbital Operations Hdbk, Vol. 2
11-Dec-99	18A	4.462		FM - 1 Flight Prom Delivered to Spacecraft

11-Dec-99	18B	4.462		Schedule Payment
11-Jan-00	19A	6.617		Ship FM - 1 to Launch Site
11-Feb-00	19B	10.300		Schedule Payment
11-Feb-00	19C	19.547		Launch FM - 1
11-Mar-00	20A	9.078		Schedule Payment
11-Mar-00	20B	2.087		Complete IOT for FM - 1
11-Apr-00	21A	8.603		Ship FM - 2 to Launch Site
11-Apr-00	21B	7.900		Schedule Payment
11-May-00	21C	6.300		Schedule Payment
11-May-00	21D	13.438		Launch FM - 2
11-Jun-00	21E	2.087		Complete IOT for FM - 2
11-Jul-00	22A	8.300		Schedule Payment
11-Jul-00	22B	5.090		Ship FM - 3 to Launch Site
11-Aug-00	22C	13.455		Launch FM - 3
11-Sep-00	22D	6.900		Complete Satellite Testing FM-4
11-Sep-00	22E	2.087		Complete IOT for FM - 3
11-Oct-00	22F	5.600		Ship FM - 4 to Storage
N/A	23	0.000		RESERVED
11-Jun-02	24	8.333		SCHEDULE PAYMENT
11-Sep-02	25A	8.334		SCHEDULE PAYMENT
11-Dec-02	25B	8.333		SCHEDULE PAYMENT
11-Jun-03	26	8.334		SCHEDULE PAYMENT
11-Sep-03	27A	8.333		SCHEDULE PAYMENT
11-Dec-03	27B	8.333		SCHEDULE PAYMENT
		$438.040	$50.000	GRAND TOTALS

</TABLE>

NOTES: * Deferred Payments: A total of Fifty Million Dollars (U.S.$50,000,000) will be deferred, as indicated above, from Payment Numbers 6B, 8B, 10A, 12B, 13C, and 16 and will be deferred to Payment Numbers 24, 25A, 25B, 26, 27A, and 27B accordance with Article 5.5 "Deferral of Payments"

** Payment may be made on 11 July 1998 with no interest due.

***Payment 24,25A,25B,26,27A, and 27B do not include the portion of deferred interest due on each payment. The total payment for each of 24,25A,25B,26,27A and 27B is detailed in Attachment D.

ATTACHMENT A

PAYMENT PLAN
ADDITIONAL SATELLITE OPTION
PER ARTICLE 14

*PAYMENT MONTH ARO ARO	PAYMENT NUMBER	ORDERED PRIOR TO 1 MAY 99 ($000,000)	ORDERED PRIOR TO 1 MAY 2000 ($000,000)
0	1	$7.7	$8.0
4	2	$6.0	$6.3
7	3	$7.5	$7.9
10	4	$10.4	$10.9
13	5	$11.7	$12.2
16	6	$12.1	$12.7
19	7	$9.3	$9.8
22	8	$7.4	$7.8
25	9	$9.8	$10.4
28	10	$8.1	$8.5
TOTAL		$90.0	$94.5

*All payments due on the 23rd of applicable month.

ATTACHMENT A

LAUNCH VEHICLE PAYMENTS

($ IN MILLIONS)

PAYMENT DATE	PAYMENT NUMBER	PAYMENT AMOUNT*	CD EQUITY PAYMENTS
27-May-98	1	9.000	9.000
30-Jun-98	2*	46.300	

31-Jul-98	3	6.000	
31-Aug-98	4	5.300	
31-Oct-98	5	17.300	9.000
31-Jan-99	6	17.300	9.000
30-Apr-99	7	22.600	9.000
31-Jul-99	8	22.600	9.000
31-Oct-99	9	31.600	
31-Jan-00	10**	36.500	
30-Apr-00	11	44.500	
31-Jul-00	12	16.000	
	TOTAL	$275.000**	$45.000

NOTES: *Payment is due on the earlier of 30 June 1998 or the closing of the Credit Facility.

**Payment 10 and total to be adjusted after final selection of Launch services for FM-1, FM-2 and FM-3 in accordance with Sub-Article 7.1.

ATTACHMENT B

MILESTONE ACHIEVEMENT CERTIFICATION

To: CD Radio Inc.

From: Space Systems/Loral, Inc.

Subject: Milestone: No._____ Title: _____

In accordance with Article 5 of the CD Radio DARS System Contract, SS/L hereby certifies that the above Milestone has been accomplished.

Very truly yours,

Space Systems/Loral, Inc.

By: _____

Name: _____

Title: _____

Date: _____

Agreed to on behalf of CD Radio Inc.

By: _____

Name: _____

Title: _____

Date: _____

ATTACHMENT C

PROTECTION OF PROPRIETARY DATA

WHEREAS, Purchaser and Contractor desire to exchange selected company proprietary, competition sensitive or trade secret information (hereinafter referred to as "proprietary information") for the purpose of performance of the contract between the parties concerning the CD Radio Inc. digital audio radio program; and WHEREAS, Purchaser and Contractor each is willing to disclose certain proprietary information to the other on a confidential basis, and each party is willing to protect and safeguard the other's proprietary information as provided herein;

NOW THEREFORE, the parties to this agreement do hereby agree as follows:

A. In order for proprietary information to be protected in accordance with this Agreement, it must be (1) in writing, (2) clearly identified as proprietary information by each page thereof being marked with the legend "Proprietary Information" or other similar legend, and (3) delivered to an individual designated as provided in paragraph D. below. Proprietary information which is orally disclosed may only be protected under this agreement if it is identified as proprietary at the time of disclosure and is subsequently confirmed in writing by specific identification in the manner set forth in the preceding sentence no later than two weeks from the time of first oral

disclosure.

B. Neither party shall identify as proprietary information any information which is not in good faith believed by that party to be privileged, a trade secret, or otherwise entitled to such marking.

C. The receiving party shall take reasonable precautions to prevent disclosure to third parties of proprietary information meeting the above requirements. A receiving party will be considered to have taken reasonable precautions to prevent disclosure of proprietary information to a third party if the receiving party utilizes the same controls it employs to avoid disclosure, publication or dissemination of its own proprietary information of a like nature.

D. The following employees, or other individuals to be identified subsequently in writing, are the only individuals authorized to receive proprietary information exchanged between the parties pursuant to this Agreement:

(1) On behalf of Purchaser:
Name: CD Radio Inc.
Address: 1001 22nd Street, N.W.
Suite 600
Washington, D.C. 20037
Phone: (202) 296-6192
David Margolese, Robert Briskman, Richard Cooperman, David Batchelder, Stephen Low, Lawrence Gilberti, Paul Sharma, Andrew Greenbaum, Patrick Donnelly

(2) On behalf of Contractor:
Name: Space Systems/LORAL
Address: 3825 Fabian Way
Palo Alto, California 94303
Phone: (650) 852-5403
Brian Saleh, John Dietzel, Bob Prevaux, Karen Carissimi, Julie Bannerman, Pat DeWitt

E. The obligation with respect to handling and using proprietary information as set forth in this Agreement is not applicable to the following:

1) Information that is or becomes available to third parties or the general public without restriction and without breach of this Agreement by the receiving party.

2) Information that is or becomes known to either party independently of the disclosing party.

3) Information that is independently developed by the receiving party.

4) Information that is or has been furnished by the disclosing party to the Government with "unlimited" rights.

5) Information that is or becomes part of the public domain without breach of this Agreement by the receiving party.

6) Information that is or becomes available to either party by inspection or analysis of products offered for sale.

7) Information that is received by the receiving Party from a source other than the disclosing party without breach of this Agreement.

F. The receiving party shall not use proprietary information of the other party for any purpose other than the purpose set forth hereinabove, without prior written approval of the disclosing party.

G. The obligations of the parties under this Agreement shall terminate three years from the date of completion of the effort to be performed under this Agreement.

Space Systems/LORAL

Signature:
Name: Neil Barberis
Title: Vice President Programs
Date: February 23, 1993

CD Radio Inc.

Signature:

Name: Robert D. Briskman
Title: President, CDRS
Date: February 23, 1993

ATTACHMENT D

SPACE SYSTEMS/LORAL, INC./CD RADIO INC.
DEFERRED FINANCING TERM SHEET

This term sheet outlines the principal terms and conditions of the deferral of certain amounts due under the Amended and Restated Contract for Sale of DARS System (TP93002-01) (the "Contract") between SS/L and CD Radio Inc. (the "Company").

Deferral Amount:	The installments set forth on Schedule A hereto, aggregating $50,000,000, may be deferred, subject to acceleration upon the occurrence of an event of default.
Principal Amortization:	The principal amount of each deferral is payable in six installments, commencing on June 11, 2002 with the final payment on December 11, 2003, in the amounts and on the dates set forth on Schedule A hereto. Deferred interest will be added pro rata to such six installments.
Interest Rate:	10% per annum.
Interest Deferral:	All interest shall accrue (and be compounded quarterly) until December 11, 2002, be added to the deferred installments of principal and bear interest at the rate of 10% per annum. Commencing on March 11, 2002, interest on the principal balance (which shall include all accrued interest) shall be payable quarterly on March 11, June 11, September 11 and December 11 of each year in arrears. (see attached).
Optional	Prepayments: The Company shall have the right to prepay, in whole or in part, any deferred payments, together with accrued interest to the date of such prepayment, without the payment of any penalty, fee or additional cost. The Company shall notify SS/L at least three business days prior to making any such prepayment and any such prepayment shall be in a minimum amount of $1,000,000.
Mandatory Prepayments:	None

Representations and Warranties:	To cover the same subject matter and be no more extensive than those provided to the lenders under the $115,000,000 Credit Agreement (the "Credit Agreement") with Bank of America National Trust and Savings Association, as administrative agent.
Covenants:	No more restrictive on the Company than those contained in the Credit Agreement and shall contain no financial covenants other than (i) the covenant contained in clause (i) of the second sentence of Sub Article 5.1.3 of the Contract (which shall expire on January 1, 2000) and (ii) the covenant contained in clause (ii) of such sentence.
Events of Default:	Usual and customary, including in the event of a termination of the Contract and a default under the Credit Agreement or the Indenture governing the Company's 15% Senior Secured Discount Notes due 2007. Upon an event of default, the unpaid principal of and interest on the deferred amounts shall become immediately due and payable.
Security:	As collateral security for the obligation to repay the principal of, interest on, and other amounts (including expenses and indemnities) relating to, the deferred amounts (collectively, the "Obligations"), the Company will (subject to the limitations contained in the next sentence) grant to SS/L a first priority, perfected security interest in (i) all hardware now owned or hereafter acquired used in the Company's terrestrial repeater network (which, upon completion of the terrestrial repeater network, the Company will represent will have a value of approximately $50 million) and (ii) in all of its

rights under the license or lease agreements now owned or hereafter acquired (which, upon completion of the terrestrial repeater network, the Company will represent will have a value of approximately $20 million) relating to the terrestrial network. The Company will use reasonable efforts to obtain all third party consents necessary for the creation and foreclosure of the security interest in such collateral, but it shall not be required to pay the licensors or lessors to provide such consents.

Documentation: The Company's obligations will be evidenced by a deferral agreement (which will include usual and customary agency provisions and the right of SS/L to appoint an administrative agent and collateral agent under the documents), with notes and security documents, all in form and substance reasonably satisfactory to SS/L and the Company which will contain usual and customary provisions for credit agreements but not any additional principal terms and not any terms inconsistent with the provisions of this Attachment D.

Assignments: The obligations of the Company under the deferral may be assigned by SS/L to any entity at any time after an event of default. In addition, SS/L may, with the prior written consent of the Company (which will not be unreasonably withheld or delayed), assign such obligations at any time after the commencement of commercial operations by the Company to one or more banks, mutual funds or financial institutions which extend credit or buy and sell loans in the ordinary course of their business.

Miscellaneous: The deferral agreement and related security documents will contain a waiver of trial by jury and be governed by New York law.

LORAL VENDOR FINANCING STRUCTURE JULY 27, 1998

(ALL AMOUNTS IN MILLIONS OF DOLLARS)

INTEREST RATE 10.000%

<TABLE>
<CAPTION>

Payment #		Draw	Amortization	Accrued Interest	Interest Paid	Balance
<S>	<C>	<C>	<C>	<C>	<C>	<C>
	8/5/98	10.180				10.180
	9/11/98	10.180		0.103		20.463
	12/11/98	10.180		0.510		31.153
	3/11/99	6.487		0.768		38.409
	6/11/99	6.487		0.968		45.864
	9/11/99	6.486		1.156		53.506
	12/11/99			1.334		54.840
	3/11/00			1.367		56.207
	6/11/00			1.417		57.624
	9/11/00			1.452		59.076
	12/11/00			1.473		60.549
	3/11/01			1.493		62.042
	6/11/01			1.564		63.606
	9/11/01			1.603		65.209
	12/11/01			1.626		66.835
	3/11/02				1.648	66.835
24	6/11/02		(11.139)		1.685	55.696
25A	9/11/02		(11.140)		1.404	44.556
25B	12/11/02		(11.139)		1.111	33.417
	3/11/03				0.824	33.417
26	6/11/03		(11.138)		0.842	22.279
27A	9/11/03		(11.140)		0.562	11.139
27B	12/11/03		(11.139)		0.278	0.000
	3/11/04				0.000	0.000
		50.000	(66.835)	16.835	8.353	0.000

</TABLE>

CD RADIO DARS SYSTEM

EXHIBIT A

STATEMENT OF WORK

21 JULY 1998

Prepared for
CD RADIO INC.
1180 Avenue of the Americas
14th Floor
New York, NY 10036

Prepared by:
SPACE SYSTEMS/LORAL
3825 Fabian Way
Palo Alto, California 94303-4604

CONTENTS

SECTION 1 -- SCOPE

This Statement of Work (SOW) defines all goods, services, data, and documentation to be furnished by Space Systems/Loral (hereinafter the "Contractor") to CD Radio Inc. (hereinafter the "Purchaser") for the CD Radio DARS System. The Contractor shall design, develop, manufacture, test, transport to the launch site in a suitable container prepare the satellite for launch, provide for launch and Launch Support Services, provide all transfer orbit operations to geosynchronous orbit, perform in-orbit test (IOT), and deliver on

orbit a completely operational communications satellite system as follows:

1.1 BASIC PROGRAM CONTENT

a. Four complete communications satellites as shown in Annex 1 in accordance with the Performance Specification (Exhibit B to the Contract) and Product Assurance Plan (Exhibit C to the Contract), and tested in accordance with a Program Test Plan (Exhibit D to the Contract). Four satellites are to be delivered as specified in the Contract.

b. Procurement of Launch Services for three satellites and management of the Launch Services contract.

c. Necessary ground support equipment, to permit full checkout and test of the satellite during qualification and acceptance testing and prelaunch operations, shall be made available, as required, to support the program.

d. Provide personnel, facilities, and equipment for Launch Services for three satellites, including shipping the satellite to the launch site, satellite preparation at the launch site, support for installation on the launch vehicle, launch, and launch operations in conjunction with the selected Launch Vehicle supplier, from lift-off through launch vehicle separation.

e. Necessary tracking, telemetry, and command (TT&C) ground station capability to be made available for transfer orbit operation after separation from launch vehicle, drift orbit operation, station acquisition and IOT. Contractor-owned or -leased and/or Purchaser-provided facilities and equipment may be used (the equipment required for payload check-out is Purchaser-furnished). Purchaser shall make available his northern and southern hemisphere ground stations as required from separation through completion of IOT. Any transfer orbit and IOT unique capabilities, personnel, or equipment shall be the Contractor's responsibility.

f. Provide personnel, facilities, communication links, and equipment for Mission Operations Services from separation from the launch vehicle through completion of IOT for three satellites.

g. Data and software as specified in Annex 2 herein.

h. Satellite operations training of Purchaser personnel.

i. Short and long-term storage as may be required.

j. Delivery of the fourth satellite to a ground storage facility as specified in the contract.

k. Provide technical support to investigate on-orbit anomalies for the life of the satellite per the Contract.

l. Delivery of a Dynamic Spacecraft Simulator including associated executable software and manuals as specified per the Contract.

1.2 PROGRAM OPTIONS

(Optional). Mission operations equipment training and support (including both classroom and hands-on) to accomplish an orderly transition to full customer operation of the satellite within 12 months after launch.

SECTION 2 -- REQUIREMENTS

The goods, services, data, and documentation to be provided by the Contractor are defined herein. The Contractor shall submit documentation in accordance with the requirements of Annex 2 of this SOW. For any document submittal requiring Purchaser approval, the approval or disapproval of the Purchaser shall be provided within 30 days after submittal. Approval is automatic after 30 calendar days if no response is received by the Contractor.

DELIVERABLE DOCUMENTATION
As a minimum, the specifications, drawings, plans, and procedures listed in Annex 2 of this SOW, and any applicable change notices, shall be delivered for Purchaser approval or information. The Contractor shall submit all changes, either (at the Contractor's option) as change insertion sheets together with an effectivity matrix indicating the latest revision status of each page of the document, or as a complete reissue of the document. All documentation shall be produced in accordance with good commercial standards and "Approval" document delivery shall be as specified in the Contract. "Information" documents shall be delivered to the Resident Purchaser Representative, or if not in residence, to the designated representative.

The Contractor shall assist in the preparation of documents required by third parties, such as Federal Communications Commission (FCC), ITU Radio Communication Bureau, insurance agencies, and other Governmental or world regulatory bodies implementation of this program.

APPLICABLE PROGRAM DOCUMENTS
The applicable documents are the Exhibits listed in Article 2.1 of the Contract.

2.1 DELIVERABLE DATA AND DOCUMENTATION TO BE FURNISHED BY CONTRACTOR

2.1.1 PROGRAM MANAGEMENT PLAN
A Program Management Plan shall be delivered to the Purchaser in accordance with Annex 2.

This plan will define the approach to be taken in the management of all aspects of the program including:

a. Program Organization and Management
b. Technical Baseline Management
c. Program Controls Management
d. Subcontracts Management

2.1.2 PROGRAM SCHEDULE REPORTS
A Baseline Schedule shall be developed and updated monthly and shall accurately track the progress of all aspects of the program against the baseline including:

a. Hardware and Software deliveries
b. Subcontractor performance
c. Major program reviews
d. Subsystem and component acceptance and qualification tests
e. System-level verification tests
f. Prelaunch, launch and post-launch activities
g. Identify critical paths
h. Critical issues

2.1.3 RESERVED

2.1.4 DOCUMENTS
The following documents shall be submitted for information:

a. Spacecraft to launch vehicle Interface Control Documents (ICDs).
b. Complete panel layout drawings (north panel and south panel).

2.1.5 INTERMEDIATE DESIGN REVIEW/REPEATER CDR
The Intermediate Design Review (IDR) data shall include the items listed below.

IDR
a. Performance Compliance Matrix
b. System Design Specification
c. Subsystem Design Changes
d. Updated Program Test Plan (as required)
e. Mass, power, pointing, fuel budgets, TC&R link budgets

f. Results of the following unit design reviews:
    1. Solar Array
    2. Battery
    3. S-Band Antenna
    4. X-Band Antenna
    5. DAPM/TAAPM
g. Preliminary orbital elements for each satellite
h. Payload performance budgets
i. Launch vehicle interface status

REPEATER CDR
a. Repeater description
b. Results of design analyses
c. Subsystem specification
d. All pertinent test data on breadboards and Ems
e. Results of failure mode, effects and criticality analysis
f. Results of reliability analysis
g. Mass and power budgets
h. Performance compliance matrix
i. Repeater performance budgets
j. Comm panel integration and test plan
k. Additional gain stage design description and analysis

2.1.6 CRITICAL DESIGN REVIEW DATA
Critical Design Review (CDR) data for the satellite shall include the items listed below.

a. A narrative description of the satellite and each subsystem adequate to explain the supporting data.
b. Results of design analyses for system and each subsystem.

c. System Specification, system level ICDs and configuration drawings, panel layout drawings, subsystem specifications and block diagrams.*
d. All pertinent test data on breadboard and EMs.
e. Results of failure mode, effects, and criticality analysis.
f. Results of a reliability analysis by subsystem and for the complete satellite.

- ---------------------------

* Pertinent lower level drawings, specifications and ICDs will be made available for review at the Contractors facility

g. Mass, power, pointing, and fuel budgets, payload performance and link budgets.
h. Launch vehicle interface requirements and compatibility.
i. Preliminary orbital injection plan.
j. Mission operations plan through IOT.
k. Updates to the Program Test Plan (as required).
1. Performance Compliance Matrix.
m. Final optimized orbital elements and EIRP plots for each satellite.

2.17 DESIGN ANALYSIS REPORT
The Contractor shall prepare design analysis reports as identified in the following subparagraphs. The reports are to be furnished as the part of CDR data package.

2.1.7.1 COMMUNICATION SUBSYSTEM ANALYSIS
The Contractor shall prepare a complete and comprehensive Communications Subsystem Performance Analysis Report. This report shall summarize important characteristics and parameters of the communications subsystem including EIRP and G/T budgets, phase noise, radio frequency (RF) amplitude response, antenna performance analysis, PIM and multipacting analysis.

2.1.7.2 THERMAL ANALYSIS
A complete and comprehensive thermal design nodal analysis shall be performed in which all critical cases shall be analyzed, including transfer orbit, main satellite thruster firing transients, plume heating analysis, beginning and end-of-life solstices, and equinox, including eclipse transients.

2.1.7.3 STRUCTURAL ANALYSIS
An analysis of the satellite structure shall be performed in which all major structural elements are modeled and margin of safety determined.

2.1.7.4 ELECTRICAL POWER SUBSYSTEM ANALYSIS
An analysis of the electric power subsystem shall be performed.

2.1.7.5 FUEL BUDGET ANALYSIS
An analysis of the fuel requirements of the satellite shall be performed to demonstrate the adequacy of the fuel load provided to meet mission requirements for each satellite.

2.1.7.6 RELIABILITY ANALYSIS
Reliability analysis shall be performed including:
a. Development of functional block diagrams of the system configuration and preparation of computer simulations expressing the configuration into probabilities of mission success.
b. Parts stress.
c. Worst-case analysis of all electronics units including effects of aging, radiation, etc.

2.1.7.7 MASS PROPERTIES ANALYSIS
A mass properties analysis shall be performed that shall include a detailed listing of the mass of each satellite's components, their relative location, and their contributions to the satellite moment of inertia matrix.

2.1.7.8 DYNAMICS ANALYSIS
A dynamics analysis shall be performed that reflects the dynamic conditions expected during transfer orbit, acquisition, and operational orbit.

2.1.7.9 CONTROL SUBSYSTEM ANALYSIS
A control subsystem analysis shall be performed that shall include noise (sensor, torque, electronic), gain, response to external disturbances, control loop stability, and the size and reproducibility of impulse bits delivered by the thrusters. The effects of thruster misalignment, plume impingement, center-of-mass uncertainties, shifts due to propellant slosh and usage, and possible flexible appendage motions shall be included.

2.1.8 COMPREHENSIVE TEST PLANS AND PROCEDURES

2.1.8.1 COMPONENT, SUBSYSTEM, AND SYSTEM TESTS
Procedures in conformance with the Program Test Plan (Exhibit D to the Contract) shall be prepared and submitted in accordance with Annex 2 of this SOW for each subsystem, and for the complete satellite. Test plans for items furnished in

subsection 2.5 shall be furnished by the Purchaser.

2.1.8.1.1 TWTA QUALIFICATION PLAN
A Qualification Plan shall be prepared and submitted for the TWTA. This plan shall include a description of TWT & EPC qualification, TWT life tests and TWT cathode tests and a TWTA reliability analysis.

2.1.8.2 PRELAUNCH TESTS AND SUPPORT SERVICES
The Contractor shall submit procedures in conformance with the Program Test Plan that shall provide for the checkout and test of the satellite before launch to ensure flight

worthiness, support for the integration of the satellite with the launch vehicle, on-pad launch operations, and coordination with the launch agency in support of the launch of the satellite. Launch vehicle documentation requirements in accordance with Annex 2 of this SOW will be included as appropriate.

2.1.8.3 ORBIT INJECTION
Detailed procedures shall be submitted that will provide for post-launch operations consisting of transfer orbit TT&C functions, main satellite thruster firing for geosynchronous orbit injection, placement on station in the correct RAAN, argument of perigee, and attitude, and in-orbit verification of satellite operation. Approvals by the Purchaser, Contractor, and launch agency (if required) shall be obtained before the Contractor's implementation.

2.1.8.4 IN-ORBIT TESTS
Detailed procedures in conformance with the Program Test Plan shall be submitted for determining and verifying satisfactory operation in orbit during the initial operating period after successful injection into geosynchronous orbit.

The IOT procedure shall include:
- a. Detailed test methods and test procedures.
- b. Test conditions.
- c. Method and procedure about how to establish satellite test configuration.
- d. Measurement equipment.
- e. Test data sheets.

2.1.9 FCC AND ITU LICENSING REQUIREMENT
The Contractor shall furnish in a timely manner such data as is required, from time to time, for compliance with FCC and ITU licensing procedures.

2.1.10 ONE-TIME DELIVERABLE DATA
The items required concurrent with delivery of the associated equipment shall be delivered as specified in Annex 2.

2.1.11 PERIODICALLY DELIVERABLE DATA
The following items are to be prepared and delivered by the Contractor:

- a. Monthly Progress Reports, including:
  1. Program major events
  2. Technical status
     - o Payload
     - o Bus

  3. Program Controls
     - o Scheduling
- b. Change control data, commencing with CDR, through satellite delivery.
- c. Major NCR listing

2.1.12 SATELLITE LOG BOOKS
The Contractor shall prepare and maintain separate log books for each flight satellite. The log book entries shall include the following items:
- a. Component and subsystem identification.
- b. Tests conducted, test set-up diagrams, test results, failures, and failure corrections unless these items are furnished separately as part of other documents. Each document containing test data should be identified in the log book.
- c. Parameter measurements (raw data).
- d. Failure observations and analysis.
- e. Discrepancies and deviations.
- f. Repair, maintenance, and modification records.
- g. History of satellite movements, shipment, and storage. The log books shall be updated with the prelaunch tests and IOTS.

2.2 DESIGN AND EQUIPMENT REVIEWS

2.2.1 RESERVED

2.2.2 INTERMEDIATE DESIGN REVIEW
An IDR shall be conducted by the Contractor at its facility. It shall cover the satellite as described in paragraph 2.1.5. The IDR shall include a management

and a technical presentation, followed by open discussions. The IDR shall be considered complete with the signing of the meeting, minutes and action item list, with closure dates established.

2.2.3 CRITICAL DESIGN REVIEW
A CDR shall be conducted by the Contractor at its facility. All items listed in Paragraphs 2.1.6 and 2.1.7 of this SOW, as appropriate, shall be addressed. The CDR shall be considered complete with the signing of the meeting, minutes and action item list, with closure dates established.

2.2.4 SATELLITE PRE-SHIPMENT REVIEW
Satellite Pre-Shipment Reviews shall be conducted by the Contractor to ensure that each satellite conforms to all the requirements of the Performance Specification (Exhibit B to the Contract), including all hardware test results, updated failure modes and effects

criticality analysis (FMECA) and reliability projections, and material review board (MRB) and failure data.

2.2.5 SATELLITE LAUNCH READINESS REVIEW
Satellite Launch Readiness Review shall be conducted at the launch site facilities by the Contractor in the presence of the Purchaser not later than 10 working days before the launch date of each satellite. The review shall cover the status of all satellite subsystems and mission support facilities through in-orbit test. The review shall be in two parts: the first, covering electrical tests, before moving the satellite to the hazardous operation facility, and the second, after fuel loading, and final close-out, before final integration with the launch vehicle.

2.2.6 IN-ORBIT TEST REVIEW
In-Orbit Test Summary Review shall be conducted by the Contractor to confirm that the satellite satisfies the acceptance criteria defined in the IOT plan, by reviewing the satellite data obtained during the period from launch through IOT. The summary review shall be conducted in the Contractor's facility within 3 days after completion of IOT. Minutes will be prepared and agreed to by the end of the day.

2.3 DELIVERABLE HARDWARE, SOFTWARE, AND SERVICES

2.3.1 SATELLITES
The Contractor shall furnish four satellites in accordance with the requirements of the Performance Specification (Exhibit B to Contract), The Product Assurance Plan (Exhibit C) and The Program Test Plan (Exhibit D). Three flight model (FM) satellites are to be manufactured, tested, shipped to the launch site, launched, and delivered on-orbit, fully tested and ready to commence in-orbit operations. The fourth flight model satellite shall be manufactured, tested, and delivered to ground storage in accordance with the Contract.

2.3.2 GROUND SUPPORT EQUIPMENT AND SERVICE
The Contractor shall make available all necessary ground support equipment and personnel to permit full checkout and test of the satellite during acceptance testing, prelaunch operations, and launching operations. Where such equipment is used to demonstrate compliance of the satellite with Exhibit B to the Contract, it shall be identified in the test procedures.

2.3.3 LAUNCH VEHICLE PROCUREMENT SERVICES AND INSURANCE PROCUREMENT SERVICES
The Contractor shall make necessary arrangements for the procurement of Launch vehicles and Launch Services.

The Contractor shall make necessary arrangements for a reasonable number of surveys needed by insurance company representatives at the Contractor's premises during the performance of the work. The Contractor shall use its best efforts to permit similar surveys on the premises of its subcontractors.

2.3.4 MISSION OPERATION PLAN
The Contractor shall generate and publish a Mission Operation Plan, including orbit raising timelines that will be used to guide the activities of the participants during the period starting with rehearsals before launch through to satellite acceptance in orbit.

2.3.5 SATELLITE ORBITAL OPERATIONS HANDBOOK (SOOH)
A SOOH shall be provided for use by personnel responsible for the operation of the satellite. The information contained in this document shall be the basis for the command programming required to operate, control, and maintain the satellite in the performance of the defined mission objectives. Starting with the launch event, the handbook, as a minimum, shall delineate:

a. Programming and control operations required to establish and maintain the satellite in its operational mode.
b. In-orbit satellite system checkout.
c. Satellite database including telemetry calibration data.
d. Standard Operating Procedures (SOP) (including recommended subsystem operational management)
e. Contingency Operating Procedures (COP)

f. Operational Constraints

2.3.6 TRAINING (SATELLITE SYSTEM FEATURES/PERFORMANCE)
The Contractor shall conduct a training course for the Purchaser's satellite operators. This course shall be conducted for experienced personnel at the Contractor's satellite control facilities and shall be structured to train the Purchaser and its assigned personnel to operate and maintain the in-orbit satellites.

The Training Course Program Plan will be provided to the customer for his review and approval. The course shall include training in satellite system features and performance, all Dynamic Spacecraft Simulator hardware and software provided by SS/L, and operational maintenance. The classroom course will prepare experienced personnel to operate the satellites.

2.3.7 SYSTEM INTEGRATION

2.3.7.1 MISSION PLANNING AND INTEGRATION MEETINGS
The Contractor shall conduct the mission planning and integration meetings with the launch agency and others supporting the mission planning efforts.

2.3.7.2 INTERFACE COORDINATION
The contractor shall coordinate all activities with the launch vehicle provider, and others as necessary, to support the delivery of the satellite to the launch base, its integration with the launch vehicle, and its placement on-station ready to commence operation. The required documents and analyses shall be prepared by the Contractor.

2.3.8 LAUNCH SERVICES AND ORBIT OPERATIONS

2.3.8.1 PRELAUNCH AND LAUNCHING SERVICES
The Contractor shall provide personnel, equipment, and documentation necessary to execute the tasks delineated below related to the flight satellites. This will include those services necessary to:

a. Conduct inspection and performance testing of the satellite at the launch site.
b. Conduct any necessary assembly and checkout, including propulsion subsystem fueling and pressurization.
c. Support satellite/launch vehicle integration.
d. Support satellite launch vehicle integrated system tests.
e. Conduct flight readiness performance tests.
f. Conduct the prelaunch and support the launching services through separation from the launch vehicle.

2.3.8.2 TRANSFER ORBIT OPERATIONS
The Purchaser's representatives shall be allowed access to the Contractor's facility to observe rehearsals and orbit raising operations on a non-interference basis.

2.3.8.2.1 REHEARSALS
Contractor rehearsals shall be held starting approximately 3 months before launch. Each phase of the mission shall be rehearsed, with emphasis placed on the early injection phase. Alternate operating modes of the ground complex shall be exercised, including selected satellite and ground system failures. Rehearsal log books shall be used to indicate areas requiring improvement or additional training for personnel concerned.

2.3.8.2.2 POST-LAUNCH SERVICES
The Contractor shall provide the necessary materials, personnel, and services to acquire satellite telemetry and orbit data, perform necessary calculation and analysis, and the required commands to take the satellites from the specified transfer orbit to the specified geosynchronous orbit locations. During transfer orbit until delivery on-orbit, the Contractor shall be permitted full use of the Southern Hemisphere satellite TT&C Station provided by the Purchaser. The Purchaser is responsible for ensuring the full operational readiness of this station prior to each launch. Any transfer orbit unique capabilities, personnel or equipment shall be the Contractor's responsibility.

2.3.8.2.3 INITIAL OPERATIONS INCLUDING IN-ORBIT TEST
The Contractor shall perform operations including IOT of the satellites. A summary report containing analysis of actual performance compared with calculated performance shall be supplied for each satellite.

In-orbit test shall be performed with the satellite controlled from SS/L's Mission Control Center in Palo Alto, or from the Purchaser's Satellite Control Facility (SCF). The Purchaser shall permit SS/L staff full access to the SCF to temporarily install specialized test equipment owned by SS/L, control the satellite, and monitor the satellite telemetry and communications response, using Purchaser's ground station equipment and antennas.

2.3.8.2.4 COMMUNICATIONS AND DATA LINES
The communications and data lines required for services specified in paragraphs

2.3.8.2.2 and 2.3.8.2.3 shall be provided by the Contractor, excluding the lines to ground stations provided by the Purchaser.

2.3.9 TRANSFER ORBIT TT&C STATIONS
During transfer orbit, the Contractor shall be permitted full use of the Southern Hemisphere TT&C station provided by the Purchaser. The Contractor shall make available all other TT&C stations required to support the launch operations until handover to the operational SCF station. The Contractor shall verify compatibility between transfer orbit TT&C stations and the satellite by compatibility testing before the launch of the first satellite. The TT&C station interface requirements shall be defined in the Ground Station Interface Specification (to be mutually agreed).

2.4 DELIVERABLE ITEMS AND DUE DATE
Deliverable hardware and software and their delivery due dates shall be in accordance with Annex 1 of this SOW. Deliverable documents and their due dates shall be in accordance with Annex 2 of this SOW.

2.5 SPECIAL REQUIREMENTS
The Contractor shall consider all assigned command radio frequencies and command address codes as proprietary information that shall not be publicized except as approved in writing by the Purchaser.

ANNEX 1

DELIVERABLE HARDWARE LIST

Number	Item	Quantity	Due Date	Delivery Place
1	Satellite (FM-1)	1	Per the Contract	Per the Contract
2	Satellite (FM-2)	1	Per the Contract	Per the Contract
3	Satellite (FM-3)	1	Per the Contract	Per the Contract
4	Satellite (FM4)	1	Per the Contract	Per the Contract
5	Dynamic Spacecraft Simulator	1	Per the Contract	Per the Contract

ANNEX 2

DELIVERABLE DOCUMENT LIST

<TABLE>
<CAPTION>

Number	Title	Class	Quantity	Due Date (1)	SOW Section
<S>	<C>	<C>	<C>	<C>	<C>
	Basic Contract Documents				
1	Program Management Plan	I	3	June 11, 1997	2.1.1
2	Program Scheduling Chart	I	3	June 11, 1997	2.1.2
3	Satellite Top-Level Assembly Drawings (including Structure and Equipment Installation) Top Drawings	I	1	PDR, CDR, and Final Satellite Review	2.1.4
	a. Preliminary CIL	I	1	At CDR	
	b. As built CIL	I	1	At Final Satellite Review	
4	Drawings and Data Required for Radio Application	A	1	As required	2.1.10, 2.1.3
5	IDR/Repeater CDR Data				
	a. Data Package				
	IDR	I	10	7 working days before review	2.1.5
	Repeater CDR	I	10	10 working days before review	2.1.5
	b. Presentation Package	I	As required	At review	2.1.5
	c. Minutes	A	1	At conclusion of the review	2.2.2
	d. Action Items	A	1	As scheduled in the minutes	2.2.2
6	CDR Data				
	a. Data Package	I	10	15 working days before review	2.1.6
	b. Presentation Material	I	As required	At review	2.1.6
	c. Minutes	A	1	At conclusion of the review	2.2.3
	d. Action Items	A	1	As scheduled in the minutes	2.2.3
7	Updated Program Test Plan	I	3	30 days before CDR	2.1.8.1
8	System Test Procedure (Satellite)	I	3	30 days before FM-1 Test	2.1.8.1
9	System Test Report (Satellite)	I	3	At Final Satellite Review	2.2.4
10	Reserved				

11	Prelaunch Test Procedure	I	3	At Shipment	2.1.8.2
12	Orbit Injection Plan	I	3	At CDR	2.1.8.3
13	In-orbit Test Plan	A	3	6 Months before launch	2.1.8.4
14	TWTA Qualification Plan	A	3	30 days before CDR	2.1.8.5
15	In-Orbit Test Procedure	I	3	6 months before launch	2.1.8.4
16	Summary Report of In-Orbit Test Data	I	3	Completion of IOT +3 days	2.2.6
17	In-orbit Test Review Minutes	A	As required	Completion of IOT +4 days	2.2.6
18	In-orbit Test Report	I	3	45 days after IOT	2.2.6

Class Code: A = For Approval by Purchaser
I = For Information, delivered to Resident Purchaser Representative.

Notes: (1)* Due date is 15 days before review for System and Alenia CDRs

Number	Title	Class	Quantity	Due Date (1)	SOW Section
	Basic Contract Documents (Continued)				
19	Ground Support Equipment List and Configuration	A	1	At IDR	2.3.2
20	Monthly Progress Report	I	6	10th day of each month	2.1.12
21	Change Control Data	I	1	As required	2.1.11
22	Satellite Log Books	I	1	At Final Satellite Review	2.1.12
23	Training Course Program Plan	A	2	12 months before launch	2.3.5
24	Training Course Manual and Training Aids	I	As required	At training	2.3.5
25	Mission Operation Plan	I	6	6 months before launch	2.3.6
26	Satellite Orbital Operations Handbook (SOOH)	A	10	6 months before launch	2.3.7
	SOOH, Vol I (Technical Description of Satellite)		10	12 months before launch, updates required	
	SOOH, Vol II SOP		10	6 months before launch	
	SOOH, Vol III COP		10	6 months before launch	
	SOOH, Vol IV Satellite Parameters Handbook (Calibration data)		10	1 month before launch	
27	Documentation Required by Launch Agency	I	3	As required	2.3.8.2
28	Ground Station Interface Specification	I	3	12 months before launch	2.3.9
29	Nonconformance Reports	I/A	3	As required per Ex. C, Table 2-1	Per contract
30	Telemetry and Command Database (soft copy)	I	1	Prelim 12 months before launch, updates as required, final at IOT	
31	Dynamic Simulator Documentation				
	Data Packages	I	6	Per Contract	Per contract
	Operating Manuals	I	10	Per Contract	Per contract

Class Code: A = For Approval by Purchaser
I = For Information, delivered to Resident Purchaser Representative.

Notes: (1)* Due date is 15 days before review for System and Alenia CDRs

ABBREVIATIONS AND ACRONYMS

ALC	Automatic Level Control
CDR	Critical Design Review
CIL	Configuration Identification List
CRT	Cathode Ray Tube
EDLA	Effective Date of License Award
EIRP	Equivalent Isotropic Radiated Power
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FCC	Federal Communications Commission

FM	Flight Model
FMECA	Failure Modes and Effects Criticality Analysis
G/T	Gain per Noise Temperature (Figure of Merit)
ICD	Interface Control Drawing
IDR	Intermediate Design Review
IFRB	International Frequency Registration Board
IOT	In-Orbit Test
ITU	International Telecommunications Union
LSS	Launch Support Services
MRB	Material Review Board
N/A	Not Applicable
O&M	Operations and Maintenance
PDR	Preliminary Design Review
PVA	Perigee Velocity Augmentation
RAAN	Right Ascension of Ascending Node
RF	Radio Frequency
RAP	Request for Proposal
SCF	Satellite Control Facility
SOOH	Satellite Orbital Operations Handbook
SOW	Statement of Work
TBD	To Be Determined
TT&C	Tracking, Telemetry, and Command
TWT	Traveling Wave Tube
PIM	Passive Intermodulation Products

NCR	Non-Conformance Report
COP	Contingency Operating Procedures
SOP	Standard Operating Procedures

Exhibit B

Satellite Performance Specification

EXHIBIT B
SATELLITE PERFORMANCE SPECIFICATION

21 JULY 1998

Prepared for:
CD RADIO INC.
1180 Avenue of the Americas
14th Floor
New York, NY 10036

Prepared by:
SPACE SYSTEMS/LORAL
3825 Fabian Way
Palo Alto, California 94303-4604

CONTENTS

ILLUSTRATIONS

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INTRODUCTION

This document specifies the performance of the Digital Audio Radio Satellites. Three satellites, to be delivered in orbit, shall form a constellation that provides improved elevation angle compared to geostationary satellites.*

The satellites shall be provided with * communications antennas. The attitude control subsystem shall point the communications uplink and downlink antennas to cover the Continental United States (CONUS) continuously during the nominal 16 hour active phase of the orbit. During the remaining 8 hours, the satellite payload shall be in standby mode with minimal radiated energy. The S-Band communications transmit antenna shall be optimized to maximize the flux density on the ground during the operational period.

The satellites shall be compatible with the launch constraints, restrictions, environments, and limitations of the Proton, Atlas IIIA and Sea Launch launch vehicles, and shall also be able with other potential launch vehicles that do not impose any physical or environmental constraints more severe than the above-listed launch vehicles.

The spacecraft shall be designed to comply with all performance specifications stated herein, and shall have the capability of providing an anticipated mission life of 15 years, subject to optimization by the system CDR, but in no event to be less than 12 years.

Definitions for the terminology used within this specification are provided in Appendix A.

Finalization of To Be Confirmed (TBC) and To Be Defined (TBD) parameters shall be mutually agreed between CD Radio and SS/L.

SECTION 1 -- SATELLITE SYSTEM SPECIFICATION

1.1 ORBIT DEFINITION
*

1.2 STATIONKEEPING
*

1.3 ON-ORBIT ENVIRONMENT
The satellite shall be designed and built to meet all satellite performance specifications during and after exposure to the orbital environments expected in the orbits specified in 1.1 throughout the operational life specified in 1.6.2.

The design of the satellites shall also minimize the occurrence and/or effect of electrostatic charging, passive intermodulation and multipaction.

1.4 LAUNCH VEHICLES
The satellites shall be designed to fit within the dynamic envelopes of the Proton, Atlas IIIA and Sea Launch launch vehicles.

1.4.1 LAUNCH VEHICLE ENVIRONMENTS
The design of the satellite shall be compatible with the launch vehicle environments specified in the launch vehicle manuals.

1.5 DEFINITION OF COORDINATE AXES
The satellite axes are defined as a right hand triad fixed in the satellite. When the satellite is operational, the +Z axis is nominally in the orbit plane pointing toward the center of the earth.

1.6 LIFE REQUIREMENTS

1.6.1 MISSION LIFE
The mission life of the satellite shall include the orbit raising phase after the satellite separates from the launch vehicle followed by the deployment and in-orbit test phase followed by the operational phase.

1.6.2 OPERATIONAL LIFE
The spacecraft shall be designed to operate in accordance with the performance requirements of this specification, during the active phase of the orbit when transmitting at full power, and shall have the capability of providing an

anticipated mission life of 15 years, subject to optimization by the system CDR, but in no event to be less than 12 years. This requirement shall be met for 3[sigma] launch vehicle and spacecraft dispersions.

Operation of the repeater at reduced EIRP is permitted to maintain positive DC power margin during eclipse season, when the spacecraft is in the orbit normal configuration with no yaw steering. This EIRP reduction shall not exceed 0.5 dB with respect to the requirements of paragraph 2.1.4. The start of reduced EIRP operation is predicted to occur after approximately 12 years of orbital life based on nominal TWTA efficiency, solar array degradation and no solar array circuit failures. The Spacecraft Orbital Operations Handbook (SOOH) shall define procedures for reduced EIRP operations.

1.6.3 STORAGE LIFE
The satellite shall be capable of meeting the life requirements specified in 1.6.1 and 1.6.2 after being subjected to ground storage in a controlled environment for up to two years with periodic maintenance. Several more years of ground storage shall be possible with refurbishment of appropriate spacecraft equipment.

1.7 RELIABILITY
Satellite reliability shall be demonstrated by analysis to meet the requirements specified herein. FIT rates derived from in-orbit experience shall be used, if applicable.

1.7.1 PAYLOAD
*

1.7.2 SPACECRAFT BUS
*

1.8 ECLIPSE OPERATION
The satellite shall be capable of meeting all performance requirements during eclipse during the specified operational life, with the specific exception noted in paragraph 1.6.2.

1.9 IN-ORBIT DELIVERY
The spacecraft shall be delivered in their specified orbits following successful completion of IOT.

1.10 RADIATION ENVIRONMENT
The satellite electronic equipment shall be designed to meet all performance requirements over a 15 year life in the presence of the radiation environment associated with the specified orbits.

1.11 SINGLE EVENT UPSETS (SEU)
The design of the satellite shall be such that the effects of single event upsets are minimized. Design techniques such as 2-out-of-3 voting shall be used to make the system SEU immune. System recovery mechanisms such as data refresh and command retries will be used. No SEU shall cause the spacecraft to be in a non-restorable (latch-up) state. Single event upsets capable of causing service interruption shall be limited to the following three conditions only:

1) An SEU causes the active CPU to restart, and the redundant CPU has previously failed.

2) An SEU causes the active CPU to restart while the ADCS is in stationkeeping mode.

3) An SEU causes the DCU-B pulse converter to turn off while the ADCS is in stationkeeping mode.

Compliance verification for this requirement shall be by analysis only.

SECTION 2 -- COMMUNICATION PAYLOAD SPECIFICATIONS

2.1 TRANSMIT PAYLOAD
All transmit payload performance parameters specified herein shall be satisfied when the transmit payload power amplifiers (PA) are operated at single carrier saturation unless specified otherwise. Transmit payload operational requirements shall not be applicable when the PAs are driven above single CW carrier saturation. During IOT the fixed gain mode will be used for measurement of transfer curves and other channel characteristics. For the transfer curve measurements, it shall be possible to set the TWTA input drive to any level up to +1 dB with respect to saturation. During IOT, both the fixed gain and automatic level control (ALC) modes will be used for payload testing. Subsequent to IOT, the ALC mode will be used for normal operations. Antenna blockage shall be avoided and clear field of view shall be maintained when the reflector is steered.

For reference, a simplified payload block diagram is provided in Figure 2-1.

2.1.1 FREQUENCY PLAN

The allocated downlink frequency band is 2320.0 MHz to 2332.5 MHz. The transmit payload of each satellite shall be capable of operating at either of the following channel center frequencies:

Frequency #1: 2322.10 MHz
Frequency #2: 2330.40 MHz

2.1.2 USEABLE BANDWIDTH
The minimum usable bandwidth of each channel shall be 4.2 MHz.

2.1.3 POLARIZATION
*

2.1.3.1 CROSSPOL ISOLATION
*

2.1.4 EIRP
*

Figure 2-1. CD Radio Satellite Payload Block Diagram
(FOR REFERENCE ONLY)
*

2.1.4.1 PA REDUNDANCY
*

2.1.4.2 PA SWITCHING
*

2.1.5 COVERAGE
*

2.1.6 OUT-OF-BAND EMISSIONS
*

2.1.7 SINGLE CARRIER TO THIRD ORDER LNTERMODULATION (C/3IM)
*

2.1.8 PHASE SHIFT
*

2.1.9 AM/PM CONVERSION
*

2.2 RECEIVE PAYLOAD

2.2.1 FREQUENCY PLAN
The allocated uplink frequency band is 7060.0 MHz to 7072.5 MHz. The receive payload of each satellite shall be capable of receiving and downconverting signals at either of the following channel center frequencies:

Frequency #1: 7062.10 MHz
Frequency #2: 7070.40 MHz

2.2.2 USEABLE BANDWIDTH
The useable bandwidth of each channel shall be 4.2 MHz.

2.2.3 POLARIZATION
*

2.2.4 G/T
*

2.2.5 COVERAGE
*

2.2.6 SATURATION FLUX DENSITY
*

2.2.7 GAIN CONTROL
*

2.2.7.1 AUTOMATIC LEVEL CONTROL (ALC)
*

2.2.7.2 FIXED GAIN CONTROL
*

2.2.8 IN-BAND FREQUENCY RESPONSE

2.2.8.1 GAIN FLATNESS
The gain flatness over the channel bandwidth shall not exceed the following limits (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
Levels (dB)	*

2.2.8.2 GAIN SLOPE
The gain slope shall not exceed the following values (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
gain slope (dB/MHz)	*

2.2.9 GROUP DELAY
The group delay variation shall not exceed the following limits (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
Group Delay, nsec	*

2.2.10 NARROWBAND RECEIVE OUT-OF-BAND RESPONSE
The response relative to that at the center frequency of each channel shall be less than the limits defined below (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
Response, dB	*

2.2.11 WIDEBAND RECEIVE OUT-OF-BAND RESPONSE
The wideband receive out-of-band response, relative to the response at channel center frequency shall not exceed the following:

*

2.2.12 PHASE SHIFT
*

2.2.13 AM/PM CONVERSION
*

2.3 TOTAL PAYLOAD

2.3.1 IN-BAND FREQUENCY RESPONSE

2.3.1.1 GAIN FLATNESS
The gain flatness over the channel bandwidth shall not exceed the following limits (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
Levels (dB)	*

2.3.1.2 GAIN SLOPE
The gain slope shall not exceed the following values (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
gain slope (dB/MHz)	*

2.3.2 GROUP DELAY
The total group delay variation shall not exceed the following limits (design goals are shown in parentheses):

Offset from channel center frequency (MHz)	*
Group Delay, nsec	*

2.3.3 REPEATER SPURIOUS OUTPUTS

2.3.3.1 IN-BAND SPURIOUS OUTPUTS
*

2.3.4 OUT-OF-BAND EMISSIONS
*

The level of all other out-of-band emissions shall not exceed the following values:

Frequency offset from downlink band center frequency	Specification
*	*

2.3.5 MODULATION
*

2.3.6 FREQUENCY TRANSLATION
*

2.3.6.1 SHORT-TERM FREQUENCY TRANSLATION STABILITY
*

2.3.6.2 LONG TERM FREQUENCY TRANSLATION STABILITY
*

2.3.6.3 PHASE NOISE
*

2.4 TELEMETRY, COMMAND AND RANGING

2.4.1 LAUNCH, TRANSFER ORBIT, ON-ORBIT AND CONTINGENCY MODE REQUIREMENTS
*

2.4.1.1 FREQUENCY PLAN
The TC&R subsystem shall operate in the following frequency bands during all mission phases.

2.4.1.1.1 TELEMETRY
*

2.4.1.1.2 COMMAND
*

2.4.1.1.3 RANGING TONES
*

2.4.1.2 ANTENNA COVERAGE
*

2.4.1.3 TELEMETRY TRANSMIT POLARIZATION
*

2.4.1.3.1 AXIAL RATIO
*

2.4.1.4 COMMAND RECEIVE POLARIZATION
*

2.4.1.4.1 AXIAL RATIO
*

2.4.1.5 EIRP
*

2.4.1.6 COMMAND SENSITIVITY
*

2.4.1.7 SATELLITE ADDRESS
Each satellite shall have a separate and distinct satellite address.

2.4.3 TELEMETRY AND COMMAND CHARACTERISTICS/FORMATS
The following characteristics/formats are for both transfer orbit and on-orbit operations.

2.4.3.1 TELEMETRY
The telemetry subsystem shall permit the remote determination of the status and performance of the satellite subsystems and critical elements necessary for the safe operation of the satellite. It shall satisfy the requirements summarized in Table 2-1. Each satellite shall have a unique address assigned and transmitted each frame.

Table 2-1. Telemetry Specifications
*

2.4.3.1.1 SIMULTANEOUS TELEMETRY AND RANGING
Each telemetry transmitter shall provide the capability to transmit

simultaneously the ranging tones along with normal and dwell telemetry.

2.4.3.1.2 MODULATION
*

2.4.3.1.3 MODULATION INDEX
*

2.4.3.2 COMMAND
The command subsystem shall permit the remote control of the satellite including the capability to perform orbital maneuvers, attitude maneuvers, battery charge management, switching of redundant units and ranging. It shall satisfy the requirements of Table 2-2.

TABLE 2-2. COMMAND SPECIFICATIONS
*

2.4.3.2.1 FALSE COMMAND PROBABILITY
*

2.4.3.2.2 SIMULTANEOUS COMMAND AND RANGING
The satellite shall be capable of operating in a simultaneous command and ranging mode.

2.4.4 RANGING
The satellite ranging baseband output of each receiver shall be routed to the appropriate telemetry transmitter where, upon ground command, the ranging tones will be modulated onto the downlink carrier.

2.4.4.1 FLUX DENSITY LIMITS
*

2.4.4.2 RANGING ACCURACY
*

2.4.5 BEACON TRANSMITTER
*

APPENDIX A

A1.0 DEFINITIONS
These definitions are included as an aid to understanding the meaning of terms used within this specification. The definitions do not convey additional requirements over and above those in Section 2.0 and are for reference only.

A1.1 HIGH POWER AMPLIFIER (PA)
The portion of the payload that provides the final stage of active amplification of the single channel.

A1.2 LEFT HAND CIRCULAR POLARIZATION (LHCP)
A circularly polarized wave in which the electric field vector rotates counterclockwise when viewed in the direction of propagation.

A1.3 RIGHT HAND CIRCULAR POLARIZATION (RHCP)
A circularly polarized wave that has a rotation of its electric field vector in a clockwise direction when viewed in the direction of propagation.

A1.4 RANGE CORRECTED EFFECTIVE ISOTROPIC RADIATED POWER (EIRP)
*

A1.5 AXIAL RATIO
The ratio of the major axis to the minor axis of the polarization ellipse.

A1.6 RECEIVE PAYLOAD
The receive payload contains the communications service RF equipment starting with the X-band antenna and continuing to the output of the channel amplifiers (reference Figure 2-1).

A1.7 TRANSMIT PAYLOAD
The transmit payload contains the communications service RF equipment starting with the channel amp output T-Switches, and continuing to, and including, the S-band antenna (reference Figure 2-1).

Exhibit C
Product Assurance Plan

[picture/graph here]

CD Radio
DARS System

EXHIBIT C
PRODUCT ASSURANCE PLAN

Prepared for:
CD RADIO INC.
1001 22nd Street NW,
Washington, DC 20l037

Prepared by:
SPACE SYSTEMS/LORAL
3825 Fabian Way, Palo Alto,
California 94303-4604

CD RADIO
DARS SYSTEM

EXHIBIT C
PRODUCT ASSURANCE PLAN

Prepared for:
CD RADIO INC.
1001 22nd Street NW
Washington, DC 20037

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CD RADIO SPACE SYSTEMS LORAL

P R O P R I E T A R Y

CONTENTS

ILLUSTRATIONS

TABLES

ACRONYM LIST

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A CDR Critical Design Review

A/D	Analog-to-Digital
AAM	Apogee Adjust Maneuver
ACE	Attitude Control Electronics
ACU	Antenna Control Unit
ADCS	Attitude Determination and Control Subsystem
AE	Autumnal Equinox
AGC	Amplitude Gain Control
A-hr	Ampere-Hour
AIT	Assembly, Integration & Test
ALC	Automatic Level Control
AM	Amplitude Modulation
AMF	Apogee Maneuver Firing
ANA	Automatic Network Analyzer
AOC	Attitude and Orbit Control
AOCS	Attitude and Orbital Control Subsystem
AOS	Acquisition of Signal
APL	Approved Parts List
APM	Antenna Positioning Mechanism
APU	Auxiliary Power Unit
ASIC	Application-Specific Integrated Circuit
ASP	Analog Signal Processor
AT	Acceptance Test
ATE	Automated Test Equipment
B	
BIU	Bus Interface Unit
BOL	Beginning of Life
BPSK	Biphase Shift Keying
BSCS	Bus Supervisory and Control System
C	
C/31M	Ratio of Carrier-to-Third-Order Intermodulation Products
CAB	Corrective Action Board
CAD	Computer-Aided Design
CASS	Coarse Analog Sun Sensor
CATR	Compact Antenna Test Range
CCB	Configuration Control Board
CDDI	Contract Data Delivery Index
CDRL	Contract Documentation Requirements List
CE	Conducted Emission
CHAMP	Conical Horn Analysis by Model Processing
CI	Configuration Item
CIC	Cover Integrated Cell
CIL	Configuration Identification List
CIP	Contract Implementation Plan
CLA	Coupled Loads Analysis
CLT	Closed-Loop Tester
CLTC	Closed-Loop Test Computer
CM	Center of Mass
CM	Configuration Management
CMD	Command
CMOS	Complementary Metal-Oxide Semiconductor
CN	Correction Notice
COP	Contingency Operating Procedure
CPA	Central Pivot Assembly
CPC	Command and Protect Circuit
CPT	Comprehensive Performance Test
CPU	Central Processing Unit
CSCI	Computer Software Configuration Item
CSM	Cost and Schedule Management
CSS	Control Safety System
D	
DBS	Direct Broadcast Satellite
dc	Direct Current
DCM	Document Control Manager
DCU	Data Concentrator Unit
DDL	Deliverable Documents List
DDTL	Digital Data-Tracking Loop
DHE	Data Handling Electronics
DHS	Data Handling Subsystem
DIRA	Digital Integrating Rate Assembly

ACRONYM LIST (CONTINUED)

DOD	Depth of Discharge
DRAS	Defect Reporting and Analysis System
DRB	Drawing Review Board
DRI	Data Requirements Instruction
DRO	Dielectric Resonator Oscillator
DSP	Digital Signal Processor
DSR	Document Status Report
DSS	Digital Sun Sensor
DTU	Data Translation Unit
E	
E-W	East-West
EAGE	Electrical Aerospace Ground Equipment
EC	Eccentricity Control
ECD	Estimated Completion Date
ECO	Engineering Change Order
EDAC	Error Detection and Correction
EDC	Effective Date of Contract
EDI	Electronic Data Interchange
EDM	Electrodischarge Machining
EED	Electro-Explosive Device
EGSE	Electrical Ground Support Equipment
EIRP	Equivalent Isotropic Radiated Power
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOC	Edge of Coverage
EOL	End of Life
EPC	Electrical Power Conditioner
EPI	Eagle Picher, Inc.
EPS	Electrical Power Subsystem
EPW	Electrical Pulsewidth
EQM	Engineering Qualification Model
ER	Established Reliability
ES	Earth Sensor
ESA	Earth Sensor Assembly
ESD	Electrostatic Discharge
EWSK	East-West Stationkeeping
F	
FAA	Failure Anomaly Analysis
FACAS	Failure Analysis and Correction Action System
FARM	First American Records Management
FDIR	Failure Detection, Isolation, and Recovery
FET	Field-Effect Transistor
FM	Flight Model
FM	Frequency Modulation
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FOV	Field of View
FQT	Formal Qualification Testing
G	
G/T	Antenna Gain-to-Noise-Temperature Ratio
Ge	Germanium
GFRP	Graphite-Fiber Reinforced Plastic
GIDEP	Government Industry Data Exchange Program
GMT	Greenwich Mean Time
GN2	Gaseous Nitrogen
GOES	Geostationary Operational Environmental Satellite
GSE	Ground Support Equipment
GTO	Geosynchronous Transfer Orbit
H	
HCE	Heater Control Electronics
HDR	High Data Rate
HED	Hull Effect Device
HEDD	Hughes Electron Dynamics Division
HEMT	High Electron Mobility Transistor
HLCD	High-Level Command Decoder
HLPC	High-Level Pulse Commands
HPA	High-Power Amplifier
HPBW	Half Power Beamwidth

ACRONYM LIST (CONTINUED)

HSS	High-Speed Serial
HTFB	High Temperature Forward Bias
HTRB	High Temperature Reverse Bias
I	
I/O	Input/Output
IBO	Input Back-Off
IC	Integrated Circuit
ICD	Interface Control Drawing
ID	Identification
IF	Intermediate Frequency
IFA	Intermediate Frequency Amplifier
IFD	In-Fight Disconnect
IMCB	Intra-Module Control Bus
IMUX	Input Multiplexer
Insat	Indian National Satellite
IOP	Infrared Optical Package
IOT	In-Orbit Test
IR	Infared
IR&D	Independent Research &.Development
IRES	Infrared Earth Sensor
Isp	Specific Impulse
IST	Integrated System Test
ISTI	International Space Technologies, Inc.
J	
K	
KIP	Key Inspection Point
KSC	Kennedy Space Center
L	
LAA	Linear Actuator Assembly
LAN	Local Area Network
LAT	Lot Acceptance Test
LC	Launch Complex
LDR	Low Data Rate
LED	Light-Emitting Diodes
LEO	Low-Earth Orbit
LET	Linear Energy Transfer Coefficient
LLA	Low-Level Amplifier
LNA	Low-Noise Amplifier
LO	Local Oscillator
LOM	Launch Operations Manager
LOS	Loss of Signal
LRR	Launch Readiness Review
LSM	Launch Services Manager
LSTP	Local Solar Time of Perigee
LTWTA	Linearized Traveling Wave Tube Amplifier
LV	Launch Vehicle
LVDT	Linear Variable Differential Transducer
M	
M&P	Materials and Processes
MAPL	Materials Authorized Parts List
MAPS	Mission Analysis and Planning Software
MATE	Microwave Automatic Test Equipment
MCC	Mission Control Center
MCP	Materials Control Program
MEU	Multiple-Event Upset
MGSE	Mechanical Ground Support Equipment
MIB	Minimum Impulse Bit
MIC	Microwave Integrated Circuit
MIPS	Million Instructions per Second
MLI	Multilayer Insulation
MMH	Monomethylhydrazine
MMIC	Monolithic Microwave Integrated Circuit
MOB	Make-or-Buy
MODS	Mission Operations and Data System
MP	Multipaction
MPA	Medium-Power Amplifier
MPCB	Materials Process Control Board
MQRB	Materials Qualification Review Board
MRB	Material Review Board
MRR	Manufacturing Readiness Review
MSB	Most Significant Bit
MSD	Mirror Scan Drives
MSM	Microwave Switch Matrices
MSPSP	Missile System Prelaunch Safety Packaging

USE OR DISCLOSURE OF THE DATA CONTAINED ON THIS SHEET IS SUBJECT TO THE RESTRICTION ON THE TITLE PAGE.

ACRONYM LIST (CONTINUED)

MST	Main Satellite Thruster
MSTF	Main Satellite Thruster Firing
MTTF	Mean-Time-To-Failure
MW	Momentum Wheel
MWA	Momentum Wheel Assembly
N	
N-S	North-South
N-Star	Satellite Program for NTT
N2O4	Nitrogen Tetroxide
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency
NASTRAN	NASA Structural Analysis
NC	Normally Closed
NCR	Nonconformance Report
NFR	Near-Field Range
NiH	Nickel-Hydrogen
NO	Normally Open
NOAA	National Oceanic and Atmospheric Administration
NPR	Noise-to-Power Ratio
NSI	NASA Standard Initiator
NSSK	North-South Stationkeeping
NTO	Nitrogen Tetroxide
O	
O&M	Operations and Maintenance
O/S	Operating System
OBO	Output Back-Off
OJT	On-the-Job Training
OL	Orbital Location
OMI	Operations and Maintenance Instructions
OML	Orbital Maneuver Lifetime
OMUX	Output Multiplexer
PAA	Pivot Axis Assembly
PAML	Program Authorized Materials List
PAP	Product Assurance Plan
PAPL	Program Approved Parts List
PAPM	Product Assurance Program Manager
PAPrL	Program Authorized Process List
PCB	Parts Control Board
PCM	Program Configuration Manager
PCM	Pulse Code Modulation
PCU	Power Control Unit
PDC	Product Data Control
PDMS	Program Data Management System
PDR	Preliminary Design Review
PDU	Power Distribution Unit
PEA	Pitch Earth Acquisition
PFD	Phase Flux Density
PFM	Protoflight Model
PIM	Passive Intermodulation
PIU	Pyro-Integration Units
PLL	Phase-Locked Loop
PM	Phase Modulation
PMD	Propellant Management Device
PO	Physical Optics
PPE	Program Parts Engineer
PPF	Payload Processing Facility
PPO	Pin Photodiodes
PRM	Perigee-Raising Maneuver
PROM	Programmable Read-Only Memory
PSDB	Product Structure Data Book
PSK	Phase-Shift Keying
PSR	Preshipment Review
PSU	Power Supply Unit
PTR	Post Test Review
PVA	Perigee Velocity Augmentation

OSR	Optical Solar Reflector	PWB	Printed Wiring Board
P		PWM	Pulsewidth Modulated
PA	Product Assurance	PWPF	Pulsewidth Pulse Frequency

ACRONYM LIST (CONTINUED)

Q		SCM	Software Configuration Management
QA	Quality Assurance	SCPC	Single Carrier Per Channel
QAPL	Qualified Approved Parts List	SCPL	Standard Company Parts List
QC	Quality Control	SCR	Strip Chart Recorder
QM	Qualification Model	SCRB	Software Configuration Review Board
QML	Qualified Manufacturing List	SDM	Scan Drive Mechanism
QPI	Quality Program Instruction	SDRL	Subcontract Data Requirements List
QSL	Qualification Status List	SECDEP	Single Bit Error Correction and Double Bit Error Detection
QUAL	Qualification		
R		SEE	Single-Event Effect
RAM	Random Access Memory	SEL	Single-Event Latchup
RCVR	Receiver	SEU	Single-Event Upset
RDN	Reliability Discrepancy Notice	SFD	Saturation Flux Density
RE	Radiated Emission	SIA	Sedal Interface Adapter
REA	Roll Earth Acquisition	SiO	Silicon Oxide
RF	Radio Frequency	SK	Stationkeeping
RFAM	Request for Approval of Material	SKM	Stationkeeping Maneuver
RFAP	Request for Approval of Process	SLRR	Satellite Launch Readiness Review
RMR	Request for Material Review	SLT	Satellite Local Time
RMS	Root Mean Square	SMD	Surface-Mounted Device
ROM	Read-Only Memory	SOE	Sequence of Events
RPU	Range Processing Unit	SOH	Satellite Operations Handbook
RS	Radiated Susceptibility	SOOH	Satellite Orbital Operations Handbook
RSS	Root Sum Square	SOP	Standard Operating Procedure
RTS	Real-Time Software	SOSD	Satellite Operating Support Documentation
RW	Reaction Wheel		
RWA	Reaction Wheel Assembly	SOW	Statement of Work
S		SPAR	Supplier Product Assurance Requirements
S/C	Spacecraft		
SA	Sun Acquisition	SPD	Sampling Phase Detector
SAAPM	Single-Axis Antenna Positioner Mechanism	SPF	Single-Point Failure
		SPFI	Single-Point Failure Item
SADA	Solar Array Drive Assembly	SPLL	Sampling Phase-Locked Loop
SAM	Sun Acquisition Mode	SPSR	Satellite Pre-Shipment Review
SATM	Software Assurance Task Manager	SPT	System Performance Test
SCA	Subcontracts Administration	SQA	Software Quality Assurance
SCC	Space Communications Corporation	SQPP	Software Quality Program Plan
SCE	Spacecraft Control Electronics	SRB	Satellite Review Board

ACRONYM LIST (CONTINUED)

SS	Summer Solstice	TQM	Total Quality Management
SS/L	Space Systems/Loral	TRB	Test Review Board
SSES	Subcontract Status and Expedite System	TRR	Test Readiness Review
		TSO	Timing Source Oscillator
SSM	Support Subsystem Module	TTE	Thomson Tubes Elecroniques
SSOW	Subcontractor Statement of Work	TWT	Traveling Wave Tube
SSTP	Switch State Time Plan	TWTA	Traveling Wave Tube Amplifier
SSU	Sequential Shunt Unit	U	
STE	System Test Equipment	UV	Ultraviolet
STP	Satellite Test Plan	V	
STRB	Specification and Test Review Board	VCO	Voltage-Controlled Oscillators
T		VMS	Virtual Memory System
T&C	Telemetry and Command	VSWR	Voltage-Standing Wave Ratio
TAAPM	Two-Axis Antenna-Pointing Mechanism	W	
TBD	To Be Determined	WAD	Work Authorization Document
TC&R	Telemetry, Command, and Ranging	WCA	Worst-Case Analysis
TCP	Telemetry and Command Processor	WCAB	Working Corrective Action Board
TDHS	Test Data Handling System	WCFA	Wideband Current Feedback Hybrid Amplifiers
TDMA	Time-Division Multiple Access		
TLM	Telemetry	WIP	Work-in-Process
TMF	Trim Maneuver Firing	X	
TNC	Terminal Network Controller	XMTR	Transmitter
TPU	Telemetry Processing Unit		

INTRODUCTION

This Product Assurance Plan, developed for the CD Radio program, consists of three elements:

1. Compliance to the Requirements of the Request for Proposal

2. Extensions to the Standard Product Assurance Plan required for CD Radio

3. The Standard Commercial Product Assurance Plan for SS/L

All three items, taken together, constitute the Product Assurance Plan.

SECTION 1 - COMPLIANCE TO THE REQUIREMENTS

The following text provides explanations of SS/L's compliance to assumed requirements similar to the Apstar IIR. A summary of SS/L's approach to product assurance is provided in the following paragraph, "General Approach." It explains the motivation for standardizing the Product Assurance program along the lines of other DBS programs, including the Tempo, PanAmSat and Telstar programs, among others.

1.1 GENERAL APPROACH

Space Systems/Loral uses a standard product assurance approach for Direct Broadcast Satellites (DBS) to maintain the capability to deliver high quality product within the schedule constraints required by SS/L's customers. The standard plan is presented in appendix. It is compliant to the requirements of CD Radio.

SS/L's system provides for manufacturing of components common to all satellites using a common products program structure for procurement and control. These common components are then delivered to flight stores, awaiting a need from one of SS/L's satellite programs.

All of SS/L's DBS programs, which have delivery schedules on the order of 2 years, use this system, and it is necessary that this system be used for the program to achieve timely delivery of the spacecraft. Many components may already be in stock and ready for use on the program.

The considerations provided in these sections will fully adapt requirements to our DBS approach. If any differences between SS/L's approach and the requirements of CD Radio are considered of exceptional importance, SS/L's standard approach could be modified. It would be important, however, to fully assess the impact of any such changes prior to implementation.

SECTION 2 - ADDITIONS AND EXPLANATIONS FOR USE WITH THE STANDARD PLAN

The following items are necessary for proper implementation of the CD Radio program. These form a part of the Standard Plan when it is used for space flight hardware and software intended for use on the program.

2.1 STRESS/OPERATING FAILURE RATE MULTIPLIERS (REF. TABLE 2-4 OF THE PLAN)

Orbit on Station duration for use in reliability calculations shall be for a period of two months and 15 years.

2.2 RADIATION

The Radiation Design Life and Worst-Case Analyses shall be in accordance with a 15-year mission, plus an estimated two months of in-orbit testing, with 20% margin (i.e., the Radiation Design Life shall be greater than or equal to 15 years at the orbital position of 115.5(degree) eaST).

2.3 FAILURE REVIEW BOARD (FRB)

FRB will be held with local customer participation for unique payload items, from the completion of unit level acceptance forward, and for occurrences during system-level acceptance or protoflight test, from reference functional test forward.

2.3.1 DELIVERABLE DOCUMENTATION

Documents that are deliverable to the customer include the items shown in Table 2-1.

2.3.2 NONCONFORMANCE REPORTING

Customer Reporting of nonconformances shall be in accordance with the following Figure 2-1.

TABLE 2-1. DELIVERABLE DOCUMENTS

<TABLE>
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DELIVERABLE DOCUMENT	WHEN DELIVERED	INTENDED USE
<S>	<C>	<C>
Critical Items List	With the proposal and when updated	For review
Qualification Status List	At PRR - see the test plan for qualification status in the proposal.	For review
Single Point Failure List	With the proposal and when updated	For review
Parts List	With the PRR* and when updated	For review
Materials List	With the PRR* and when updated	For review
Process List	With the PRR* and when updated	For review
Noncomformance and failure reports list	With the Monthly Report	For review
Nonconformance Notifications summarized in section 1.2	Within one working day from discovery at SS/L	Delivered to customer technical representatives on site for review
Failure Review Board Reports as representatives summarized in Section 1.2	Delivered prior to the Failure Review Board	Customer on-site technical will participate

* PRR is Production Readiness Review (ref. management plan)
</TABLE>

Daily Reports, consisting of notification for any new nonconformances for unique payload items at the A/T level, or any nonconformances at system test level will be distributed to resident customer technical representatives.

|
|
|
\|/

These notifications constitute an invitation to become involved in the Material Review Board activities. Such involvement will include the provision of any intermediate information required by the customer to form his position for final disposition in the Failure Review Board.

|
|
|
\|/

During the System Test phase of the program weekly summaries of nonconformances will be distributed as part of the satellite integration and test meeting.

|
|
|
\|/

Monthly Failure Review Board meetings will be held, with customer participation, to present the conclusions of SS/L, and to officially authorize closure of Material Review activities.

Figure 2-1. SS/L and Customer Interface for Nonconformance Management

SECTION 3 - THE STANDARD PRODUCT ASSURANCE PLAN

The SS/L standard Product Assurance Plan, Document No. E038152, is used for commercial programs. This document is presently at revision level A. Any updates to this document will be provided to SS/L's commercial customers for information.

Should any of the contractual conditions of any program be affected by future changes in this plan, then those elements of the plan that affect the contractual conditions will be submitted to the customer for approval.

The Commercial Programs Product Assurance Plan, Document No. E038152, Rev. A, is provided as Attachment 1.

ATTACHMENT 1

DOCUMENT NO. E038152, REVISION A
COMMERCIAL PROGRAMS
PRODUCT ASSURANCE PLAN

SPACE SYSTEMS / LORAL
3825 Fabian Way
Palo Alto, CA 94303-4604
CAGE ODJH2

DOC CODE TS
Document No. E038152
Revision A

COMMERCIAL PROGRAMS
PRODUCT ASSURANCE PLAN

PROGRAM: COMMERCIAL	
SPECIFICATION ENGINEER	FAILURE REPORTING AND ANALYSIS
SURVIVABILITY ENGINEERING	CONFIGURATION MANAGEMENT
RELIABILITY ASSURANCE	QUALITY ASSURANCE
PROGRAM PRODUCT ASSURANCE	PARTS ENGINEERING
MATERIALS AND PROCESSES	SOFTWARE QUALITY ASSURANCE
	RELEASE
	DATE

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CHANGE RECORD

REV	AUTHORIZATION	REASON FOR CHANGE	AFFECTED PAGE(s)
Initial Release			
A	K. Dodson	Updates to coincide with current operating procedures	A11

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1. PRODUCT QUALITY ASSURANCE PLAN

1.1 Introduction and Scope

1.1.1 Introduction and Scope

This Product Quality Assurance (PA) Plan describes the PA activities to be conducted by Space Systems/Loral (SS/L) in the design, development, manufacture, assembly, test, delivery, and launch of spacecraft to assure high product quality and reliable performance in service on orbit. Specific controls, analyses and procedures are addressed for each PA discipline. These disciplines include:

a. Design Support Reliability
b. Parts Assurance Engineering
c. Quality Assurance
d. Software Product Assurance
e. System Safety
f. Supplier Control
g. Failure Reporting, Analysis and Corrective Action
h. Space Radiation Survivability (SS/L Systems Engineering performs this function)
i. Configuration Management (SS/L Systems Engineering performs this function)

1.1.1.1 Objectives of the Plan

Objectives of the plan are to:

a. Maximize the use of qualified and flight-proven hardware.
b. Provide a standardized set of long-life space qualified parts, materials and processes
c. Provide 100% inspection of all flight hardware
d. Ensure survival for the contractual mission duration of hardware by qualification testing with parameters set at levels higher than the requirements of nominal orbital operation
e. Verify workmanship by inspection and adequate levels and duration of acceptance testing
f. Ensure by analysis that all parts are conservatively derated including derating for aging and radiation effects

1.1.1.1 Objectives of the Plan (Continued)

g. Integrate procurement, manufacturing and test nonconformances and failures into a system providing for multi-program visibility, follow-up on corrective actions, and trend analysis to identify and provide for corrective action to prevent recurrence
h. Identify items subject to wearout or depletion and verify by analysis and test that they have adequate margins over their normal mission performance/life requirements
i. Ensure by analysis that the reliability, redundancy and cross-strapping configurations of all systems are adequate to meet reliability requirements.
j. Monitor and ensure control of the development of space flight and test software, to ensure that it is produced to acceptable standards
k. Ensure spacecraft and personnel safety by a system of design features, controls and procedures
1. Provide monitoring and control of all subcontractors to ensure that they will meet the PA requirements
m. Ensure that the customer is kept apprised of the status of the PA Program by providing appropriate input to the program reports.

1.1.1.2 PA Management

SS/L uses an integrated approach to the PA areas to achieve its historically

high performance. All of the relevant PA disciplines report through the Vice-President of Product Assurance. The Vice-President of Product Assurance reports to the Executive Vice-President.

Each Program Manager is delegated authority to meet contractual requirements by the Executive Vice President. He is responsible for supplying technical, procurement, and management direction to the in-house functional groups and the subcontractors involved in the program. To aid in this effort, a specific individual from the SS/L Product Assurance directorate is appointed as the system Product Assurance Program Manager. This individual is responsible to the Program Manager for implementation of the Product Assurance program, but also maintains an independent direct reporting route to top SS/L management through the Vice-President of Product Assurance.

1.1.1.2. PA Management (Continued)
The PA Program Manager acts as the focal point within the project for the Product Assurance disciplines, for the customer and for subcontractors concerning Product Assurance matters. He ensures that all appropriate aspects of Product Assurance are addressed by SS/L, and that Product Assurance tasks and missions are competently accomplished. He prepares PA input to progress reports. The PA Program Manager is supported by dedicated program engineers from each of the PA disciplines.

1.1.1.3 Organization and Management of Subcontractor Activities
The requirements of this plan are imposed on subcontractors and suppliers with the same level of rigor as for SS/L in-house activities, as applicable to each procurement. Product Assurance specialists working with the design teams and procurement personnel in each discipline ensure that source selection is limited to organizations which have demonstrated satisfactory performance on past procurements. Since all but a few subcontractors have furnished the same equipment for other programs, SS/L has a thorough knowledge of their capabilities and has established long-term personal relationships with their engineers and managers. Verification that requirements are completely specified in procurement documents is achieved by PA participation in the Specification Review Boards which review and approve them. Both the Statement of Work and the Performance Specifications invoke the Product Assurance requirements on suppliers, SH-EO32894, Subcontractor Product Assurance Requirements Specification. Subcontractor selection and control are discussed in Section 8.

1.1.1.4 Reference Documents

Government

US MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-STD-975	NASA Standard Electrical Parts List for Grade 1
MIL-STD-883	Test Methods & Procedures for Microelectronics
MIL-STD-1576	Electroexplosive Subsystems Safety Requirements and Tests Methods for Space Systems
MIL-STD-45662A	Calibration System Requirements
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
MIL-STD-1522A	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
ESMCR 127-1	Eastern Space and Missile Center Range Safety Regulations
ERR 127-1	Eastern Range Regulation for Range Safety, 30 June 1993
FED-STD-209	Engineering Standard for Controlled Environments
MIL-STD-462	EMC Test Methods
NHB 5300.4(3A-1)	NASA Soldering Criteria
MIL-S-19500	Semiconductor Devices, Specification for
MIL-T-23648	Resistor, Thermal, Insulated, General Spec for
MIL-H-38534	Hybrid Microcircuits, General Specification for
MIL-I-38535	Integrated Circuits Manufacturing, General Spec for
MIL-STD-1246	Product Cleanliness Levels and Contamination Control Program
MIL-STD-45662A	Calibration System Requirements

SS/L

E88-5050	SS/L Engineering Standards for Controlled Environments
SS/L QA Manual	SS/L Quality Assurance Manual, Vols. 1-4
PAPL LGXXXXXX	Program Approved Parts List
PAML LGXXXXXX	Program Approved Materials List
PAPRL LGXXXXXX	Program Approved Process List
APMPL	Approved Parts, Materials and Process List
SS/L E88 Series	SS/L Engineering Process Requirements
SH-EO32894	Subcontractor Product Assurance Requirements
DES E07.11.06	Galvanic Corrosion of Dissimilar Metals

1.1.1.4 Reference Documents (Continued)

Others	
AD.05	SS/L Alliance Document - EEE Parts Requirement
ESA-PSS-01-20	QA Requirements for ESA Space Systems (Metrology and Calibration)
ESA-PSS-01-608	Generic Specification for Hybrid Microcircuits
ESA-PSS-01-701	Data for Selection of Space Materials
ESA-PSS-OI-702	A Thermal Vacuum Test for the Screening of Space Materials
ESA-PSS-01-736	Materials Selection for Controlling Stress Corrosion Cracking
ESA-PSS-01-737	Determination of the Susceptibility of Metals to Stress Corrosion Cracking
ASTM-E-595-93	Total Mass Loss and Collected Volatile Condensable Materials from Outgassing
ASTM-E-1248-93	Standard Practice for Preparation of Aerospace Contamination Control Plans
ESA SCC QPL	Qualification Parts List
ESA-PSS-01-708	The Manual Soldering of High Reliability Connections
CSG-RS-IO-CN Volume 1	CSG Safety Regulations, General Rules, 12 August 1991 (Reglements de Sauvegarde du Centre Spatial Guyanais)
CSG-RS-22A-CN Volume 2, Part 2	CSG Safety Regulations, Specific Rules, Spacecraft, 12 August 1991
LKE-T9405-026, Rev. 1	Proton Users Safety Guidelines, 12 July 1994
XSLC-SS931113	Long March, Xichang, China, Safety Requirements Document, 13 November 1993
CGWIC-CSLTCG-SRD	China Great Wall Industry Corporation, China Satellite Launch Tracking Control General Safety Requirements
MDC H3224B	Commercial Delta II Payload Planners Guide

1.1.1.5 Acronyms

AIT	Assembly Integration and Test	Ge	Germanium
APL	Advanced Parts List	GSE	Ground Support Equipment
BOL	Beginning of Life	KIP	Key Inspection Point
CCN	Contract Change Notice	MAGE	Mechanical Aerospace Ground Equipment
CDRL	Contract Data Requirements List	MGSE	Mechanical Ground Support Equipment
CIDL	Configuration Identification Data List	MIP	Mandatory Inspection Point
CMD	Command	MRB	Material Review Board
CN	Correction Notice	NCR	Nonconformance Report
COTS	Commercial Off-the-Shelf	PA	Product Assurance
CR	Change Request	PAIS	Product Assurance Information System
CRB	Change Review Board	PAML	Program Authorized Materials List
DPA	Destructive Parts Analysis	PAPL	Program Authorized Parts List
DRB	Drawing Review Board	PAPM	Product Assurance Program Manager
DVM	Design Verification Matrix	PAPrL	Program Authorized Processes List
ECP	Engineering Change Proposal	PCB	Parts Control Board
EEE	Electrical, Electronic, and Electro-Mechanical	PM&PE	Program Materials and Process Engineer
EGSE	Electrical Ground Support Equipment	PPE	Program Parts Engineer
EMI	Electromagnetic Interference	PPL	Parts Physics Lab
EOL	End of Life	QA	Quality Assurance
ESD	Electrostatic Darge	QSL	Qualification Status List
FIT	Failure Per 109 Hours	RDN	Reliability Discrepancy Notice
FMECA	Failure Modes, Effects, and Criticality Analysis	RFAM	Request for Approval
FRB	Failure Review Board	RFAP	Request for Approval Process
GaAs	Gallium Arsenide	SCM	Software Configuration Management
SCPL	Standard Company Parts List	SPF	Single-Point Failure
SEU	Single-Event Upset	WCA	Worst Case Analysis
SOH	Spacecraft Orbital Handbook		

2. RELIABILITY

2.1 Scope

The reliability program ensures that the reliability analyses of the spacecraft are performed with uniform contractual ground rules and standards. This plan establishes the criteria for analytical demonstration of specified quantitative and qualitative reliability requirements.

The reliability program ensures fulfillment of the reliability mission and design life requirements of the spacecraft and its equipment. The reliability program is planned, implemented, and integrated in conjunction with other PA functions and with design, development, and production functions. All reliability program activities are carried out in parallel with the design process, and in close cooperation with design engineers.

The reliability program activities include:

a. Failure modes, effects, and criticality analysis (FMECA) with single-point failure (SPF) identification
b. Parts stress analysis (parts application review)
c. Worst-case analysis (performed by design engineering at SS/L)
d. Reliability assessment
e. Qualification Status Listing
f. Critical Items Listing

2.2 Failure Modes, Effects, and Criticality Analyses (FMECA)

2.2.1 General

To ensure that potential failures in the hardware are recognized early, system, subsystem, and equipment FEECAs will be performed. In addition to preparing FMECAs for electronic assemblies, FMECAs will be prepared for mechanical, electromechanical, and pyrotechnic assemblies. The spacecraft mission phases, environmental constraints, and hardware operating modes will be considered in the analyses. Failure effects will be analyzed to determine the need for design change or other action and that the proper compensatory measures are implemented.

2.2.1 General (Continued)

The FMECAs will be performed to the circuit functional level or subassembly level (mechanical items) with emphasis on equipment interface failure effects, propagation of failure effects to redundant, cross-strapped, or interfacing assemblies, and identification of single-point failure effects and fail-safe features. Failure modes or effects that require corrective actions will be followed and documented in a formal way and tracked until resolution is complete.

2.2.2 FMECA Approach

The FMECAs will be generated from the start of the design phase and updated throughout the design phases. All heritage hardware FMCCAs will be reviewed to ensure that the failure modes and effects for spacecraft hardware items are addressed, updated as necessary, and criticality classifications assigned in accordance with program usage and missions. Criticality classifications will be assigned to rank lower level effects and establish their resulting influence on spacecraft operation.

FMECAs will be implemented to:

- Document the interfacing failure modes of functional blocks of spacecraft hardware and the resulting failure effects on spacecraft assemblies, subsystems, and the spacecraft.
- Identify and eliminate single-point failure items whenever possible and minimize the probability of occurrence of the residual risks.
- Identify critical failure effects for concentration of efforts in the areas of quality, inspection, manufacturing controls, design review, configuration control, and traceability.
- Determine the need for more reliable designs; change in designs affecting parts, materials, or processes; adequacy of fail-safe design features; possibilities for design simplification; and/or sufficiency of redundancy and cross-strapping.
- Ensure that product design features minimize failures or loss of redundancy which could result from high temperature, chemical agents, EMI/ESD effects, vibration (detachment of parts), mechanical interaction or shock. Ensure sufficient failure protection against common mode failures (i.e. use of common parts for redundant circuits, redundant circuits on common broads or in common assemblies, inadequate thermal isolation of redundant circuits, etc.).

2.2.3 Single-Point Failures

Single-point failure items are defined as items which, if failed, result in the inability to use the communication functions of the spacecraft. These items will be identified as part of the FMECA effort. Corrective action to eliminate or mitigate the causes of single-point failure effects will be a key activity of the FMECA analyses.

2.2.4 FMECA Contents

The FMECA activity will be carried out in a systematic way to ensure that all spacecraft items and their interfaces are adequately addressed. Lower level FMECAs will be used as input in a buildup process to generate the subsystems and spacecraft higher level FMECAS. FMECAs will be documented and will provide:

- A description of the functional elements of the hardware being reviewed along with the applicable interfaces, redundancy features, and implementation and operational features
- Description of the function and technical parameters of the

hardware being analyzed for an adequate understanding of its role in the spacecraft operation
- The criticality of the failure effects identified at the hardware level
- The means by which the failure effects may be observed such as telemetry, operational anomalies, or test.

2.2.5 Criticality Classification

A criticality level will be assigned to each hardware item according to the severity of the effects. The criticality levels at the various levels of spacecraft indenture will be in accordance with Table 2-1.

Table 2-1. Criticality Categories

Criticality Categories	Assembly/Equipment Level	Subsystem Level	Spacecraft Level
1	Failure mode results in risk of loss or degradation of other equipment (risk of failure propagation) or constitutes a safety hazard	Failure mode results in risk of loss or degradation of other functional subsystems (risk of failure propagation) or constitutes a safety hazard	Failure mode results in complete loss of the spacecraft and all of its missions (referring to specified requirements) or constitutes a safety hazard.
2	Failure mode results in complete loss of operational capability of the equipment under consideration.	Failure mode results in complete loss of operational capability of the subsystems under consideration.	Failure mode results in partial loss or severe degradation of mission.
3	Failure mode results in severe degradation of operational capability of the equipment under consideration.	Failure mode results in severe degradation of operational capability of subsystems under consideration.	Failure made results in only minor or negligible degradation of mission.
4	Failure mode results in only minor or negligible degradation of equipment under consideration.	Failure mode results in only minor or negligible degradation of subsystems under consideration	(No category 4 for the spacecraft.)

2.2.6 System FMECA Report

A system FMECA report will be prepared. The system FMECA will include the following types of information:

- A description of the mission, function, and interfaces
- The functional block diagram of the system with a description of the function of the subsystems
- A summary of the system FMECA results
- Failure effects and single point failure items system summary list.

2.3 Parts Derating and Application Review

2.3.1 General

Stress analysis will be performed for both electrical parts and mechanical elements. For electronic equipment, parts derating and application review analyses will be performed to identify noncompliances with the program derating requirements and to direct the necessary changes to the design to comply with the program-derating requirements. For structural elements, stress analyses will verify compliance with the required safety factors for all missions.

2.3.2 Parts Derating and Application Review Analysis of Electronic Equipment

All flight equipment will be analyzed to determine individual part stresses (voltage, current, power, temperature, etc.) in transient as well as in steady state conditions. The reference equipment temperature to be used in the analyses will be the maximum acceptance temperature. The parts stresses will be compared to the program derating criteria which is summarized in Table 2-2. In those cases where the program derating criteria provides insufficient information, or if data is considered as not applicable, other sources can be used with justification.

Exceptions to the program derating requirements will be granted by SS/L Reliability only after all applicable design alternatives have been investigated

and the risks associated with the electrical stress or part application discrepancies have been determined and found acceptable. All applications exceeding these criteria must be approved by SS/L Reliability before incorporation into the design.

Table 2-2. Parts Derating Requirements Summary

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Table 2-2. Parts Derating Policy (continued)

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Figure 2.3-1. Maximum Allowable Current for Single Wire

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A list of the parts exceeding the stress criteria will be summarized and presented at the applicable design review for the hardware being reviewed.

2.3.3 Stress Analysis of Structural Elements and Mechanisms

The compliance of the structural elements and mechanisms with the required safety factors will be verified by engineering. Applications with safety factors which do not meet these criteria (where it is not feasible or possible to correct by means of redesign or other means) must be approved by SS/L Reliability before incorporation into the design.

A list of the elements exceeding the required safety factors will be included in the appropriate analysis along with actions being taken to resolve the discrepancies and, if applicable, justification for retention of each discrepancy.

2.4 Worst-Case Analysis (WCA)

2.4.1 General

The worst-case analysis ensures that item electrical and/or mechanical performances comply with the applicable equipment specification under worst-case operating conditions.

SS/L and its subcontractors will perform electrical performance worst-case analyses or evaluations on all hardware items for critical parameters.

SS/L Engineering organizations are responsible for the completion of worst-case analyses on flight hardware items for which they have design responsibility. They are required to ensure that the analyses are adequately prepared, that design margins are adequately demonstrated by analyses and/or tests, and that the documentation is complete and sufficient for review.

Reliability personnel will be responsible for ensuring that worst-case analyses are appropriately completed and that the results of the analyses ensure compliance with all applicable requirements. Applications exceeding these criteria (where it is not feasible or possible to correct by means of redesign or other means) must be approved by SS/L Reliability before incorporation into the design.

2.4.2 Analysis Method

WCA are required to demonstrate sufficient operating margins for all operating conditions of the individual circuits. The analyses will consider (as applicable) such factors as:

a. Part parameter variations
b. Normal and contingency operating modes including unit and system turn-on and turn-off
c. Full range of input voltage, current, and frequencies variations
d. Thermal stress (acceptance temperature used in the analysis)
e. Circuit stimulus
f. Aging and radiation effects
g. Potential race conditions (i.e., mismatch in delay times).

2.4.2 Analysis Method (Continued)
A combination of testing and analysis may be employed to obtain results through actual measurements. The analysis method will be tailored to the circuit function, and to the adequacy of the analytical models. True WCA, root mean square method, or Monte Carlo simulation may be used. For parts submitted to radiation lot acceptance test, the parameter drift values will be derived from radiation test of parts by comparing the tested values with the pretest value.

2.5 Reliability Assessment

2.5.1 General
Reliability numerical evaluation will be performed for components, equipment, subsystems and for the spacecraft to demonstrate compliance with the contractual numerical reliability requirements. The reliability assessments will be updated during the program to include the impact of design changes and more detailed design information as the spacecraft hardware design matures. The results of quantitative reliability assessments will be reported and provided as part of design reviews. Reliability trades will also be used during all phases of the program to identify the relative merits of alternative designs and to assist in problem resolution (i.e., to determine the possible numerical reliability impact resulting from a potential design change).

Reliability functional block diagrams will be developed and used to represent the system and subsystem design configurations as they operate over the specified mission phases. These functional block diagrams will in turn be the basis for the reliability block diagrams that indicate the redundancy, cross-strapping, and single thread items of the designs. The reliability block diagrams then become the basis for defining the quantitative reliability of hardware from the unit to the end item spacecraft level. Mathematical models (either discrete or dynamic) will then be used, along with the failure rates calculated for the hardware items, to determine numerical reliability.

Quantitative reliability requirements will be specified in the applicable equipment, subsystem, and system performance specifications.

2.5.2 Reliability Assessment Assumptions
Quantitative reliability assessments will be made assuming the following:

- The design assessed is representative of the flight design.
- Useful life of a component begins after the satisfactory acceptance test of the component.
- Mission phases are independent. Stresses experienced in a phase do not affect the failure rate of succeeding phases.
- Part failure rates are usually constant during the useful life period and wearout factors are not operative during the required mission life unless otherwise stated and appropriate models will be used in those cases.
- Individual part failures are independent.
- Parts and materials are qualified for their application and environment.
- Circuit design performance margins are sufficient for the effects of production variance, radiation environment, thermal environment, and aging. Production processes and testing do not introduce unknown latent damage or failure mechanisms and are approved for use for the mission.
- Failures rates are estimated in accordance with the requirements of this plan.

2.5.3 Mission and System Definition
The reliability assessments will clearly define the mission functions and modes of operation including descriptions of functional modes of operation, alternate modes of operation, equipment duty cycles, required operational periods and the environmental profile over the mission time.

2.5.4 Failure Rates Standards

2.5.4.1 Program Failure Rates
The failure rates listed in Table 2-3 cover items not listed in MIL-HDBK-217 or are more representative of space usage. MIL-HDBK-217 will be used to determine electrical piece part failure rate for those parts not listed in Table 2-3.

2.5.4.1 Program Failure Rates (Continued)

For the equipment Preliminary Design Review, the parts count reliability prediction method of MIL-HDBK-217 may be used.

For the Critical Design Review, the reliability will be predicted using the part stress method, using actual electrical stresses and component operating

temperatures.

2.5.4.2 Failure Rate Thermal and Electrical Stress Derating
Thermal and electrical stress influences on part failure rate will be incorporated into the reliability assessments as soon as the necessary design data are available and the stress analyses are completed. The final assessment of each design will incorporate failure rates derived from the calculated stress ratios and the operating temperature of the units or equipment.

For those cases in which the operating temperature may change over life as a result of thermal degradation, the equipment operating temperature may be assumed to be one third of the maximum "predicted" temperature at the beginning of the mission and two thirds of the "predicted" temperature at the end of the mission (or equipment life).

Equipment operating temperature = 1/3 * BOLMAX Tem + 2/3 EOLMAX Temp

Table 2-3. Fixed Failure Rate Items

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Table 2-3. Fixed Failure Rate Items (Continued)

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2.5.4.3 Failure Rate Adjustment Factors
The multiplying factors listed in Table 2-4 shall be used to assess mission reliability for environmental mission phases and for operating and nonoperating conditions. These factors are applicable only to the designated mission phase under evaluation and are to be applied to the base rate to adjust for mission phase environmental and equipment operating conditions.
When applicable, duty cycle multiplying factors will be used.

Table 2-4. Stress/Operating Failure Rate Multipliers

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2.5.4.4 Quality Factor Adjustments

Table 2-5 provides a list of equivalencies between failure rate quality levels specified in MIL-HDBK-217 and those specified by European Space Agency documents.

Table 2-5 Quality Level Equivalencies

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2.5.4.5 Reliability Assessment Documentation
A reliability assessment analysis will be prepared for spacecraft design review data packages. Each reliability assessment will include the following information:

- A description of the item, types of redundancy, and the item operational modes
- A functional block diagram of the design
- A reliability model for each operating phase which is analyzed including:
  - Reliability block diagrams
  - Failure rates for each block of the reliability block diagram
  - Mathematical models or applicable dynamic model data
  - Probability of success results
  - A comparison of the results with the specified requirements.

An example of a reliability assessment for a subsystem is shown in Figure 2.5-1.

2.6 Qualification Status List

2.6.1 Qualification Status of Equipment
All spacecraft equipment must be qualified for use an orbit. Heritage items

(components, assemblies) with a prior history of successful performance on other SS/L programs will be qualified by similarity if used again without significant changes. Items with relatively minor changes from previous applications will require modified qualification testing described as delta qualification. New designs and heritage designs with significant changes will require complete qualification testing. This applies to both in-house built and subcontracted items.

2.6.2 Qualification Status List
A Qualification Status List (QSL) will be established and maintained. This list will summarize for each configured equipment the manner by which a qualified status is achieved. It will list each equipment item of the spacecraft by subsystem and will include the following information:

- Description of each equipment
- Next higher assembly
- Manufacturer's name

Figure 2.5-1. Reliability Model (Example)

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2.6.2 Qualification Status List (Continued)

- Delta qualification requirements
- Current qualification status/screening and applicability of qualification test versus requirements
- Basis for qualification (qualification test results, heritage, and qualification on other programs)
- Contract on which the test was conducted
- Test Report number

The QSL will constitute the program's definitive data base for qualification status above EEE piece part level. Electrical part qualification status is monitored and reported in the Program Authorized Parts List (PAPL). Reliability also will maintain files of qualification test procedures, test reports, and acceptance data when it includes qualification or delta qualification results.

2.7 Correction Notices for Reliability Discrepancies
SS/L uses a closed-loop system to log, track, and ensure resolution and corrective action of reliability discrepancies. Correction Notices (CNs) are written against derating and part application issues as well as design issues uncovered as part of the FMECA and numerical assessment tasks.

2.8 Critical Items Listing and Control
SS/L will develop and maintain a listing of critical items. This listing contains items which are deemed critical based on their sensitivity to wear, depletion or degradation. The methods used by SS/L to ensure that these items are capable of performing their missions will be included in this list, as will the life test history and the status of any ongoing life tests.
This list will be maintained current throughout the program.

3. PARTS PROGRAM

3.1 General
The objectives of the Parts Program Plan are to document the methods and procedures for implementing the program requirements, and to provide ground rules which assure reliable performance of the Spacecraft. Contained in this plan are the guidelines, procedures and methods which will be implemented to fulfill these objectives. Implementation of this plan ensures that an integrated and coordinated management of the selection, qualification, application, procurement, control, and standardization of parts will be applied. Space Systems/LORAL and subcontractors to SS/L will implement the parts program described herein.

3.2 Program Plan
This plan outlines the requirements for selection, standardization, procurement, screening and testing, qualification and receiving inspection of all parts. Subcontractors to SS/L will submit listings of all parts used on the program for review and approval. In order to administer, coordinate and to oversee the Parts Program Plan, a Program Parts Engineer (PPE) will be appointed from the Parts Assurance Engineering section.

3.3 Parts Approval
All Electrical, Electronic and Electro-mechanical (EEE) and associated hardware

parts for this program require Parts Assurance Engineering and Space Systems/Loral approval prior to use. EEE parts acceptability for use, qualification requirements and qualification status will be determined during their approval cycle.

3.3.1 Parts Control Board (PCB)
A PCB will be established to ensure that only approved and reliable parts are used. The PCB is chaired by the PPE and its membership includes Electrical and Mechanical Design Engineering, Materials Engineering, Survivability Engineering, Material Procurement, Product Design Engineering, Manufacturing Engineering and Program Management Office representatives.

3.3.1 Parts Control Board (PCB) (Continued)
The PPE will provide guidance in the selection and standardization of parts, selection, development, qualification and approval of new part manufacturers, and selection of new sources for diminishing and sunset technology parts. In addition, the PPE will guide the standardization process in order to maximize the use of standard and common parts which will ensure the lowest cost and high reliability parts for the program.

The PCB will investigate and resolve any issues for those parts with GETUP or other industry Alerts or Advisories and prohibit the use of unreliable parts. The PCB will utilize the existing radiation databases to allow for timely and early identification of radiation soft parts and actions necessary to meet part reliability and performance requirements.

The SS/L Parts, Materials and Process List (APMPL) will contain all qualified and approved parts, materials and processes, including MIL qualified (QPL) parts. The APMPL will be incorporated with a data manager, and integrated with the Product Manager (PM) system for company wide access.

Product Manager is a system that is replacing our current EEMS, PC-APL and Master Parts Catalog system for the management of parts. It will be utilized to implement the APMPL.

The Program Authorized Parts List (PAPL) is a subset of the APMPL, and is program specific. It is the means for recording EEE parts and hardware, and their approval status. The PAPL is used by subcontractors, design engineers, procurement, and by QA in supply requisition review, receiving inspection, and parts kitting inspection.

3.3.2 Parts Control Board Approval
All parts used in flight hardware will be assessed prior to PCB approval. The Advanced Parts List (APL) is the preliminary parts list submitted by engineering and subcontractors for approval by the PCB. The PCB will provide the necessary guidance and controls for the APLs generated by Engineering and will identify parts problems early in the program and review and approve all parts not listed in the APMPL.

3.4 Parts Selection and Standardization

Design Engineering shall select Parts from the APMPL and APLs. Emphasis will be placed on parts selection to ensure that only parts capable of meeting the program requirements are used.

The use of standard parts will maximize the use of existing part procurement specifications and will be a primary factor in providing a cost-effective parts control program.

The order of preference for part selection is as follows:

a. Parts listed in the APMPL
b. Parts listed in the NASA Standard Parts List, MIL-STD-975 as Grade 1 parts
c. Parts Qualified to JANS, Class 'S', Class "V", or SMD "S" level of the US Military Specification system
d. Parts which are qualified to US Military Specification, Established Reliability (ER) specifications, failure rate "S" or "R"
e. Parts qualified by SS/L and other users for various space programs or similar space applications via SCDs or Part Specifications
f. Parts from ESA/SCC QPL or qualified parts from (CNES QFT IN 500, section 1) with additional testing as specified in Alliance Document AD-05
g. Parts listed in MIL-STD-975 as Grade 2 with additional provisions for upgrade screening
h. Parts qualified to JANTXV/Class B of the US Military Specification system with approved additional upgrade screening and testing

3.4.1 Standard Parts
Parts are considered to be standard and acceptable when they are listed in the APMPL or in the NASA Standard Parts List, MIL-STD-975 as Grade 1 parts or in the

ESA/SCC QPL. Only those parts that meet the design electrical, mechanical, and program environmental, inspection, qualification, radiation and reliability requirements will be used.

3.4.2 Non-Standard Parts Control

A non-standard part is defined as any part not listed in APMPL, or not listed in the NASA Standard Parts List, MIL-STD-975, as Grade 1 parts or in the ESA/SCC QPL. Nonstandard parts of verified acceptability that will be procured in accordance with the requirements of a similar standard part type may be used after approval by the PCB. The rationale for selecting nonstandard part(s) and supporting data attesting to their acceptability for application, both as to performance and reliability, shall be documented by the user (designer-responsible engineer) and submitted to the PCB.

3.4.3 Parts Screening and Testing

All EEE parts used in flight equipment will be screened/tested per the applicable ESA/SCC or MIL-Specification requirements or SS/L generated and approved part specifications. The screening/test inspections are performed by the SS/L approved part manufacturers or screening/test facilities.

The basic groundrules for part screening are provided in Table 3-1 (for active electrical parts), and in Table 3-2 (for passive electrical parts). Clarifications and explanations for these tables are provided the Screening Matrix Notes, which are included in Table 3-3. Destructive Physical Analysis requirements are also provided in these tables.

Detailed notes for these tables are provided as Table 3-3.

3.4.3.1 Radiation Hardness

All EEE parts used in flight equipment are subject to Radiation Hardness evaluation based on the spacecraft or flight equipment's intended application and use. Inherently radiation soft parts are subject to lot by lot testing and verification. SS/L established procedures will be used for the selection, evaluation and application control process of all EEE parts.

Table 3.1. Active Parts Screening Matrix

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Table 3.2. Passive Parts Screening Matrix

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Table 3-3. Screening Matrix Notes (page 1)

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Table 3.3. Screening Matrix Notes (page 2)

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3.4.4 Parts Qualification

All parts used in flight equipment will be qualified or must have been previously qualified for space flight. Part qualification is required for new technology and previously unqualified parts. The qualification requirements will be specified by Parts Assurance Engineering. Qualification testing will be

performed in accordance with standard test methods specified in the applicable Military or ESA/SCC Standards for a similar part type.

3.4.5 Part Specification
Part specifications will be generated for all new nonstandard parts. Part specification will specify screening/test and other applicable inspections and qualification test requirements utilizing the guidelines of a previously qualified ESA/SCC, JANS/Class S, QML V or similar part types. Part specifications shall be used by the SS/L purchasing for procurement of EEE and associated hardware parts.

3.4.5.1 Hybrid Part Specifications
Hybrid parts will be approved by the PCB. Hybrids shall be screened/tested and qualified per the applicable part specifications generated to the guidelines of MIL-PRF-38534.

3.4.6 Subcontractors Part Specifications
Subcontractors may use either Space Systems/LORAL specifications or their own specifications that meet program requirements and are approved by SS/L. The PPE is responsible to ensure that all in-house and subcontractor specifications are complete and are controlled documents.

3.4.7 Parts Upgrade Screening
PCB approved Class B microcircuits and hybrids, and JANTXV transistors and diodes, due to schedule and design constraints, may-be used provided they are upgrade screened/tested in accordance with NASA/GSFC 311-INST-001 or other SS/L approved procedures, and they meet the radiation hardness requirements.

3.4.8 ESA/SCC System
All parts shall be screened at a minimum, in accordance with the requirements of Alliance Document AD-05.

3.5 Approved Parts, Materials and Process List (APMPL)
The APMPL is an on-line commuter system listing all approved and qualified parts for spacecraft equipment. This system is maintained by Parts Assurance Engineering.

Parts not listed in the APMPL will not be accepted for inclusions in equipment parts lists by PH. Unlisted parts will be submitted to the PCB and Parts Assurance Engineering for the selection and approval process.

3.5.1 Program Approved Parts List (PAPL)
The PAPL is program specific listing of program approved/authorized parts. The PAPL contains standard parts selected from the APMPL and other nonstandard parts that are approved for use (pending their successful qualification) by the PCB. The PAPL will provide parts listing of all parts, including subcontractor supplied parts, for a specific program/spacecraft.

3.6 Parts Procurement Control
A parts procurement control system is established and will be used to provide parts for the program. Within the established system, Product Assurance reviews the "purchase requisitions" and imposes the program requirements on the Purchase Order(s). The on-line PAPL is the governing document for the approved part and the part number and the approved part manufacturer and other pertinent program and procurement requirements. Material Control and Procurement utilizes the PAPL for all part procurements.

Scheduling and coordination of procurement activities are accomplished by the Space Systems/LORAL Hi-Rel Parts and Material Planning or by Subcontracts Administration. Space Systems/LORAL Product Assurance is responsible for part specification documentation, engineering, coordination, qualification and qualification assessment, and quality control activities. Subcontractor performance to the same requirements will be reviewed, approved, and monitored by Space Systems/LORAL Product Assurance.

Parts testing and qualification, in general, is accomplished by the part manufacturer. On occasion, Space Systems/LORAL Parts Test Laboratory or an independent test laboratory approved by Space Systems/LORAL may perform some or all of the part testing as necessary.

3.6.1 Bonded Stores/Parts Transfer
Space Systems/LORAL has a Hi-Rel Space Parts Inventory in bonded stores. Parts procured for other spacecraft programs may be considered for use on this spacecraft provided they meet the program requirements and are approved by the PCB. At such time a formal "material transfer" for the subject program may be requested. A part transfer can only be made if the transfer is approved by the PPE after the initial PCB approval.

3.7 Parts Derating
Parts derating requirements are established and are specified in the program derating criteria. See Paragraph 2.3 for parts stress derating requirements.

3.8 Destructive Physical Analysis (DPA)
DPA will be performed on any part type and each lot date code as required by the screening matrix. DPA is performed to verify the compliance of the part to the specification requirements and to satisfy the reliability concerns for the program. DPA requirements will be specified in the program specific PAPL. DPA is performed by SS/L approved test or DPA laboratories. In general, DPA is performed on devices defined as non-standard parts.

3.9 Parts Traceability and Lot Control
All flight EEE parts and associated hardware will be traceable to the procurement lot, screening/test and inspection lot, and to the part manufacturer. Parts requiring individual serialization for the purpose of recording electrical performance parameters during screening will have serial number traceability to test data, lot date code, inspection and wafer lots.

3.10 Receiving Inspection of Parts
Upon receipt of parts, inspections will be performed to ensure quality and traceability requirements in accordance with the PAPL and other instructions specified by the Program Parts Engineer.

Receiving inspection of parts will consist of but not be limited to the following:

a. Sample visual and mechanical inspection. In addition, visual and mechanical inspection will be performed as part of DPA.
b. Sample Destructive Physical Analysis for applicable part types.
c. Review of data will be performed. For PRF-38535, QML-V, MIL-M-38510 Class S, JANS S, ERMIL parts and ESA/SCC Qualified Parts, only data package review will be performed.
d. All parts will be handled as ESD sensitive. Special handling procedures are implemented upon receipt of part for inspection and continued through installation into equipment.
e. Age control

3.11 Control and Disposition of Nonconforming Parts
All nonconforming EEE parts or part lots are tagged, segregated and locked in MRB, pending review and disposition by the Parts Material Review Board (Parts MRB).

3.12 Problem Notifications/Alerts
Space Systems/Loral and all SS/L subcontractors will initiate and distribute any problem notifications including alerts received from external sources, regarding quality and application problems identified during all phases of the program.

Space Systems/Loral and all SS/L subcontractors will review any problem/alert notification immediately to propose necessary corrective actions.

3.13 Handling and Storage
Space Systems/Loral and all SS/L Subcontractors will establish and implement procedures for handling and storage of parts to prevent possible degradation. As a minimum, the following requirements shall be met:

a. Appropriate measures and facilities to segregate and protect parts during receiving inspection, storage, and delivery to production manufacturing
b. Control measures to ensure that electrostatic discharge (ESD) sensitive parts are identified and handled only by properly trained personnel, at established ESD controlled stations, using antistatic packaging, tools and manufacturing techniques
c. Control of environmental factors, such as temperature and humidity.

3.14 Shelf Life Control (relifing)
SS/L implements a system of review for parts which have been within stores for a period of more than five years prior to issue into the manufacturing environment. This provides for retest of critical parameters for certain part types which may be subject to change during the storage period. This system is documented by our internal operating procedures. For subcontractors, SS/L may request a similar relifing policy if there are concerns regarding the stability of parts to be used for the program.

4. QUALITY ASSURANCE

4.1 Quality Assurance Documentation
A Quality Assurance Program will be implemented to assure conformance with all

applicable quality standards and criteria. This program will be carried out in accordance with detailed quality assurance procedures, which are documented in the SS/L Quality Assurance Manuals. Quality Assurance will work closely with engineering, manufacturing and management to verify that items are built to the high standards required for space flight.

The quality assurance program includes many specific tasks and responsibilities, which are summarized in this plan.

4.1.1 Document Review
Quality Assurance will provide review of specific documentation to assure that all applicable quality provisions are passed to the appropriate performing organizations.

4.1.1.1 Procurement Documents Review
QA will audit procurement documents to ensure that the program quality requirements are included or referenced.

Procurement documents audit shall include:

a. Latest revision of the drawings, engineering change orders, specifications, inspection/ test instructions, reliability, and quality requirements

b. Verification that all parts are listed in the PAPL and that all materials are listed in the PAML

4.1.1.2 Manufacturing Documents Review
QA will review manufacturing routing documentation to ensure the proper placement of inspection points. Manufacturing documents including work orders, drawings and procedures are audited by QA before the start of manufacturing to ensure that all applicable requirements are incorporated.

This audit includes, as a minimum, verification that:

a. The latest revisions of drawings and procedures are present in each work package, and are approved
b. Inspection Points have been defined
c. Work orders have been approved
d. Only approved Parts, Materials, and Processes are included in the work package

4.1.1.3 Test Procedure Review
QA will review test procedures to assure that they indicate the Parameter to be tested, the equipment to be used, the environment in which the test is to be conducted, and the acceptance criteria. QA will also verify that these documents are referenced in the planning documentation at the appropriate operational step.

QA will assure that test data sheets become part of the documentation for record retention, and contain objective evidence of conformance to the requirements.

4.2 Manufacturing and AIT Quality Assurance

4.2.1 QA Management and Planning
QA activities will be planned, carried out and recorded in compliance with the project schedule and requirements. The project QA documentation will be clearly identified and controlled. QA task planning will be initiated by the PA Manager to be compliant with the overall PA task planning.

4.2.2 Procurement
Necessary procurement control of subcontractors and suppliers will be instituted based upon clear definition of PA requirements in the applicable Statement of Work, purchase orders and associated specifications.

4.2.2.1 Procurement Sources
Subcontractors, suppliers and manufacturers having a quality assurance system conforming with the appropriate SS/L A requirements will be selected. Formal surveys of subcontractor, manufacturer and supplier facilities and quality assurance systems will assure that they are capable of supplying items or services which meet all quality requirements of SS/L.

4.2.2.2 Subcontractor and Supplier Surveillance
The degree of source surveillance and inspection will vary defending on the overall evaluation of the product quality, previous performance, facilities and organization and the magnitude and complexity of the tasks to be performed. Requirements placed on subcontractors will include a systematic nonconformance reporting system providing closed loop control to ensure effective analysis and corrective action.

Reporting documents may be those used in the subcontractor's existing system,

but format and contents must be approved by SS/L. A feedback system for reporting nonconformances will be initiated and maintained in accordance with the requirements of the Statement of Work and the Subcontractor Product Assurance Requirements.

4.2.3 Incoming Inspection
Incoming inspections will be carried out in accordance with the procurement documents and the applicable engineering and QA requirements. Additional specific program requirements may be applied by QA instructions which are used to detail inspection procedures. Each received flight type item is identified on the incoming inspection report which also serves as a record to provide traceability to the supplier.

Items that have been source inspected are checked for identification, damage and evidence of accomplishment of the source inspection. When required at the option of SS/L (e.g., because of the complexity of source inspected items) further testing is accomplished.

Critical items and age-sensitive material will receive special attention during incoming inspection as defined by QA instructions. These instructions will provide the inspector with all necessary information with respect to detailed procedures, methods and techniques to be applied.

4.2.3 Incoming Inspection (Continued)
All acceptable hardware and materials are identified with appropriate inspection stamps when released by incoming inspection.

4.2.4 Manufacturing and Stores Control
Items manufactured or assembled by SS/L and its subcontractors will be subject to inspection and test programs to ensure that applicable contract, drawing, specification and procedure requirements are fulfilled. Quality Assurance will ensure that the item (or equipment) inspected is compatible with the configuration indicated on the controlling work order, that controlled documents are used, and that the inspection records reflect the as-built configuration of the item produced.

Age-sensitive materials and articles are clearly marked to show when the lifetime will be expended. Bonded Stores maintains complete records and identification of age-sensitive parts, materials and supplies. QA surveillance is maintained for this area, and only conforming items are allowed to enter bonded stores.

4.2.4.1 Manufacturing Flow Charts and Work Orders
Flow charts (routing flow guides, or RFGS) will be prepared to indicate all operations during manufacturing and equipment level assembly in sequence. These flow charts will also identify inspection points (KIPs/MIPs) and approved processes.

Based on the flow chart, work orders will be issued detailing the manufacturing flow, serving as well for authorization and control of manufacturing and assembly steps.

QA will audit the work orders for:

a. proper identification
b. inclusion of adequate inspections in accordance with QA requirements
c. consideration of relevant project requirements
d. use of latest issue of referenced documents
e. use of approved parts, materials and processes

4.2.4.2 In-Process Inspections
In-process inspections will be carried out in accordance with the applicable manufacturing documentation to:

a. Verify the use of controlled work instructions (drawing, manufacturing procedure, work order, process documents, standards)
b. Verify that previous steps on the shop order are signed or stamped off
c. Assure that process verification samples are provided and tested/inspected as defined in the manufacturing specification
d. Review workmanship
e. Perform visual inspection
f. Measure parameters as applicable
g. Prove logging of operating times during manufacturing or test for limited life items as required
h. Determine if environmental conditions are as specified

4.2.4.3 Key and Mandatory Inspection Points
Key and Mandatory Points (KIP/MIP), when required, will be selected and must be performed with acceptable results before further manufacturing or test. KIPs and

MIPs will be defined in the Manufacturing Flow Chart at the equipment level and in the Assembly, Integration and Test Plan for system level. Key Inspection Points will be performed in-house without participation of next higher contract level. Mandatory Inspection Points require participation of the next higher contract level.

4.2.4.4 Mandatory Inspection Point Program

a. In-House Items. SS/L Quality Assurance has the full responsibility of accepting in-house items after review of documentation and performance of specified hardware inspections. The project PA Manager is responsible for MIPs follow-up and notification to the customer when required.
b. Subcontracted Items. The subcontractor's Product Assurance Manager has the responsibility for MIPs in the subcontractor plant and to notify the customer in accordance with the Statement of Work.
c. MIPs Location. MIPs will be defined from equipment level up to system level. They will be performed at the hardware's location.

4.2.4.5 Workmanship Standard and Certification Program
Manufacturing standards provide workmanship and inspection criteria for operations to be performed. Where necessary, new or revised standards meeting design requirements, will be developed to cover any special requirements of the program. Manufacturing standards are called out on applicable drawings, plans or procedures and are readily available to manufacturing, assembly, test and inspection personnel. Certification of personnel will be performed after nomination by management. Formal certification for specific processes or operations will be reached by dedicated courses. Verification of aptitude to perform the work is performed by the Parts, Materials, and Processes Assurance Department through consideration of capability and experience.

4.2.5 Assembly and Integration Surveillance
Quality Assurance surveillance of assembly and integration activities will assure that all tasks are accomplished in line with applicable and released procedures and relevant QA regulations including documentation as required.

4.2.5.1 Inspections
Inspections will be performed in accordance with established inspection procedures. Results will be recorded either by separate inspection or by entries in relevant AIT procedures as requested by the inspection procedure and depending on the complexity of inspection. Any nonconformance detected during the inspection will be recorded on a nonconformance report and processed according to the nonconformance processing procedure.

The inspection status will be recorded in the work order documentation and will be maintained current.

Mandatory Inspection Points, when required, will be performed during the assembly and integration phase.

4.2.5.2 QA Surveillance and Audit

Assembly and integration activities will be witnessed or monitored by QA. The QA tasks will be composed of the following aspects:

a. Checking of plans and procedures with respect to applicability
b. Witnessing/Monitoring of hardware activities and QA acceptance
c. Ensuring implementation and maintenance of lists for hardware configuration status recordings leading to the final as-built list
d. Ensuring proper handling according to procedure
e. Ensuring adherence to safety provisions
f. Maintaining of cleanliness and contamination control
g. Control of specified environment
h. Maintaining a nonconformance reporting system
i. Verification of correct control of limited life items
j. Recording of activities for traceability
k. Review of the Acceptance Data Package
1. Control of the non flight item list up to the complete removal before launch.
m. Ensuring only approved parts, materials and processes are used for hardware manufacturing.

4.2.5.3 Release for Testing
After accomplishment of assembly and integration activities, a final inspection will be performed prior to release of the hardware for further steps. The release will be based on the following criteria:

a. Final inspection successfully performed
b. Nonconformance reports are closed or dispositioned to have no impact on further progress
c. Validation status of the test equipment to be used is acceptable.

4.2.5.4 Test Surveillance
Qualification and acceptance test will be witnessed or surveillance supplied by QA as required. The QA system will record and report any unusual phenomenon, occurrence, difficulty and questionable condition.

4.2.5.4 Test Surveillance (Continued)
During testing, Quality Assurance will:

a. Ensure that the test procedures are followed and that all test equipment and facilities used are in accordance with relevant test documents and test equipment meets metrology control requirements
b. Ensure complete and accurate recording of data and test results
c. Document nonconfomances and their dispositions
d. Stop the test in case of danger for personnel or the item under test
e. Witness all critical test operations as defined in the shop orders
f. Verify the environmental conditions and prepare preventive provisions for cleanliness and contamination control.

4.2.6 Log Documentation and Traceability
Manufacturing records will be continuously maintained as manufacturing progresses. Each end item equipment will have its own complete and accurate documentation file. This will provide traceability for all manufacturing steps and for the conditions under which they took place.

4.2.7 Delivery Review
Upon completion of the test sequences and final inspection, a formal acceptance of the satellite(s) will be performed. A preshipment review will be convened which will review all relevant data to verify that all specified requirements have been satisfied, any deviations are properly documented and accepted and, finally, will authorize the item(s) for delivery.

4.2.8 Metrology and Calibration
Metrology control is implemented to ensure calibrated status of equipment used for acceptance measurements during formal test such as qualification and acceptance testing.

The metrology system will be compliant to MIL-STD-45662A or ESA-PSS-01-20.

4.2.8 Metrology and Calibration (Continued)

To assure appropriate calibration control, QA will:

a. Verify periodic calibration of measurement equipment by calibration laboratories.
b. Check calibration status of inspection and test measurement devices before use for formal testing.
c. Identify and separate equipment out of calibration.
d. Participate in nonconformance review when measurement results indicate potential calibration error.

Metrology control will be implemented by the SS/L calibration laboratory with QA verification of appropriate calibration status.

4.2.8.1 Calibration and Maintenance Program

Records of each test equipment tool, gauge model, manufacturer and performance will be maintained. These records will be used to determine need for corrective actions. These corrective actions may include calibration period changes, preventive maintenance or removal of measurement equipment from use.

Each calibrated equipment will be provided with a tag or decal indicating:

a. Validity of calibration
b. Date of recalibration
c. Calibration laboratory identification

4.2.8.2 Traceability

Individual measurement results must have the ability to relate through an unbroken chain of calibrations to one or more of the following:

a. U.S. national standards maintained by the National Institute of Standards and Technology (NIST) and the U.S. Naval Observatory.

b. Fundamental or natural physical constants with values assigned or accepted by NIST.
c. National standards of other countries which are correlated with U.S. national standards.
d. Ratio type of calibrations.
e. Comparison to consensus standards.

4.2.9 Cleanliness and Contamination Control
Stores, workshops, test, and inspection areas are equipped to meet required environmental conditions with respect to temperature, humidity and cleanliness. A Contamination Control Plan per ASTM E-1548-93 will be prepared when imposed per program requirements.

When clean conditions are required for working operations related to manufacturing, assembly, integration and test of hardware, an appropriate clean area per FED-STD-209 will be utilized.

Additional provisions for contamination sensitive hardware will be provided, such as:

a. Preparation and application of special handling procedures.
b. Definition of cleaning methods to be employed and specification of purity requirements of materials used for cleaning processes.
c. Definition of methods to prevent contamination of clean items and assemblies.
d. Definition of methods for measuring the cleanliness level of controlled areas.
e. Permissible contamination levels on flight hardware per MIL-STD-1246 and ASTM E-1548-93.

4.2.10 Cleanliness and Contamination Control
Stores, workshops, test, and inspection areas are equipped lo meet required environmental conditions with respect to temperature, humidity and cleanliness. A Contamination Control Plan per ASTM E-1548-93 will be prepared when imposed per program requirements.

4.2.11 Tools and Tooling Control
Hand tools, such as crimp tools, stripping tools and torque wrenches, shall be subject to validation and periodic revalidation. This is done using a Hand Tool Certification Record (HTCR). The HTCR is initially developed in cooperation with Quality Assurance. It includes initial certification, as well as recertification records, and is maintained in custodial work station files where the tool is used. This is addressed by our internal Product Inspection Instruction PII-1100.

Tools such as molds and mandrels shall be verified either by inspection of the item against the manufacturing drawing for the tool, or by inspection of the first article produced by the tool. A Tooling Certification Record (TCR) is used to document the certification of these tools. The TCR is maintained in the Mechanical Inspection area files. Detailed procedures for mold and mandrel certification is provided in PII-1101. Drill templates, assembly fixtures, shop aids and lead forming die shall be certified and maintained in accordance with PII-1102 through 1105, respectively.

4.2.12 Ground Support Equipment Control
GSE control is performed to ensure that MGSE and EGSE equipment will be accepted and released for use with qualification and flight hardware. Tasks to be performed will be defined an the basis of applicable data packages, the safety analysis and AIT procedures.

4.2.12.1 GSE Hardware
The QA activities for GSE hardware include:

a. Review of GSE interface drawings for compatibility with spacecraft hardware
b. Performance of acceptance inspection
c. Survey of GSE acceptance tests
d. Review and approval of acceptance test results
e. Check of hardware release status before use on satellite
f. Performance of regular inspections during use phase to detect degrading parts
g. Assurance of adherence to applicable handling procedures.

4.2.12.2 GSE Software
Software QA efforts include the following activities:

a. Adherence to standards and procedures.
b. Review of software test plans and procedures.
c. Participation in software validation testing.

Configuration control of EGSE software and its documentation will be ensured by the Software Configuration Control organization.

4.2.13 Handling, Storage, Preservation, Marking

4.2.13.1 Handling
During all phase of incoming inspection, manufacturing, assembly, integration and testing, QA personnel will monitor the handling of hardware items.

Inspections at predetermined points will ensure that all items are adequately protected against deterioration of quality characteristics by handling.

Special boxes, containers and transportation vehicles will be utilized for items which are susceptible to handling damage. Special handling equipment and controlled areas will be provided for proper handling of critical items.

4.2.13.2 Storage Control
Stored items will be protected against contamination, deterioration, damage, or possible confusion of the items. Adequate safety and cleanliness, preventive maintenance and age control will be provided. Limited life items will be specially identified and controlled with respect to shelf life time.

All hardware items will be stored in environmentally controlled areas with limited access for authorized personnel only. Special storage environments will be provided if necessary.

4.2.13.3 Marking and Labeling
It will be ensured by the responsible QA personnel that marking and labeling for packaging, storage, handling and shipping is in accordance with applicable specifications and procedures. In general, handling, storage and/or shipping procedures contain detailed marking and labeling instructions.

4.2.13.4 Preservation and Packing
Preservation and packaging will be accomplished to protect hardware against deterioration, contamination and damage or degradation during transport and storage.

Flight hardware will be packed in specially provided containers. These containers will be designed for the hardware and will take into consideration any requirement with respect to configuration, fragility and environment. Components, assemblies and parts shipped separately will be packed in accordance with the applicable specification.

4.2.13.5 Shipping Control
Shipping activities will be monitored by quality assurance to ensure that items to be shipped are properly preserved, packaged and identified to prevent degradation during transport. Documents and records accompanying each shipment will be verified to ensure conformance with established procedures and specifications.

Prior to shipping, inspections will be conducted to assure that all quality requirements are met.

4.3 Quality Assurance During the Launch Campaign

PA tasks will in particular comprise the following tasks:

a. Single point of contact to customer and launch site authorities for PA matters and safety aspects.
b. Review and approval of test and inspection procedures and any required modifications.
c. Participation in launch site daily meetings.

Access privileges at subcontractors' facilities will be specified for designated QA and Reliability personnel in all program subcontracts, for both SS/L and customer representatives.

Subcontractor surveillance will be accomplished by performing the following main tasks:

a. Review and approval of subcontractor PA Plans, compliance matrices or equivalent
b. Approval of subcontractor documentation including

    1. EEE parts list
    2. Materials list
    3. Process list
    4. Manufacturing and inspection plan
    5. Test procedures for qualification and acceptance tests, including incoming inspection of parts and materials.
    6. Software documentation

c. Definition of Mandatory Inspection Points (MIPS) and performance of

mandatory inspections as appropriate
d. Performance of process reviews for critical processes
e. Surveillance of tests when appropriate
f. Participation in subcontractor MRBs, as required
g. Performance of Audits
h. Attendance of Subcontractor PA meetings and project reviews

4.4.2 Definition of Major and Minor Nonconformances
Nonconformances shall be classified as either major or minor.

4.4.2.1 Major Nonconformance
A major nonconformance is one that departs from contract requirements involving safety, performance, durability, reliability, physical or functional interchangeability, use, operation or mass.

4.4.2.2 Minor Nonconformance
Any nonconformance which does not impact any area specified above as major nonconformances. Generally speaking, it departs from requirements in a matter which is not significant and does not affect use or operation.

4.4.3 Material Review Dispositions
QA procedures and instructions require that, after each nonconformance is documented, it receives a review and disposition by authorized personnel. Nonconforming articles or materials are withheld from further operations while awaiting disposition by authorized personnel. Disposition of nonconforming conditions may be accomplished by authorized personnel as follows:

a. If the nonconformance is such that completion of operations or rework to established drawings, specifications, standards, or procedures will provide correction, this disposition is recorded and normal inspection and test operations are carried out during and after this rework
b. If the article or material is obviously unfit for use, it will be dispositioned as scrap and procedures followed in identifying, controlling, and disposing of same
c. If an article or material is found to be nonconforming on receipt, it may be dispositioned as return to supplier. Copies of all information describing the nonconformance will be returned with the articles so that adequate remedial and preventive action can be taken
d. If articles or material can be repaired in accordance with manufacturing standards, or other authorized standard repair procedures, this disposition is recorded along with special inspections and test operations that are to be carried out during and after this repair.

e. If further investigation is required to locate and define the nonconformance, this disposition is recorded along with instructions for the investigation.
f. Minor nonconformances that do not adversely affect end-item safety, reliability, durability, performance, interchangeability, or other basic contract objectives, may be dispositioned, "use as is". When this disposition is used, a statement of the reason or justification will be documented on the NCR.
g. Nonconformances not defined by the above five categories will be addressed by the MRB.

4.4.4 Material Review Board (MRB)
An MRB will be established for the purpose of dispositioning Major nonconformances and failures. The MRBs will be responsible for the investigation of causes and instituting corrective actions including retest programs. The MRB will:

a. review and evaluate the nonconformance to determine the cause of nonconformance
b. recheck classification for nonconformance
c. review records of previous similar or identical nonconformance, if applicable
d. determine a disposition and corrective actions including actions to preclude recurrence
e. approve procedures for repair, if applicable
f. ensure accurate records of MRB actions
g. define retest requirements, if applicable
h. determine if a Request for Waiver is to be issued to formalize deviations from the required baseline in case of "use as is" disposition
i. verify the hardware is flight worthy (has not been damaged by electrical or thermal overstress . . .)

Unanimous agreement of MRB members is required. Immediate disposition by the MRB is required to avoid impact on program schedule and cost.

The customer shall actively participate in the disposition of major nonconformances that have an effect on system level contract requirements.

4.4.5 Nonconformance Reporting
The nonconformance control system will include written procedures for the reporting and complete documentation of nonconformances and activities.

SS/L will maintain periodic status summaries of nonconformances and the progress of their disposition, corrective action and close-out.

4.4.6 Trend Analysis
SS/L will use its system of nonconformance trend analysis to review and analyze nonconformances for trends and to determine and implement corrective action. The trend analysis will include a periodic review of open problems across the program and those from other in-house programs for potential impact.

4.5 Waivers
Waivers serve to identify the areas of noncompliance to contractual requirements and to obtain formal customer agreement for not meeting these requirements. Systems or Subsystems Engineering will justify and identify impact of each nonconformance requiring a waiver. Waiver requests will be submitted to the customer through the program control and the program manager.

Each waiver request submitted to the customer will include: a unique reference number; the title or subject; the name of the equipment, requirement, or performance parameter; a description of the request; a justification of the request (including the reason); and the date of issue.

4.5.1 Definition of Waiver
A waiver is a written authorization to accept a design or item which before, during, or after production have been found to depart from specific contractual requirements.

4.5.2 Waiver Reporting and Approval
Requests for waivers are issued for each noncompliance to the applicable documents of the contract. Waivers to contract requirements require approval by both SS/L and the customer. For waiver of nonconformances affecting single units, the request for waiver and waiver may be processed on the NCR. In this case, the NCR will remain open until the waiver is granted or denied.

5. MATERIALS AND PROCESSES

5.1 Scope
This plan establishes the policies applicable for selection and use of materials and processes in flight equipment, subsystems and systems. The objective of the Materials and Process Control Program is to assure that only correct, qualified, functionally acceptable materials and processes are used for flight hardware, and to assure proper documentation and control of all materials and processes.

The implemented plan ensures the adequacy of all materials and processes for the intended applications and verifies that the materials and processes comply with project contractual, design, quality and performance requirements.

This plan provides detailed procedures relative to:

a. Control and approval of materials and processes
b. Selection requirements for materials and processes
c. Standardization to minimize the number of material types used
d. Testing and qualification of new materials and processes
e. Assurance of the proper selection and application of materials.

The same policy is applied within SS/L and at Subcontractors and Suppliers.

5.2 Policy for Control and Approval of Materials and Processes

5.2.1 General
The basic elements for the management of the materials and processes are:

a. Materials and Processes Control Procedures
b. Program Authorized Materials lists (PAML)
c. Program Authorized Processes Lists (PAPrL)
d. Requests for Approval of Materials (RFAM) and Requests for Approval of Processes (RFAP), if needed
e. Qualification reports and test plans when necessary.

5.2.1 General (Continued)
The basic objectives are to control the selection, procurement, and qualification of materials and processes to assure that only acceptable materials and processes are used, and that the materials and processes are applied appropriately.

Materials and Process engineers report functionally to the PA manager, and support the project team to implement these requirements.

5.2.2 Materials and Processes Control Procedures
The review of materials and processes is carried out by the Program Materials and Processes Engineer (PMPE) assisted, as necessary, by other relevant experts and specialists (e.g., design, inspection, development, manufacturing, test). The Materials and Processes Control Board is convened when necessary to evaluate and disposition problems, anomalies, and failures of materials and processes.

This procedure begins early in the project during initial equipment design and selection of materials and processes, and continues throughout manufacturing, test and integration. All materials and processes used on the program, as well as all materials specifications, must be approved by SS/L Program Materials and Processes Engineering.

The SS/L Program Materials and Processes Engineer:

a. Verifies that materials and processes lists are representative of the design
b. Reviews and approves materials and processes lists and documents the revision level of these specifications
c. Assures that materials and processes are appropriate and satisfactory for the intended applications
d. Supports investigations into material and process nonconformances
e. Participates in project design reviews
f. Approves the new materials and processes qualification activities and manages the review and approval of new materials and processes.
g. Reviews and approves drawings, change notice and process documents to verify correct use of acceptable materials and processes.
h. Reviews processes considered proprietary at subcontractor facilities, and ensures that adequate monitoring is provided for these processes.

5.2.3 Materials and Processes Lists

5.2.3.1 General
The materials and process lists are the basic documents for the management of the materials and processes activity. They reflect the current design at the time of issue and include all the materials and processes employed in the manufacture of flight hardware. Each material and process is identified, and its application is defined.

The PAML and PAPrL list all materials used at the highest level of assembly. Subcontractors are required to submit PAML, and PAPrLs for their equipment. These subcontractor lists are incorporated into the program PAML and PAPrL.

5.2.3.2 Contents of the Lists
Materials and processes lists are broken down into clear categories to facilitate locating each item in the documentation.

The lists include the following detailed information for each material and process used.

For Materials

a. Item number (as the reference of the material in the material list)
b. Precise identification or commercial designation of each material manufacturer, vendor or supplier, and procurement specification or standard
c. Processing parameters (finish, temper, condition, cure cycle, mix ratio, outgassing properties, etc.), location where used, quantity used and general information on applications
d. Approval status, heritage usage and any comments.

For Processes

e. Item number (as the reference of the process in the processes list)
f. Clear description of the process
g. Manufacturing and inspection, specification reference(s)
h. Use and location at equipment level
i. Approval status and comments
j. Title and revision letter.

5.2.4 Request For Approval of Material (RFAM) and Process (RFAP)
A Materials and Processes Control Board will review and approve or disapprove all requests for the use of non-standard materials and processes. The PMPE will chair the M&PCB. Members of the M&PCB will include appropriate representatives of engineering and manufacturing when necessary.

If there is a need to use a material or process:

a. that is not space proven, or
b. that has been used on previous space projects but not for the same application or environment and needs additional qualification tests, a Request For Approval Material (RFAM) or Process (RFAP) is required. Previous projects materials and processes lists will be used to determine if the RFAM/RFAP is necessary.

The following information is provided with the RFAM/RFAP

a. Justification for use of the unqualified material/process (if necessary)
b. Qualification plans and schedule.

After approval of the qualification plans and schedule by SS/L, the qualification tests are implemented to demonstrate the conformance to the project requirements.

Upon completion of these tests, a qualification test report is submitted to SS/L for approval. The RFAM or RFAP is closed and the materials or processes lists are revised to add those materials and processes which have been qualified successfully.

5.3 Selection Policy and Specific Requirements
It is the policy to use only those materials and processes that have been demonstrated to be suitable for use:

a. By demonstrating satisfactory use on previous space projects with similar applications and environmental conditions.
b. After qualification by a formal qualification program, and verified per the RFAM or RFAP.

5.3.1 Materials
Materials are selected in accordance with all design, quality, and performance criteria for their intended application.

A materials standardization effort is conducted by the PM&PE to minimize the number of material types used on the program. The standardization program restricts program usage to qualified materials, and restricts procurement to approved vendors for each material. The plan is applied to all flight equipment.

5.3.1.1 General
Materials and processes are assessed by the PMPE. Functional requirements originate from design or manufacturing engineering. Materials and Process Engineering identifies and determines process parameters, test methods and acceptance criteria.

Specific areas of concern include corrosion prevention, structural adequacy and integrity, safety, minimum susceptibility to environmental factors, use of space qualified and approved materials, radiation resistance, combined environmental efforts, and controlling potential sources of outgassing to prevent contamination of optical and thermal surfaces.

5.3.1.2 Flammability
*

5.3.1.3 Galvanic Couples
*

5.3.1.4 Stress Corrosion Cracking
*

5.3.1.5 Outgassing
*

5.3.1.6 Waived Materials
Materials not meeting all program requirements may be approved for limited application usage where it is not practical to use a fully approved material.

Some examples are: Materials not compliant with outgassing requirements but which are functionally required; Materials which cannot be treated in a manner which would make them acceptable; and materials used in very small quantities so that undesirable attributes have negligible effects. These situations require waivers for their inclusion in the PAML, and such waivers, with their requirements and limitations, will be noted in the material listing.

5.3.1.7 Age Sensitive Materials
All age sensitive materials are identified with an expiration date by receiving inspection. Test and verification of material properties is performed on incoming materials and on any age sensitive materials that have passed their normal expiration date.

5.3.1.8 Limited Shelf Life Materials
Limited shelf life materials are identified, their properties are controlled, and upon acceptance at incoming inspection, expiration dates are marked on their containers. Use of expired material will be subject to recertification. The material may be requalified for specified controlled additional periods subject to satisfactory evaluation of parameters sensitive to deterioration (mechanical, chemical, and physical properties).

5.3.1.9 Traceability and Lot Control
All flight materials will be traceable to vendor lot, receiving lot and purchase order. All age sensitive items will be marked with expiration and scrap dates. Material lots will be recorded on manufacturing documentation so that full traceability is maintained.

5.3.1.10 Contamination Control
*

5.3.1.11 Fluid Compatibility
Materials that will be in contact with an identified fluid will be compatible with that fluid. If adequate compatibility data is not available then testing is performed according to NHB-8060-1, test number 15.

5.3.1.12 Specifications
Each material is controlled by a detailed specification or a standard. Specifications define the material properties, requirements, test methods and acceptance criteria.

5.3.2 Processes

5.3.2.1 Selection
Processes are selected on the basis of their compatibility with the materials to which they are applied, and their proven consistency in achieving the specified design, quality, and project performance requirements. All processes must demonstrate acceptable performance with the materials used, and must produce acceptable, reproducible products.

5.3.2.2 Control of Processes

General Policy is to verify that:

a. Processes are defined, controlled and are recognized as suitable for use under appropriate conditions (environment and cleanliness).
b. Personnel certification requirements are clearly described.
c. Operations are performed by certified personnel where applicable.
d. The process specifications, manufacturing and inspection procedures include clear acceptance criteria, are formally issued and have been approved. Subcontractor process specifications are submittable to SS/L by specific request.
e. All process changes are documented, and must be submitted to SS/L PMPE for approval prior to being used on flight hardware.
f. Materials associated with the processes are approved and appear on the materials list.
g. Any changes to approved processes must be reflected by a revision level change.

Special Processes are those which the quality cannot be completely ensured by inspection of the end article only. They are specifically identified and controlled. Process control is ensured by means of adequate procedures and personnel certification and/or machine certifications.

All processes used at SS/L and by subcontractors are defined and listed in the Program Authorized Process List (PAPrL). Any new processes must be fully evaluated and qualified before they are approved for use on flight equipment, by means of the RFAP procedure.

6. SOFTWARE PRODUCT ASSURANCE

6.1 General

This section defines and presents the SS/L Software Product Assurance (SPA) program as it relates to software engineering, quality, and configuration management.

This program is governed by approved SS/L software operating policies and standards. These policies and standards are applicable to onboard/flight software, simulation software, test software, firmware, Electrical Ground Support Equipment (EGSE), Mechanical Ground Support Equipment (MGSE) and ground station software.

SS/L's software quality assurance requirements will be implemented and passed down to subcontractors.

6.2 Software Product Assurance

The Software Product Assurance (SPA) organization will appoint a Software Assurance Task Manager (SATM). The SATM has the responsibility for generation and implementation of the Software Product Assurance Plan (SPAP).

The objective of the SPAP is to define the plans for SS/L, and specifically SPA, to provide:

a. Assurance that a process, including methods and tools for developing and controlling software and its associated documentation, is established and implemented as defined by applicable plans, policies, and software related contractual requirements.
b. Objective evaluations of the software, associated documentation, and the software development process itself.
c. Identification to management as early as possible in the process, of software related issues/problems, which could affect cost, schedule, software quality, or software safety.
d. Autonomous Verification & Validation (V&V) of the software and acceptance/approval for use and release to the SS/L central configuration management Engineering Data Control (EDC).

6.2 Software Product Assurance (Continued)

SPA will provide an ongoing evaluation of the software development process and its associated products through participation, review, and metrics analysis as described in the SPAP.

6.2.1 Software Product Assurance Resources

SPA engineers at SS/L have computer science degrees and many years of hands-on experience. The department has a well-rounded educational and experience base, including formal training and experience as test engineers, software project, functional management, and process engineering.

Each SPA engineer has access to a networked, personal computer or workstation with the latest software for word processing, graphics, spreadsheet, database, metrics analysis, and scheduling. Products created using these tools are standardized for reuse on new programs to increase productivity and decrease time-to-delivery.

SPA also has access to a company-wide database for problem tracking and metrics analysis. These tools provide close to real-time review and data collection that is combined at the company level to track cost of quality within SS/L.

6.3 Software Development Life-cycle

SPA will ensure that software development follows a life-cycle that is divided into phases with each phase representing a "quality gate." Criteria for successful completion of a phase will be reviewed to ensure successful completion. Typically, the completion of a particular phase will allow progression to the next, however phase overlap can occur without affecting software quality.

6.3.1 Software Development Resources

Software engineering at SS/L uses state-of-the-art networked personal computers and workstations, CASE tools, test tools and management tools to estimate, plan, develop and test software in a highly proficient manner producing high quality products proven repeated on many successful programs. Software Product Assurance is an integral part of this networked environment and plays a vital role from requirements analysis to contract end.

6.4 Reuse of Software

In the case of already developed software reused without modification, SPA will verify that the software and software documentation is controlled per SS/L

policies. Software that will be reused on a particular program will be appropriately identified and controlled prior to the critical design review.

For reused software that is to be modified, SA will ensure that all changes are documented and traceable and that the required regression testing/qualification takes place. This will be done by returning to the appropriate life cycle phase of development for the affected part and performing the needed Software Engineering, Configuration Management and Software Assurance tasks as prescribed in the approved software program plans.

6.5 Software in Logical Devices

Software that will eventually reside in EPROM/ROM will be developed and controlled in the same manner as any other software. Once the software is loaded into the hardware/firmware device, the device will be controlled the same as any other hardware device.

6.6 Commercial Off-The-Shelf (COTS) Software

COTS software (e.g., compilers, development tools, analyzers, etc.) will be evaluated for the following aspects:

a. Adequate documentation and conformance to established project requirements
b. Capability of the supplier/vendor to provide support throughout project life and operation
c. Usage and correctness

COTS software and application-derived software that is used in the testing of deliverable products shall be controlled by version in accordance with internal procedures. In addition, version numbers shall be printed on test results or documented in another approved method (e.g., log book) to ensure version-to-serial/lot number traceability.

6.7 Software Configuration Management

Software Product Assurance will ensure that a compliant Software Configuration Management (SCM) program is documented and implemented to identify, track, and control each software item and associated product. SPA will participate in the change and approval process and will periodically evaluate the complete SCM program for compliance to requirements.

6.7.1 Problem Reporting and Corrective Action

Software problems, changes and enhancements will be documented on approved Software Problem/Change Reports (SPCRs) throughout the software development lifecycle. Outstanding SPCRs will be addressed at each software phase review (when passing a "quality gate") and at the test readiness evaluation meetings.

6.8 Software Metrics

Software Product Assurance shall implement a software metric program tailored for each contract. This capability shall be described in the Software Product Assurance Plan.

6.9 Software Subcontractor Control

Software Product Assurance will ensure Statements of Work (SOWs) to subcontractors contain the appropriate software quality requirements and flowdown. The required tailored, software quality program will be reviewed with the subcontractor for understanding.

6.9 Software Subcontractor Control (Continued)

SPA will evaluate the subcontractors' software engineering/development process and provide approval/disapproval to Procurement QA for adding to the SS/L Approved Supplier List (ASL). If the required process is found lacking, Software Product Assurance may assist the subcontractor toward achieving approval.

Periodic evaluations during the software development life cycle will be performed by the SATM in accordance with the program Subcontractor Product Assurance Plan (SH-E032894) and the program Software Product Assurance Plan.

As necessary, the SS/L SPA organization will review software documentation and witness/monitor software qualification to ensure the correctness of the supplied product.

7. SYSTEM SAFETY PROGRAM

7.1 General

The spacecraft, its relevant Ground Support Equipment at the launch site and Launch Site Operations, will be designed in compliance with the safety

requirements applicable at the chosen launch site and in accordance with TR00764, SS/L Environmental Health and Safety Procedures Manual.

7.2 Objectives

The objectives of the safety activities are:

a. To identify and either eliminate or control the hazards associated with the spacecraft as defined in the applicable Range Safety Regulations.
b. To establish an orderly safety documentation process.
c. To coordinate spacecraft safety and occupational safety activities.
d. To document compliance with Range Safety Regulations.

7.3 Safety Responsibility

The responsibility for functional safety extends from the top level down through the line organizations. A major objective during the operational phase is to assure compliance with safety requirements and to assure safe launch operations.

A Safety engineer, within the program PA organization, will be responsible for identification of safety controls.

Product Assurance personnel verify compliance with safety aspects:

a. in design concept during design and development phases
b. in design drawings during production
c. in procedural documents during the build-up and checkout of the hardware.

7.4 Launch Site Operations

A launch operation manager will manage the spacecraft launch activities at the launch site. His responsibilities include build-up and checkout from equipment arrival until departure. He ensures that operations are in compliance with the launch range regulations.

7.5 Safety Requirements

Safety requirements will be in accordance with the applicable documents listed in paragraph 1.1.1.4. Compliance with specified requirements and criteria will be verified during the safety analytical process.

7.6 Hazard Analysis

Hazard analysis provides a description of potential hazards associated with spacecraft element operations or interfaces. They include guidelines for the elimination and/or control of hazards.

CSG Safety Regulations, ESMCR 127-1 Eastern Space and Missile Center Safety Regulations, 127-1 Eastern Range Regulation, LKE Proton Users Safety Guidelines, and XSLC Safety Requirements Document will be used during hazard analyses activities.

The Range Safety program will be composed of individual safety programs for each of the elements plus an integrated system analysis effort, which will serve to tie together, direct, and manage the total program and the interrelationship among its elements. The environments and mission phases will be taken into account as soon as possible for the early analyses.

The results of the analyses may be presented on hazard report forms.

7.7 Safety Assessment

The satellite design will be reviewed in light of compliance with the safety requirements applicable at the chosen launch site.

7.8 Integration and Test Operations Safety

The integration and test program will be implemented for testing flight hardware prior to integration with the launcher. The spacecraft will be assembled and receive a complete system production acceptance test before shipment to the launch site. The GSE components will be acceptance tested and following verification will be utilized with the flight system at the launch site. All integration and test activities occurring at SS/L facilities will be in accordance with TR00764, SS/Ls Environmental Health and Safety Procedures Manual.

Launch site checkout operations include system testing of both the satellite and GSE individually and the final integrated system testing.

The AIT Subcontractor will control integration and test operations extended up to that point when the spacecraft will commit for launch. During the assembly and test operations, the AIT Subcontractor's safety functions, consisting of system safety and occupational (Industrial) Safety, maintain an active role in the manner described below. The two safety functions complement each other to provide safety in design and safety in operations.

7.8.1 Safety Reviews, Test Planning and Data
Product Assurance reviews test documentation to ensure that test procedures directing hazardous operations reflect conformance to safety requirements for the protection of personnel, facilities, and equipment, and to ensure that the hazards associated with the conduct of the test are minimized. System Safety reviews test results to determine any anomalous conditions that impact the safety of the design under consideration and to assure compliance with safety criteria.

7.8.2 Safety Monitoring of Tests/Operations
Environmental Health and Safety monitors in-plant operations designated as hazardous. The occupational safety activity augments the inspection function to ensure an understanding of, and adherence to the safety requirements related to the operations and to safety operation procedures.

7.8.3 Safety Review of Procedures
Environmental Health and Safety at the launch site works closely with operations personnel in the development of procedures which are used for the prelaunch integration and checkout of the systems. The procedures containing hazardous operations will be reviewed. In addition, those procedures must be reviewed and approved by Range Safety.

7.9 System Safety
The system safety element of SS/L safety programs encompasses operations at SS/L facilities and at the launch site. In general, the following activities will reflect SS/L occupational safety program:

a. Product Assurance implements safety requirements including applicable regulatory standards for occupational safety and health of employees.
b. Planning documents are reviewed to determine regulatory implications.
c. Safety operating procedures governing potentially hazardous operations are generated.
d. Procedures related to hazardous operations are reviewed.
e. Safety surveillance and inspections of activities, facilities and equipment are maintained to ensure compliance with safety requirements.
f. Safety surveillance and inspections of activities, facilities and equipment are maintained to detect unsafe conditions or practices with follow-up corrective action where indicted.
g. Personnel training and certification activities receive active safety participation to assure competence in personnel assigned to hazardous operations.

7.10 Safety Approval Process

7.10.1 ARIANE Launch - Safety Submissions
Safety documents will be submitted in three phases. In addition, on request, attendance at dedicated meetings is foreseen.

7.10.1.1 Phase 1 Submission
SS/L will prepare a file containing a description of the hazardous systems, and will also cover all safety related activities.

7.10.1.2 Phase 2 Submission
SS/L will submit the hazardous system manufacturing qualification and acceptance documentation.

7.10.1.3 Phase 3 Submission
SS/L will submit verification and operating procedures for systems classified as hazardous.

7.10.2 DELTA Launch - Safety Data Submittal
SS/L will perform system safety hazard analysis for the spacecraft, ground equipment and operations, and provide those analyses in a system safety data package to MCDONNELL DOUGLAS SPACE SYSTEMS COMPANY (MDSSC). Sufficient data will be provided to confirm compliance with the applicable safety requirements and concurrence with hazard analysis results. Those analyses will support development of the Missile System Prelaunch Safety Package (MSPSP) required for safety approval of the spacecraft design, tests and launch activities. The MSPSP which may be written by MDSSC, is the data package which describes the launch vehicle, the payload and its hazardous subsystems and operations. Parts of this document summarize the system safety analyses for the spacecraft and include analysis of the spacecraft to launch vehicle interfaces. The MSPSP also includes information concerning all hazardous tasks accomplished during payload processing. Safety Working Group and Technical Interchange Meetings will be held to ensure exchange of the safety data necessary to verify compliance with range safety requirements.

The MSPSP is formally approved by the 45th Space Wing. (SPW).

7.10.3 ATLAS Launch - Safety Data Submittal
Sufficient data will be provided to conform compliance with the applicable safety requirements and concurrence with hazards analysis results.

Those analyses will support development of the Missile System Prelaunch Safety Package (MSPSP) required for safety approval of the spacecraft design, tests and launch activities.

Parts of this document summarize the system safety analyses for the spacecraft and include analysis of the spacecraft to launch vehicle interfaces. The MSPSP also includes information concerning all hazardous tasks accomplished during payload processing. Safety Working Group and Technical Interchange Meetings will be held to ensure exchange of the safety data necessary to verify compliance with range safety requirements.

The spacecraft MSPSP, written by SS/L, is the data package which describes the payload and its hazardous subsystems and operations. Lockheed-Martin also develops a MSPSP which describes the launch vehicle and its hazardous subsystems and operations.

The MSPSP is formally approved by the 45th Space Wing (SPW).

7.10.4 PROTON Launch - Safety Data Submittal
The hazard analyses and system safety data for launch from the Baikonyr cosmodrome on the Russian Proton launch vehicle will be submitted in phases similar to the procedure used for launch an ARIANE from CSG. The Lockheed Krunichev Energia (LKE) Proton Users Safety Guidelines document is being tailored and implemented for launch of Temp FM-1. A similar procedure will be followed for all subsequent launches of commercial communications satellites on the Proton launch vehicle.

7.10.5 Long March Launch - Safety Data Submittal
The safety data submittals for launch from Xichang, China on the Long March launch vehicle will also be patterned after the ARIANE CSG procedure except that the data flow will be more selective. SS/L will also take a more active role in the pre-launch ground operations safety control at Xichang than other launch bases.

8. SUBCONTRACTOR SELECTION AND CONTROL

Product Assurance activities by the SS/L subcontractors will be governed by SS/L Specification No. E032894, Subcontractor Product Assurance Requirements and the associated Statement of Work (SOW). For subcontracted items which are in continuing production from previous programs, earlier versions of the Subcontractor Product Assurance
Requirements may be used.

8.1 Subcontractor Selection

SS/L will select subcontractors by assessment for those subcontractors not yet selected at the time of contract award. A part of this assessment will be an evaluation of the Subcontractor Product Assurance Program, including the compliance to SS/L's product assurance requirements. SS/L will support these evaluations by performing pre-award quality surveys as appropriate.

Subcontractors must demonstrate compliance with our requirements by means of objective criteria such as materials and processes lists, history of successful past performance for equivalent applications, and acceptable documentation and quality systems.

8.2 Subcontractor Control

The purpose of subcontractor surveillance is to ensure that PA requirements including configuration requirements are met by the subcontractors during design, procurement, manufacture, assembly, and test phases.

The SS/L PA Program Manager will have overall responsibility for subcontractor surveillance and will have direct contact with the subcontractor's PA managers.

When program activities commence, subcontractor performance will be monitored by means of resident or visiting QA personnel, reliability and QA monitoring of test discrepancy reporting, review of analyses and corrective action, approval of parts screening and test specifications, approval of reliability analyses, and review of other design documentation and deliverable items.

QA will also monitor performance of subcontractors by periodic audits. Audits will verify continued compliance with invoked requirements, and will evaluate the effectiveness of the subcontractors Product Assurance systems.

Access privileges at subcontractors' facilities will be specified for designated QA and Reliability personnel in all program subcontracts, for both SS/L and customer representatives.

Subcontractor surveillance will be accomplished by performing the following main tasks:

a. Review and approval of subcontractor PA Plans, compliance matrices or equivalent
b. Approval of subcontractor documentation including

    1. EEE parts list
    2. Materials list
    3. Process list
    4. Manufacturing and inspection plan
    5. Test procedures for qualification and acceptance tests, including incoming inspection of parts and materials.
    6. Software documentation

c. Definition of Mandatory Inspection Points (MIPs) and performance of mandatory inspections as appropriate
d. Performance of process reviews for critical processes
e. Surveillance of tests when appropriate
f. Participation in subcontractor MRBs, as required
g. Performance of Audits
h. Attendance of Subcontractor PA meetings and project reviews

9. FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION SYSTEM (FRACAS)

The SS/L PA system includes a coordinated method for internally reporting failures and discrepancies from receipt of material through spacecraft launch by means of a closed loop system that ensures effective analysis and corrective action for hardware, software, processes and all other problem areas.

9.1 Scope of Failure Reporting

The PA FRACAS will monitor all nonconformances and failures from receipt of material through launch of flight equipment. This includes all SS/L documented nonconformances, and failures of both SS/L and subcontractor-supplied hardware material and software.

The following functions will be performed at various levels:

a. Nonconformance summary reporting and review will be conducted on a program and on a functional area basis. This effort will be performed utilizing the Product Assurance Information System (PAIS) and will encompass reporting and review of all Nonconformance Records (NCRs). This effort will include the identification and analysis of nonconformance trends. Nonconformances summary reporting provides an overview of MRB and Quality Control (QC) actions on all nonconformances, except for powered test failures and failures of mechanical items which are addressed by the Failure Review Board (FRB).
b. Failure reporting summarization and review will be performed on all MRB- level nonconformances defined as requiring FRB. These failures are defined to be those associated with all powered electrical and mechanism tests on spacecraft qualification, protoflight, flight, critical items, and life test equipment. Failure of system test equipment (STE) and spacecraft handling equipment (SHE) will be reported and reviewed if the failure occurs while the STE or SHE is connected to flight hardware. These failures are entered into the NCR on-line database using PAIS. Each failure will be reviewed by the program FRB chairman. The disposition of the hardware falls under the purview of the applicable MRB, but the final decision for closure of the report and the final corrective actions are the responsibility of the FRB chairman and board members.

9.1 Scope of Failure Reporting (Continued)

c. Corrective action review will be conducted on an on-going basis. This review will utilize the following databases:

    1. Nonconformance Record (NCR)
    2. Correction Notice (CN)

9.1.1 In-Plant SS/L Operations

Failure and nonconformance reporting for in-plant operations conform to the following:

a. SS/L nonconformance reporting will start at receipt of material for all items.
b. SS/L failure reporting will start at the functional test level for

all items. Functional test level is defined as the first powered operation of a module or the first operation of a mechanism.

9.1.2 Subcontracted Items

Subcontractors shall provide nonconformance, failure and corrective action reporting as required by their SOW from SS/L and as described in the SH-E032894 Subcontractor Product Assurance Requirements. Nonconformance and failure documentation formats may be those used in the subcontractors existing systems, but their content must be approved by SS/L prior to use. Formal failure reports shall be submitted to SS/L for failures that occur during testing to SS/L-approved test procedures.

9.2 Definition of Nonconformances

See Paragraph 4.4.1.

9.3 Definition of Failure

A failure will generally include, but not necessarily be limited to, an occurrence of any of the following conditions as they are detected starting at first powered operation at the module or higher level, or first operation of an item of mechanical equipment.

a. Equipment performance is beyond the limits of the test specifications or test procedures. (Allowances shall be made for test instrument accuracy as specified in the specification or procedure.) Even though these conditions may not result in a classical failure of the hardware per se, such conditions are repeated in the same manner as other failure categories

9.7 Cost of Quality Reporting

The Cost of Quality is reported as defined in MIL-STD-1520C. The cost of scrap, rework and repair is reported weekly to management. The cost of "use as is" and "return to vendor" can also be supplied to management when requested.

9.8 Failure Analysis

A detailed failure analysis will be performed on items (piece parts modules, etc.) submitted for failure analysis as necessary to determine the cause of failure. Items submitted for failure analysis will undergo electrical and/or mechanical testing to verify their failure and determine their failure mode. The analysis shall proceed until either the failure cause has been determined or all reasonable avenues of investigation have been explored. Failure analysis reports will be prepared and will contain photographs of significant observations and all pertinent data associated with the analysis. All failure analysis data will be contained in the Parts Physics Laboratory (PAL) database for trending and review.

9.9 Failure Trend Analysis

All problem specific information such as part identification numbers, environments, test levels, failure levels, failure sources, cause codes, relevant dates and other selected data inherent in nonconformance summary reports, the PPL database are compatible with elements of the PAIS system and permit computer-assisted failure trend analysis from a single data base system. Follow-up action an all failure trends will be pursued on a case-by-case basis. All failure trend analysis efforts will consider both program-unique problems as well as those which may be common to other SS/L programs.

9.10 Failure Review Board (FRB)

It is the function of the FRB to review MRB actions regarding failures to ensure that the failure is fully defined, its cause(s) identified, and that corrective action taken to resolve the failure is adequate to prevent its recurrence. The FRB for each program will generally contain permanent membership representing the various engineering, manufacturing, flight assurance, and program organizations. These representatives are senior personnel who are empowered to act for their organizations and commit resources as required to resolve problem situations.

The formal FRB process requires the detailed review of each open FRB problem and all actions of the MRB with respect to the determination of the specifics of the problem, its cause, and the corrective action taken. Each open problem is reviewed monthly by the FRB for status. Trend analysis is performed using the data systems available to the FRB. The FRB will issue CNs when additional information/action is required or to initiate additional analyses to resolve each problem. Closure of problems requires unanimous approval of the FRB. Before close-out of the problem, verification must be made that remedial and preventive actions have been accomplished on both the affected hardware and the hardware or software design (as verified in test), and that the change effectivity on other identical items has been established. The FRB chairman is responsible for the closure of the problem and its transfer to the closed section of the Failure Summary Report, once such approval is obtained.

10. RADIATION

10.1 Total Dose Effects
* The total dose effects analysis shall demonstrate that all circuits are designed so that all parts can withstand the specified radiation levels for this period. For non geosynchronous environments, displacement damage effects as well as total dose effects shall be considered in the spacecraft design.

A Space Radiation Engineer will interface with System Design Engineers, Parts Procurement Engineers, Mechanical Design Engineers, Reliability Engineers, and persons from other relevant disciplines, to assure acceptable radiation design and implementation for the program.

Elements of the radiation program include:

a. Definition of the space radiation environment in terms of particle fluences and dose depth curves
b. Evaluation of shielding provided by the spacecraft structure, unit shielding and shielding provided by surrounding components
c. Definition of parts radiation acceptance criteria
d. Review of shielding analysis performed by subcontractors
e. Performance of radiation reviews with each subcontractor to:

    1. Validate the radiation database that will be used for Worst-Case Analyses
    2. Define which parts will be subjected to radiation characterization and Radiation Lot Acceptance Tests (RLAT)
    3. Establish the hardness level of each active part, and determine its acceptability based on radiation hardness level.

10.2 Single Event Effects
The spacecraft shall be designed to survive single event effects produced by interactions with cosmic rays, solar flares and high energy trapped protons associated with transfer and operational orbits.

The Single-Event Effect (SEE) analysis shall demonstrate that circuits are designed to be fault tolerant to single-event effects.

The approach to single-event hardness will include:

a. Single-event latch-up (SEL) acceptance rules
b. Single-event burn-out (SEB) and single event gate rupture (SEGR) acceptance rules
c. Definition of the single event upset (SEU) rate calculation methods
d. Definition of SEE evaluation tests (e.g. particle source, test set-up, software)
e. Analysis of test results and SEE rate estimation
f. Distribution of SEU rates for SS/L characterized parts
g. Review of SEE analysis performed by each subcontractor (at PDR and CDR levels) in order to ensure that the equipment is SEE fault tolerant
h. Determination of the SEE rates for the units, and the consequence to the system.

The following documents will be issued:

Spacecraft cosmic ray and proton environment description

Summary of single event evaluation

10.3 Parts Radiation Selection
Parts shall be selected which can survive the radiation environment of the specified mission.

The parts program shall have provisions for radiation evaluation, including the evaluation of radiation induced latch-up, single event effects, and total dose effects, as well as displacement damage effects for non geosynchronous missions. Particular attention shall be given to the low dose rate effect on electronics.

10.3 Parts Selection (Continued)
CMOS and other MOS components shall be procured as radiation hardened devices whenever hardened versions of the parts are manufactured. The minimum allowable level of radiation hardness shall be 25 krads (Si) for Geosynchronous satellites, unless exception is granted by SS/L. Any active components that cannot meet their specifications after exposure to 100 krads (Si) shall require

the approval of the SS/L Parts Control Board (PCB) for use.

Parts shall be subject to radiation testing on each lot procured if they are used in sensitive applications, have exhibited lot-to-lot variations in radiation tolerance, or if they have a radiation tolerance of less than 25 krad (Si) in their specific circuit application.

11. CONFIGURATION MANAGEMENT

11.1 General

The main objectives of Configuration Management and control are:

- To ensure that adequate definition and control of design and equipment configuration are maintained during all phases of the project.
- To manage and control the design of the spacecraft throughout the program, including design and contract changes.
- To control the as-designed assignment of equipment if applicable.
- To verify that the manufactured as-built configuration of hardware corresponds to the configuration described in the released documentation.

Configuration control will ensure that all initial designs are provided in the as-designed configuration and will reconcile, at the completion of manufacturing, the as-designed and the as-built configuration.

11.2 Configuration Identification

Configuration Management is responsible for the maintenance of all program documentation. A configuration identification system is established by providing:

- Specification of necessary configuration identification and control requirements on subcontractors and suppliers.
- Definition of spacecraft performance and design by a system of specifications and drawings.
- Configuration traceability from the co-component level to the system level.
- Establishment and maintenance of design baseline documentation.

11.2.1 Identification Method

A unique part number or material designator is assigned. QA inspection instructions call for verifying this designation before the completion of inspection. A box code system (reference designator) derived from the Work Breakdown Structure (Hardware Tree) permits a bottoms- up/top-down assembly flow. Design standards and drawings specify the method of application and location of identification numbers. They also define the type of marking such as ink nameplates, decals, or other media such as printing and silk screen. Document checkers review and approve all drawings for correctness in applying the notes to invoke these standards.

11.2.1 Identification Method (Continued)

Logs are maintained by production control to record the sequential assignment of serial numbers when drawings indicate a serialization requirement. Drawings, specifications, and other technical data, either of the new design areas or the recurrent ones, will be controlled through program reviews, key points, review boards, or test readiness reviews in order to ensure that the quality requirements of the program will be met in a timely and economical manner.

11.2.2 Retrieval of Records

Drawings, parts/materials lists, shop orders and inspection records carry the assigned identification numbers, including serial numbers where required. These records are contained in, or referenced in, the end item documentation packages and are sent to Configuration Management for accounting and file retention. From the accounting records the major components of each end item are identifiable and traceable.

11.2.3 Document Distribution

A procedure for controlling distribution of copies of documents used for manufacture or test is implemented; the system shall ensure that changes to released documents are routed directly to all personnel who are performing functions that may be affected by the change.
documents in the item specifications.

11.3 Configuration Control

A configuration control system is established to provide:

a. Continuous document control of the spacecraft configuration at all levels of hardware assembly, integration, and testing
b. Control of interfaces

c. Establishment of a baseline of configuration documents following completion of reviews by providing controlled release of documentation.
d. Effective integration of approved changes and systematic control of departures from the baseline configuration

Approval of manufacturing documentation, and of changes thereto, is done by the SS/L Drawing Review Board (DRB). This documentation is subsequently officially released and distributed by the SS/L Engineering Data Control (EDC). Each program management organization may also elect to participate in the authorization of changes which affect that specific satellite program.

The change control system thus ensures review of all changes to specifications, drawings, and procedures to verify the effects on technical performance, interfaces, reliability, safety, operations, logistics, cost, and schedule.

Configuration Management will control documentation in close relationship:

- With the PA Manager for non-conformances and requests for waivers
- With Systems Engineering for evaluation of the impact of waivers
- And with Project Control for contractual aspects of deviations or waivers.

A Change Review Board (CRB) will be organized at the responsible contractor premises.

Data management is normally implemented using standard forms:

- Change Request (CR) (equivalent to Engineering Change Proposal)
- Engineering Change Order (internal)
- Change Notice
- Contractual Change Notice (CCN).

11.3.1 Change Request (CR)
A CR can be issued by SS/L or a subcontractor. The CR is processed by the CRB who first verifies its validity and issues the resulting CR for the concerned contractor.

11.3.2 Engineering Change Order
At the conclusion of the Drawing Review Board (DRB) review of the CR, a decision is made to implement, or not, the change proposed by the relevant CR.

11.3.3 Change Notice
This document informs all users that the change has been implemented in the documentation (specifications, drawings . . .) and is applicable to the project.

11.3.4 Change Classification
Proposed changes may be of Class 1 (Class A) or Class 2 (Class B). Class 1 changes represent changes that affect contractually approved documentation and require approval by the customer. Class 2 changes are those that do not.

Generally, Systems Engineering will be responsible for classification and technical evaluation of changes; Quality Assurance and Configuration Management concurrence is also required.

11.3.5 Engineering Change Proposal
An ECP is issued by CRB if the proposed CR has an impact on any contractual document.

11.3.6 Change Request and Engineering Change Proposal
Class 1/Class A change proposals are established using a standard ECP format. All other changes will be documented on the internal company format addressing the following:

- Affected configuration items
- Technical description
- Technical justification
- Validation (qualification) tests to be performed
- Affected documents
- Impact on operations and logistics o Impact on quality, reliability, or safety
- Impact on cost and schedule.

The proposals are processed by the CRB who decides (after negotiation if necessary) to implement or reject the proposal.

For Class 1/Class A CRBs, affecting the main contract, a CCN will be prepared and sent to the customer for approval.

11.3.6 Change Request and Engineering Change Proposal (Continued)
Class 2/Class B minor changes can be processed by SS/L without formal approval of the customer.

11.3.7 Configuration Release
The purpose of Configuration Release is to establish a control point in the organization that will maintain the current issue of engineering documents.

The system shall provide control of all changes to released documentation. As a minimum, the following functions shall be performed:

- The verification of required approvals, and other criteria, required for release
- Maintenance of the originals, or master copies, of each released document in a file with controlled and limited access, thus ensuring document integrity
- A system of release records that prevents duplication of assignment of document numbers or revision letters, and provides for sequential assignment of revision letters (or numbers).
- A positive marking placed on each document to identify released documents, as distinguished from those not released.

11.4 Configuration Status Accounting
Configuration Status Accounting is established to record and report configuration information. Reports include the status of proposed changes to configuration, and the implementation of approved changes.

From the accounting records, the major components of each end item are identifiable and traceable.

Visibility of subcontractors is obtained through audits, reviews, deliverable documentation, and key points reports. Status of the proposed changes to configuration and the implementation of approved changes are maintained by Configuration Management.

11.4.1 Verifications
Verification is performed to ensure that the manufactured as-built configuration of hardware corresponds to the configuration described in the released engineering as-designed documentation.

Differences identified between the as-designed and the as-built configuration will be resolved during reconciliation, before final acceptance for each configured item and higher level assembly. Any noncompliance will be dispositioned either using the waiver procedure or the non-conformance procedure.

11.4.2 As-built Configuration List
The as-built configuration list identifies any difference between the documented design at the time of delivery of the item and its built status. The data are included in the acceptance data package together with relevant inspection reports that confirm compliance of as-designed and as-built configuration.

11.4.3 Configured Items List
A Configured Items List will be developed for each spacecraft.

CD RADIO DARS SYSTEM

EXHIBIT D

TEST PLAN

21 JULY 1998

FINAL

Prepared for
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SECTION 1 -- INTRODUCTION

1.1 SCOPE

This Program Test Plan (PTP) defines the development, qualification, protoflight, and acceptance tests that shall be performed on the spacecraft. Where equipment has previously been qualified on another program, such as Intelsat VII/VIIA and Tempo, qualification testing shall not be repeated. Also included in this plan are the test plans for launch base activities and in-orbit test. This document shall serve as a guideline, and as such, details may be negotiated between the Purchaser and SS/L.

1.2 TEST PLAN OBJECTIVES AND PHILOSOPHY

1.2.1 OBJECTIVES

The objective of the PTP shall be to assure with a high confidence level that

the spacecraft as delivered on-orbit shall satisfy its mission requirements.

1.2.2 TEST PHILOSOPHY, SPACECRAFT LEVEL
The spacecraft-level test requirements specified herein reflect a protoflight-based test program. The first spacecraft subjected to the test program shall be designated as the protoflight model (PFM) to serve as both a qualification model (QM) and flight model (FM). Accordingly, this spacecraft shall be subjected to tests that combine elements of qualification and flight acceptance testing. The spacecraft shall be qualified during the protoflight tests to the maximum extent possible without exposing the spacecraft equipment to conditions that would degrade its performance or endanger its reliability to perform its mission. Subsequent spacecrafts shall be designated as FMs and shall be subjected to acceptance-level tests.

Finalization of To Be Confirmed (TBC) and To Be Defined (TBD) parameters shall be mutually agreed between CD Radio and SS/L.

SECTION 2 -- GENERAL REQUIREMENTS

2.1 DEFINITIONS
The following definitions apply to the terminology used in this Program Test Plan (PTP).

2.1.1 DEVELOPMENT TESTS
Development tests are those tests performed to demonstrate and confirm design feasibility by using breadboard and/or Engineering Models (EMs). Development tests will be executed where there is potential for technical problems that may adversely affect the program schedule. Components used in the models may not be of flight standard.

2.1.2 QUALIFICATION
Qualification consists of demonstration by analysis or test or both that an item designed and built to a defined standard will meet its performance requirements for its specified lifetime over the complete range of expected environmental conditions. Such a demonstration can be achieved by taking, one flight item of hardware and successfully subjecting it to test levels exceeding its expected environment.

2.1.3 PROTOFLIGHT SATELLITE
The first flight satellite is intended as a medium for system or subsystem qualification. The equipment designated for the protoflight satellite is designated protoflight equipment. Equipment requiring qualification shall be subjected to protoflight level tests prior to installation on the satellite.

2.1.4 ACCEPTANCE
Acceptance consists of determining that equipment, articles, or materials are acceptable regarding design standards and workmanship, and demonstrating that they perform satisfactorily to their requirements over the range of expected flight environmental conditions. The item will have been previously qualified using essentially identical qualification hardware.

2.1.5 TEST PROCEDURE
The Test Procedure is a detailed document giving precise step-by-step details for running the test. The Test Procedure will be prepared in accordance with this PTP and is subject to the review and approval of all relevant areas of the SS/L organization before the test is started. The test procedure will contain test objectives, test methods, test setups, fixtures/jigs, test equipment, applicable drawings/documentation, and major test specifications with pass/fail criteria.

2.2 TYPES OF TESTS

2.2.1 QUALIFICATION TESTS
The purpose of the qualification tests is to demonstrate design adequacy and that performance and safety of the equipment meets specified levels over the expected range of operating conditions and environments, with a predetermined margin.

To identify the degree to which qualification testing is required, each unit on the satellite is classified according to the following categories:

a. CATEGORY A. All units designed, and requiring qualification, specifically for this program. In instances where equipment is subjected to qualification tests that do not jeopardize mission requirements, such equipment may be used on the protoflight or flight satellite.

b. CATEGORY B. Units derived from equipment developed and successfully qualified for other programs, but with design, fabrication, and/or control procedures, or with parts and materials that must be changed for this program. Such units may be qualified by a "delta qualification" program.

NOTE: "Delta qualification" is defined as the application of sufficient tests to qualify the portions of the design or requirements that have chanced since the original qualification.

c. CATEGORY C. Units developed and successfully qualified for previous programs, and whose design, fabrication, and control procedures, as well as parts and materials, need no modification for this program, but are subject to more stringent specifications for use in this program (e.g., higher performance, environmental specifications). A unit may be included in this category if it has been qualified to environmental levels that are equal to, or greater than, the satellite's expected flight environment, but less than the satellite's qualification test levels. Such units may be qualified by a "delta qualification" program.

d. CATEGORY D. Units developed and successfully qualified for previous programs, and whose design, fabrication, and control procedures, as well as parts and materials, can be used for this program without modification and whose application in this program exposes them to environments and requires performance, reliability, and life consistent with the qualification requirements of the program.

2.2.2 LIFE TESTS

All equipment susceptible to noticeable wear, degradation, fatigue, thermally induced creep, or preload induced creep during its projected lifetime (including time for fabrication storage, ground testing, and flight) is subjected to life tests under conditions representative of those experienced in-orbit and during ground testing. Table 2.2-1 gives a complete list of life test items.

TABLE 2.2-1. UNIT LIFE TEST SUMMARY

*

2.2.3 PROTOFLIGHT TESTS

The protoflight satellite will be subjected to protoflight tests that, as a minimum, satisfy the requirements in this PTP. The first of each unit classified as Category B and/or C will be subjected to protoflight tests prior to installation on the protoflight satellite. Subsequent units will be subjected to acceptance tests.

The protoflight tests will be such as to demonstrate design adequacy and workmanship. However, care will be taken not to overstress equipment in ways that would degrade performance or long-term reliability of equipment. Equipment that has successfully passed its protoflight tests will be considered

flight worthy. Completion of the protoflight test will satisfy the delta-qualification requirements for units and subsystems in Categories B and C.

2.2.4 ACCEPTANCE TESTS

All flight satellites and their units and subsystems will be subjected to acceptance tests that, as a minimum, satisfy the requirements in this PTP. The tests will verify the quality of workmanship and the performance of the equipment. The test conditions will ensure that the equipment is exposed to environments at least as severe as those in flight, considering uncertainties and tolerances in the test environment parameters.

2.2.5 DEVELOPMENT TESTS

The purpose of development tests is to verify, as a complement to the design analyses, that the design of the satellite hardware, parts, materials, and processes used for equipment fabrication, and the method used to control its quality, are adequate. Development tests may be conducted at unit, subsystem, or satellite level, if needed.

Given the high level of maturity of the satellite design, no development testing is necessary.

2.3 DOCUMENTATION

All qualification, protoflight, and acceptance tests will be performed in accordance with this PTP and detailed procedures. Qualification test reports which form a basis of "qualification by similarity" shall be made available for custom review at SS/L.

Results of performance and environmental tests will be provided in summary form to the customer. Detailed test data will be available for customer review at SS/L.

All unit data that is "carried up" to system level will be deliverable.

2.4 FAILURES AND RETEST CRITERIA

If during any qualification, life, protoflight, or flight acceptance test, any article fails to meet any of its prespecified performance objectives or any anomaly occurs with the test article or the test equipment that necessitates the interruption of the test, SS/L will undertake corrective action. Such corrective

actions, including the extent to which the test is to be repeated, will be documented in accordance with the applicable Quality Assurance procedures.

SECTION 3 -- TEST CONDITIONS

3.1 GENERAL TEST CONDITIONS

3.1.1 AMBIENT ENVIRONMENT

Unless otherwise specified, all tests shall be performed at an atmospheric pressure of between * of mercury, a temperature of between *, and a relative humidity of *. Where tests shall be performed with atmospheric conditions substantially different from the specified values, proper allowances for changes in instrument readings shall be made to compensate from the deviation for the specific conditions.

3.1.2 ZERO GRAVITY

Tests of the spacecraft conducted on the ground shall, of necessity, be conducted in a l-g field, whereas actual performance requirements shall be achieved in a zero-g field. In the case of performance tests in which the gravitational field is a significant factor, the test design will minimize or eliminate the gravity loading effect. Testing of deployable devices affected shall, as far as possible, simulate zero-g through the use of fixtures or test aids. Large area antenna reflectors shall be supported for performance tests in such a way as to eliminate, to the greatest extent possible, distortions due to the 1-g field.

3.1.3 TEST CONDITION TOLERANCES

Test condition tolerances shall be applied to the test values specified. Unless otherwise stated in this PTP or the applicable test procedure, the maximum allowable tolerances on test conditions and test measurements shall be as stated in Table 3.1-1.

3.1.4 TEST EQUIPMENT

Equipment used to perform test measurements as required by the PTP shall be of sufficient accuracy to ensure the validity of the measurement data for its intended use.

The test equipment design shall minimize the risk of damaging flight equipment through incorporating protective devices, such as overvoltage and overcurrent protection, errorproof connection, and diode protection on the equipment side of external electrical power access.

TABLE 3.1-1. ENVIRONMENTAL TEST CONDITION TOLERANCES

*

3.1.5 TEST SOFTWARE

Automated testing shall be used at the unit and subsystem level, and all tests at the spacecraft level will be automated to the greatest extent possible. The software used for these tests, either to conduct the test operations or to record the test data, shall be based on the approved test procedures, and must be tested and validated prior to use with any QM, PFM, or FM equipment. Test software documentation shall be prepared that details the conditions established by the automated test software to perform the test, and the specific data that shall be measured and recorded. Software controls shall be established that prevent the use of nonvalidated test software, and that allow any test software module to be immediately rolled back to the previous versions, should this become necessary.

3.2 ENVIRONMENTAL TEST LEVELS AND DURATIONS

3.2.1 BASIC REQUIREMENT

Unless otherwise stated in the following subsections, the development, qualification, protoflight, and acceptance tests of all equipment shall include as closely as possible simulation of the significant launch and on-orbit conditions that the equipment shall encounter during its lifetime.

For all phases in which the equipment is operative, performance shall be measured in all significant operational modes under the combination of worst-case conditions, e.g., temperature extremes with power supply noise.

3.2.2 STATIC LOADS

Load factors to be used for static-load tests shall be as follows unless otherwise specified in this PTP:

*

Static-load proof tests shall be conducted on key structural elements prior to

installation on the spacecraft as required to ensure integrity of the flight structure. The acceptance test load factor shall be used for these tests. Static load acceptance tests on composite and low ductility structures shall be *.

3.2.3 VIBRATION

Vibration tests shall be required for qualification, protoflight, and acceptance at the unit and spacecraft level. The criteria for establishing the test levels and durations for vibration testing at all levels of assembly shall be defined in Table 3.2-1. The specific requirements for vibration tests at the unit and spacecraft levels shall be specified in the following paragraphs.

TABLE 3.2-1. VIBRATION AND ACOUSTIC TEST CRITERIA

*

3.2.3.1 SPACECRAFT SINE VIBRATION

Each spacecraft in the dry launch configuration with antenna reflectors, solar panels, and other equipment stowed, shall be subjected to sinusoidal vibration along each of three orthogonal axes. Before and after vibrating each axis, a random vibration survey over the frequency range of * shall be conducted and the data shall be evaluated for anomalies.

During the test, the spacecraft shall be powered up in its launch configuration to enable status monitoring via telemetry. Telemetry and command (T&C) radio frequency (RF) links shall be established and used during monitoring and functional testing.

3.2.4 ACOUSTIC

Acoustic testing shall be required for items characterized by large ratios of surface area to mass, such as solar arrays or large antennas, which are difficult to test adequately using fixed-base random vibration. The test levels shall be determined based on analysis using the factors provided in Table 3.2-1.

3.2.4.1 SPACECRAFT ACOUSTIC TEST

The acoustic test shall be performed with the spacecraft mounted on its flight adapter or flight representative adapter. The test shall be conducted in a reverberant acoustic cell capable of generating the desired sound pressure levels. The spacecraft shall be in dry launch configuration with antennas, solar panels, etc., in their stowed position.

3.2.5 DEPLOYMENT TESTS

Deployment tests shall be applied to spacecraft equipment by means of the spacecraft-level separation tests or the pyrotechnically actuated deployment events. Performance tests conducted at the spacecraft level after completion of the pyrotechnically initiated events shall verify that no degradation of the equipment has occurred.

3.2.6 THERMAL/THERMAL VACUUM

Testing of the PFM and FM spacecraft in the thermal vacuum environment shall be required. Large assemblies such as the tower, antennas, and solar arrays whose performance shall not be significantly affected by the thermal vacuum environment shall be excluded from this requirement. Qualification, protoflight, and flight units shall be subjected to thermal/thermal vacuum cycles as defined in subsection 6.2.

3.2.6.1 SPACECRAFT THERMAL VACUUM

The PFM and FM spacecraft shall be subjected to a thermal vacuum test, such that quasi-steady-state temperature conditions are achieved.

The test shall be carried out in a test chamber equipped with a liquid nitrogen-cooled and gaseous nitrogen temperature-controlled shroud with a vacuum capability of 10-5 torr or better.

In the various phases of this test, the spacecraft shall be configured for the range of thermally representative combinations of season, lifetime, and internal power dissipation.

The test shall be designed to subject the spacecraft to steady-state soak tests, exposing the equipment to expected flight maximum and minimum temperature conditions. The temperature conditions shall include 5(degree)C margins for the flight and 10(degree)C for the protoflight. Boundaries and equipment temperaturE shall be controlled in a manner mutually consistent with the objective of the test and allowable temperature limits on equipment not being tested.

During a chamber pumpdown, the spacecraft shall be operating in launch configuration to verify that the equipment is protected against corona and arcing.

3.2.7 ELECTROMAGNETIC COMPATIBILITY

Unit and spacecraft-level electromagnetic compatibility (EMC) tests shall be conducted as specified in the following paragraphs.

3.2.7.1 UNIT-LEVEL EMC TESTS

Unit-Level radiated and conducted emissions and susceptibility tests shall be performed on all new units; conducted emissions and susceptibility tests shall also be performed on protoflight and flight models. Tests shall be performed using the methods of MIL-STD 462, and shall follow test procedures and requirements given in the EMC/ESD Control Plan. Specific test requirements on a unit-by-unit basis are presented in Section 4.

3.2.7.2 SPACECRAFT-LEVEL EMC TESTS
The PFM spacecraft shall be subjected to EMC tests to demonstrate:

a. Compatibility with the requirements of the launch site

b. Compatibility with the launch vehicle

c. Sensitivity to the in-orbit RF radiation environment

Spacecraft-level tests shall be performed using the methods of MIL-STD-462 and shall follow test procedures and requirements given in the program EMC/ESD Control Plan.

3.2.8 ELECTROSTATIC DISCHARGE TESTS
Electrostatic discharge (ESD) tests shall be performed at Qualification Testing (QT) on Category A units to determine immunity to spacecraft discharging. The unit- and spacecraft-level requirements shall be as described in the following paragraphs.

3.2.8.1 UNIT-LEVEL ESD TESTS
Unit-level ESD tests shall be performed on all new units on the QM (or the EM level if no qualification hardware is being built). Tests shall be based on the general requirements and procedures of MIL-STD- 1541; specific test requirements shall be given in the program EMC/ESD Control Plan. Specific test requirements on a unit-by-unit basis are presented in Section 4.

3.2.8.2 SPACECRAFT-LEVEL ESD TESTS
*

3.3 SPECIAL RF TESTS
Units (e.g., feeds, switches, harmonic filters, etc.) that are exposed to high RF power levels, which may result in multipaction (MP) and/or passive intermodulation (PIM) product generation, shall be analyzed. At PDR, the need for tests shall be discussed and agreed between SS/L and the customer. The tests shall demonstrate, with specified margins, the ability of the hardware to operate satisfactorily under conditions in which all the relevant channels/sources shall be simultaneously adjusted upwards to their maximum saturated output levels.

3.4 BURN-IN LOG
Operating time on flight units composed of electronic parts, excluding intermittently operating mechanisms and solar arrays, shall be monitored and logged. This shall include all time prior to launch, including, time accumulated during tests.

3.5 TYPICAL UNIT TEST PROGRAM
This section describes the tests to be performed for a typical electronic unit. Specific unit tests to be performed shall be identified on the matrices in subsection 4.1 and, where necessary, shall be described further in the appropriate subsequent subsections of section 4. The following types of tests shall be performed on the spacecraft electronic equipment, unless specified otherwise:

a. Performance Test. A baseline performance test that comprehensively verifies that performance of the item under test satisfies the requirements of its specification shall be performed at the beginning of the qualification, protoflight, or acceptance test sequence. This test shall be performed at nominal bus voltage. As a minimum, the test shall be repeated at hot and cold temperature extremes and at conclusion of the environmental test sequence, and the data shall be compared to the data from the original baseline performance test.

b. Power Consumption and Bus Voltage. The input power consumption of each unit shall be measured at steady-state nominal voltage as determined by the spacecraft power subsystem on-orbit characteristics. Undervoltage and overvoltage circuitry of the units will be tested where applicable to demonstrate margin and safe operation above and/or below the normal operational voltages.

c. Continuity/Isolation. This test shall consist of a thorough verification of all pertinent connector or connector pin interfaces such as redundant signal and power pathways, isolation diodes, power and ground isolation, signal isolation, and fuse continuity.

d. Limited Performance Test. Limited performance tests shall be

performed before, during and after environmental tests to demonstrate that the environmental exposures have not degraded the functional capability of the hardware. These limited performance tests shall be, by definition, limited in scope and shall not include all measurements contained in the baseline performance test. The measurements taken during limited performance tests shall be established based on the objectives of the particular test sequence with which they are associated, and the feasibility of making the desired measurements under the condition imposed by the test.

SECTION 4 -- UNIT AND SUBSYSTEM TEST PLAN

This section contains information on the qualification status and the qualification, protoflight, and acceptance testing planned for units and subsystems of the proposed spacecraft design.

4.1 UNIT AND SUBSYSTEM TEST SUMMARY TABLES

The test summary tables contain a listing of components for each subsystem, and indicate the item heritage, qualification status, and test plan. Qualification, protoflight, and acceptance test plans shall be presented. Where protoflight and acceptance tests are shown for the same unit, the protoflight tests shall apply to one unit only. All other units shall be acceptance tested.

The following tables contain summary test matrices for each subsystem:

4.1-1	Antenna - Unit/Subsystem Summary Test Matrix
4.1-2a	Repeater Input Section - Unit/Subsystem Summary Test Matrix
4.1-2b	Repeater High Power Section Unit/Subsystem Test Matrix
4.1-3	TT&C - Unit/Subsystem Summary Test Matrix
4.1-4	ADCS - Unit/Subsystem Summary Test Matrix
4.1-5	Propulsion - Unit/Subsystem Summary Test Matrix
4.1-6	Solar Array - Unit/Subsystem Summary Test Matrix
4.1-7	Electrical Power - Unit/Subsystem Summary Test Matrix
4.1-8	Spacecraft Control Electronics - Unit/Subsystem Summary Test Matrix
4.1-9	Thermal - Unit/Subsystem Summary Test Matrix
4.1-10	Structure - Unit/Subsystem Summary Test Matrix
4.1-11	Mechanisms - Unit/Subsystem Summary Test Matrix
4.1-12	Pyrotechnic Equipment Unit/Subsystem Summary Test Matrix

Tables 4.1-1 through 4.1-13 are included at the end of this section.

4.2 ANTENNA TESTS

This subsection shall describe the protoflight tests of the repeater antennas performed at the component and subsystem levels. Subsystem paragraph 4.2.1 shall describe the unit and subsystem qualification for the proposed antenna design. The protoflight tests shall be addressed in paragraph 4.2.1. The overall approach shall be qualify the components by constructing PFM antennas and then subjecting them to environmental exposures with test levels that shall be more severe than the levels encountered during flight. All components shall be subjected to protoflight test levels that shall be more severe than the flight levels.

The subsystem-level test shall consist of functionally testing each antenna on the antenna test range after the components have been assembled on a test fixture, which shall serve as a range adapter and as a zero-g fixture. These tests shall be performed on every antenna for the FM and PFM units.

4.2.1 PROTOFLIGHT TESTS

The qualification status and test plan for the antenna units is summarized in Table 4.1-1. A representation of the qualification protoflight test flow for the antenna reflectors and feeds is shown.

Figure 4.2-1. Antenna Protoflight Tests

*

4.2.1.1 REFLECTORS

All reflectors shall be subjected to protoflight tests. The protoflight tests shall consist of:

a. Surface Measurements. Each reflector surface shall be measured before any environmental tests. The test results shall establish the baseline data for key parameters, such as root-mean-square (RMS) surface accuracy and best-fit mechanical axis with respect to the mounting interface. This test shall be repeated once after exposure to environments (thermal environment, vibration, and acoustic tests).

b. Thermal Cycling. The reflector shall be subjected to protoflight thermal-cycling test. The temperature range shall be to protoflight temperature extremes, chamber permitting. If the chamber is not

capable of the cold temperature extremes, a reasonable best effort shall be made.

c. Static Load. Static-load testing of attachment joints shall be performed for those worst- load cases not covered by sine vibration testing.

d. Sine Vibration. The PFM reflectors shall be subjected to a three-axis sine vibration.

e. Acoustic. The reflector shall be subjected to an acoustic vibration test at the protoflight test level.

4.2.1.2 ANTENNA FEEDS

The feeds shall be subjected to protoflight tests. For the transmit feeds, a PIM test shall be performed.

a. Passive Intermodulation (PIM) Tests. These tests shall be performed on feeds. Because the PIM problems can be attributed to workmanship, this test will be performed on all FM transmit feeds. A preliminary test setup is shown in Figure 4.2-2. All PIM testing shall be performed and provided in accordance with the PIM control plan.

4.2.1.3 THERMAL DISTORTION

Reflector thermal distortion shall be verified by analytical means. The analysis model has been used before to verify performance on other programs using similar antennas and has been verified by in-orbit performance. A coupon sample of materials, which shall be used on this program shall also be used to update the model with critical thermal parameters, i.e., coefficient of thermal expansion (CTE), etc.

A coordinated series of tests on each unit or component of the antenna system and coupon tests shall be conducted to bound the effects of the thermal distortion of the feeds, reflectors, and their support structures on the overall antenna system performance. Selection of the test conditions will be based on detailed thermal, structural and RF analyses of each element and shall consider both temperature itself and temperature gradient effects. In addition to verifying the design, all temperature and distortion data obtained in these tests shall be used to adjust and correlate the analytical models. These models shall then be used to generate detailed flight performance predictions for each antenna system at various sun angles and eclipse.

4.2.2 ANTENNA SUBSYSTEM LEVEL TESTS

Each antenna assembly shall be assembled on a test fixture and shall then undergo antenna range tests to verify that all performance parameters are being met. Brief descriptions of these tests shall be provided in the paragraphs below and a schematic showing the test flow shall be shown in Figure 4.2.3.

Figure 4.2-2. PIM Test Setup

*

The antenna assembly shall have a dedicated alignment/integration and test fixture. The fixture shall support all antenna components in their zero-g spacecraft positions. An important feature of the fixture shall be the ability to move each antenna component during alignment and test within the adjustment range available at the spacecraft level. The fixture shall be designed to interface with the SS/L near-field range (NFR), or the Compact Antenna Test Range (CATR), and the optical alignment dock.

[graph here]

Figure 4.2-3. Assembly-Level Antenna Qualification and Protoflight Test

4.2.2.1 INSTALLATION OF ALIGNMENT REFERENCES

Reference alignment tools shall be installed for use during the subsystem testing, and installation of the antenna subsystems on the spacecraft. Th alignment tools shall consist of tooling balls, optical mirrors, or other key markings, which shall allow the antenna system component to be installed on the spacecraft with minimal trial and error adjustments.

4.2.2.2 MECHANICAL INTEGRATION AND OPTICAL ALIGNMENT OF REFLECTORS AND FEEDS

Each of the antenna subsystem elements, including the primary reflector, and feed shall be mounted on the test fixture. Optical alignment mirrors and tooling targets shall be installed on the reflector for use in optically aligning the reflector axis to the antenna fixture. The feed and subreflector shall similarly be optically aligned with respect to the main reflector to provide nominal beam

propagation direction.

Once this first phase alignment has been completed, the next step shall be to perform an RF alignment of the antenna subsystem.

4.2.2.3 RF ALIGNMENT OF REFLECTORS AND FEEDS
RF alignment of the actual beam direction shall be performed. The RF measurement capability of the antenna test range shall provide an accurate method of aligning the reflector and feed to form the proper beam direction of the antenna subsystem.

In addition, the results of this RF alignment process shall generate a data base of sensitivities for the various control elements of the antenna system. This data base shall also be used in other simulations for overall system optimization.

4.2.2.4 ANTENNA ASSEMBLY PERFORMANCE TESTS
Each antenna assembly shall be tested on the antenna test range to verify its performance. All key antenna parameters (i.e., contour patterns, gain, axial ratio, isolation) shall be determined.

4.2.3 ACCEPTANCE TESTS
The acceptance tests shall be indicated on the test matrix shown in Table 4.1-1. The tests that shall be performed during the acceptance test program shall be similar to the equivalent tests described in paragraph 4.2.1 for the qualification program. Environmental test levels and durations shall be adjusted to the acceptance test requirements.

4.2.4 COMPONENT LEVEL TESTS
The component-level acceptance tests shall be summarized in Table 4.1-1.

4.2.5 ANTENNA TESTS
Assembly-level integrated antenna tests shall be performed on all antennas as described in paragraph 4.2.1.4. The data generated from this test shall be used to compare directly with data measured later when the antenna subsystem has been fully integrated into the spacecraft.

4.2.6 REFLECTOR DEPLOYMENT
Reflector pyrotechnic release and deployment tests are described in Section 6 of this PTP under Spacecraft-Level Tests.

4.3 REPEATER TESTS
Subsystem paragraph 4.3.1 describes the unit and subsystem qualification for the repeater design. The protoflight and acceptance tests are addressed in paragraph 4.3.2.

4.3.1 QUALIFICATION TESTS
Qualification status and test plan for the units of the repeater subsystems are summarized in Table 4.1-2. The repeaters shall be qualified by virtue of the testing performed at the PFM spacecraft level as described in subsection 5.6 of this PTP.

4.3.2 PROTOFLIGHT AND ACCEPTANCE
Protoflight and acceptance testing of the units of the repeater subsystem is shown in the summary test matrix, Table 4.1-2. For a description of the repeater subsystem testing performed during spacecraft integration, refer to subsection 5.5 of this PTP.

4.4 TRACKING, TELEMETRY AND COMMAND
Subsystem paragraph 4.4.1 describes the unit and subsystem qualification for the tracking, telemetry and command (TT&C) design. The protoflight and acceptance tests are addressed in paragraph 4.4.2.

4.4.1 QUALIFICATION
The TT&C unit/subsystem qualification status and test plan shall be summarized in Table 4.1-3.

4.4.2 PROTOFLIGHT AND ACCEPTANCE
Unit/subsystem level protoflight and acceptance tests shall be performed on all components as summarized in Table 4.1-3. TT&C subsystem RF tests are identified in Table 6.1-2 and shall be part of the communications tests performed at the completion of module integration.

4.5 ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM
Paragraph 4.5.1 describes the unit and subsystem qualification of the attitude determination and control subsystem (ADCS). The protoflight and acceptance tests are addressed in paragraph 4.5.2.

4.5.1 QUALIFICATION
The ADCS unit/subsystem qualification status and test plan shall be summarized in Table 4.1-4.

* Therefore, no unit qualification tests shall be required for this

spacecraft.

* Transfer orbit and on-orbit flight scenarios will be tested in conjunction with EM and simulated wheels and sensors. The on-orbit scenario testing will include both yaw steering and orbit normal configurations.

4.3.1 QUALIFICATION TESTS
Qualification status and test plan for the units of the repeater subsystems are summarized in Table 4.1-2. The repeaters shall be qualified by virtue of the testing performed at the PFM spacecraft level as described in subsection 5.6 of this PTP.

4.3.2 PROTOFLIGHT AND ACCEPTANCE
Protoflight and acceptance testing of the units of the repeater subsystem is shown in the summary test matrix, Table 4.1-2. For a description of the repeater subsystem testing performed during spacecraft integration, refer to subsection 5.5 of this PTP.

4.4 TRACKING, TELEMETRY AND COMMAND
Subsystem paragraph 4.4.1 describes the unit and subsystem qualification for the tracking, telemetry and command (TT&C) design. The protoflight and acceptance tests are addressed in paragraph 4.4.2.

4.4.1 QUALIFICATION
The TT&C unit/subsystem qualification status and test plan shall be summarized in Table 4.1-3.

4.4.2 PROTOFLIGHT AND ACCEPTANCE
Unit/subsystem level protoflight and acceptance tests shall be performed on all components as summarized in Table 4.1-3. TT&C subsystem RF tests are identified in Table 6.1-2 and shall be part of the communications tests performed at the completion of module integration.

4.5 ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM
Paragraph 4.5.1 describes the unit and subsystem qualification of the attitude determination and control subsystem (ADCS). The protoflight and acceptance tests are addressed in paragraph 4.5.2.

4.5.1 QUALIFICATION
The ADCS unit/subsystem qualification status and test plan shall be summarized in Table 4.1-4.

* Therefore, no unit or subsystem qualification tests shall be required for this spacecraft.

4.5.2 PROTOFLIGHT AND ACCEPTANCE
The tests to be performed on the ADCS components and subsystems are summarized in Table 4.1-4.

4.5.3 ADCS SUBSYSTEM TEST
ADCS performance shall be verified at the subsystem level with a series of tests that demonstrate functionality and control stability. The tests shall demonstrate the correct response to all ADCS commands via the appropriate ADCS telemetry function. The closed-loop tester shall be used for functional tests of the ADCS utilizing engineering model electronics. The ADCS performance verifications shall be demonstrated using a spacecraft dynamic simulator in a closed-loop environment.

CLOSED-LOOP TESTS WITH TEST COMPUTER
Closed-loop tests of the ADCS shall be performed using the special closed loop test computer.

Figure 4.5-1 shows a block diagram of the closed-loop test computer (CLTC).

The CLTC consists of a real-time 68030 Tadpole CPU (providing telemetry and command simulation, test sequencing, and running the spacecraft dynamics software).

The CLTC provides accurate simulation of the spacecraft dynamics (including rigid body and flexible modes), simulated sensor signals (including sensor noise), and actuators, to provide a complete closed- loop test of all loops in all modes.

Figure 4.5-1. Closed-Loop Test Computer Block Diagram

*

a. The CLTC is used to evaluate the ADCS performance in all

transfer-orbit modes. The closed-loop test results taken at the subsystem level shall be quantitatively compared with analysis values and supplemented by analysis to verify that the ADCS is operating within performance requirements.

b. The CLTC is also used to evaluate the on-orbit ADCS performance. The on-orbit mode closed-loop tests shall be used in conjunction with the design analysis to verify that the ADCS is operating within performance requirements.

c. The CLTC is used to evaluate the ADCS stationkeeping performance. Proper operation of thruster firing history telemetry shall be verified as part of these tests. The stationkeeping closed-loop tests in conjunction with design analysis shall be used to verify that the ADCS is operating within performance requirements.

4.6 PROPULSION SUBSYSTEM

Paragraph 4.6.1 describes the unit and subsystem qualification for the propulsion subsystem design proposed for the spacecraft. The acceptance tests are addressed in paragraph 4.6.2.

4.6.1 QUALIFICATION

The propulsion subsystem qualification status and test plan shall be summarized in Table 4.1-5.

4.6.2 ACCEPTANCE TESTING

Acceptance tests shall be performed on all components as summarized in Table 4.1-5.

4.7 SOLAR ARRAY

Paragraph 4.7.1 describes the unit and subsystem qualification for the solar array design proposed for the spacecraft. The protoflight and acceptance tests are addressed in paragraph 4.7.2.

4.7.1 SOLAR PANEL COUPON QUALIFICATION

A qualification life test on a solar panel coupon shall be performed to demonstrate capability of the cover integrated cells (CICS) electrical connections, wiring, and substrate materials to survive the appropriate number of eclipse temperature cycles on orbit. The coupon shall consist of a representative section of substrate configured into an electrically functional solar cell circuit. The cell stack, interconnects, wiring, adhesive, and substrate shall be assembled using materials, parts, and processes identical to flight units. The coupon shall be cycled between the qualification temperature limits. *

4.7.1 SOLAR PANEL COUPON QUALIFICATION

A qualification life test on a solar panel coupon shall be performed to demonstrate capability of the cover integrated cells (CICS) electrical connections, wiring, and substrate materials to survive the appropriate number of eclipse temperature cycles on orbit. The coupon shall consist of a representative section of substrate configured into an electrically functional solar cell circuit. The cell stack, interconnects, wiring, adhesive, and substrate shall be assembled using materials, parts, and processes identical to flight units. The coupon shall be cycled between the qualification temperature limits. *

QUALIFICATION

The solar array qualification status and test plan is summarized in Table 4.1-6. Qualification plan TBD.

4.7.2 ACCEPTANCE TESTING

Protoflight and acceptance tests shall be performed as summarized in Table 4.1-6.

a. SUBSTRATE AND YOKE. During fabrication of the flight substrates and yokes, a program of careful inspections, in-process mechanical test, and final proof-load test shall be used to verify materials and workmanship. These special efforts are in recognition of the wide range in strength properties of composite materials and the potential for poor adhesively bonded joints. The static proof-load tests are based on 1.3 times worst-case limit loads from launch and apogee thruster firing.

   The cell side of each substrate shall have a * bonded to the faceskin to electrically isolate the cells from the conductive graphite-epoxy. An electrical-short test is performed, using a wet probe, to verify integrity of the insulation.

b. HOLDDOWN, RELEASE DEVICES. Each flight holddown/release device shall be inspected for proper function. Operation of the holddown/release system shall verified during the array release and deployment tests. For each lot of flight pyrotechnic cutters, a lot- acceptance test shall be performed on a few samples by the cutter vendor to verify the quality of that lot. The tests shall be performed simulating the conditions in the flight holddown/release device. This includes the flight mounting the holddown rod to be cut, and the rod preload.

c. HINGE MECHANISM. Deployment torque and torque margin measurements shall be performed on all hinges at ambient conditions. Additionally, these measurements shall be performed on all hinges of the first flight wing (PFM) at acceptance-level temperature extremes. Deployment torque and torque margin measurements shall be performed on all wing assemblies.

QUALIFICATION
The solar array qualification status and test plan is summarized in Table 4.1-6.

4.7.2 ACCEPTANCE TESTING
Protoflight and acceptance tests shall be performed as summarized in Table 4.1-6.

a. SUBSTRATE AND YOKE. During fabrication of the flight substrates and yokes, a program of careful inspections, in-process mechanical test, and final proof-load test shall be used to verify materials and workmanship. These special efforts are in recognition of the wide range in strength properties of composite materials and the potential for poor adhesively bonded joints. The static proof-load tests are based on 1.3 times worst-case limit loads from launch and apogee thruster firing.

   The cell side of each substrate shall have a 0.025-mm-thick film Kapton bonded to the faceskin to electrically isolate the cells from the conductive graphite-epoxy. An electrical-short test is performed, using a wet probe, to verify integrity of the insulation.

b. HOLDDOWN, RELEASE DEVICES. Each flight holddown/release device shall be inspected for proper function. Operation of the holddown/release system shall verified during the array release and deployment tests. For each lot of flight pyrotechnic cutters, a lot-acceptance test shall be performed on a few samples by the cutter vendor to verify the quality of that lot. The tests shall be performed simulating the conditions in the flight holddown/release device. This includes the flight mounting, the holddown rod to be cut, and the rod preload.

c. HINGE MECHANISM. Deployment torque and torque margin measurements shall be performed on all hinges at ambient conditions. Additionally, these measurements shall be performed on all hinges of the first flight wing (PFM) at acceptance-level temperature extremes. Deployment torque and torque margin measurements shall be performed on all wing assemblies.

d. PULLEYS AND CABLES. Control cable and pulleys shall be inspected prior to use. The cables shall be proof-loaded to 1.3 times limit load before use to verify strength.

e. SOLAR ARRAY DEPLOYMENT DAMPER. The damper shall be subjected to acceptance tests as shown in Table 4.1-6.

f. COVER INTEGRATED CELLS. Flight cells shall receive the acceptance tests described in Table 4.1-6.

g. SOLAR ARRAY PANEL. Acceptance tests shall be performed on each flight panel. The panel shall be assembled to its flight configuration. The acceptance tests shall be conducted in the following sequence:

   1. Visual inspection

   2. Mass determination.

   3. Reference electrical tests.

   4. Thermal vacuum tests. Each flight panel with CICs shall be thermally cycled in vacuum. Flight panel testing shall be described in Table 4.1-6.

   5. Final performance, final electrical measurements shall be made and a final visual inspection shall also be performed.

h. Solar Array Wing Assembly. The protoflight and acceptance testing of solar array wing assemblies is summarized in Table 4.1-7.

   The release/deployment test shall include full development of the solar array wing in simulated zero-g conditions. The array shall mounted by means of its solar array drive assembly (SADA) connection to a fixture that simulates the spacecraft sidewall. Each array panel shall suspended at its midpoint from a trolley which rides on an accurately leveled horizontal track. The trolley

is designed to minimize friction, while supporting the weight of the array panel during deployment. When the array is released, either by mechanical or pyrotechnic means, it shall be free to deploy. Because the trolley supports the weight of the array, the result shall be a deployment under conditions that simulate zero-g.

4.8 ELECTRICAL POWER SUBSYSTEM

Paragraph 4.8.1 describes the unit and subsystem qualification for the electrical power subsystem (EPS) design proposed for the spacecraft. The protoflight and acceptance tests are addressed in paragraph 4.8.2.

4.8.1 QUALIFICATION

The EPS qualification status and test plan shall be summarized in Table 4.1-7. The power control unit (PCU) and power distribution units (PDUS) shall be designs qualified on MCI-2.

The battery shall be the qualified Tempo design. The battery cells shall be the same as Tempo. Battery and cell tests shall be summarized in Table 4.1-7.

4.8.2 PROTOFLIGHT AND ACCEPTANCE

Unit-level protoflight or acceptance tests shall be performed on all components as summarized in Table 4.1-7.

4.9 SPACECRAFT CONTROL ELECTRONICS SUBSYSTEM

* CPUs and DCU-A and DCU-B shall be identical to the * units and each unit shall be acceptance tested. DCU-C and DCU-D shall have added trays. One DCU-C and one DCU-D shall be protoflight tested.

All other flight DCUs shall be acceptance tested. Refer to the spacecraft control electronics (SCE) subsystem summary test matrix shown in Table 4.1-8.

4.10 THERMAL CONTROL SUBSYSTEM

*

4.11 STRUCTURE SUBSYSTEM

This section describes the qualification and acceptance test that shall be performed to verify that the structure subsystem hardware satisfies all design requirements. This test program shall include protoflight static tests on the central cylinder, the repeater panels, and critical strut components. Upon completion of the component tests, the components shall be assembled into a structure subsystem (prototype or flight) for the next sequence of tests. Paragraph 4.11.1 describes the unit and subsystem qualification for the structure subsystem design. The protoflight and acceptance tests are addressed in Paragraph 4.11.2.

4.11.1 QUALIFICATION

The structure subsystem unit/subsystem qualification status and test plan shall be summarized in Table 4.1-10.

The structure shall be qualified by similarity to Intelsat VII, N-Star, and Tempo and shall not require a separate structural test model test program.

4.11.2 PROTOFLIGHT AND ACCEPTANCE TESTS

Unit/subsystem protoflight and acceptance tests shall be performed on all components as summarized in Table 4.1-10.

The qualification of the spacecraft structure subsystem shall be accomplished by the sine vibration on the protoflight spacecraft, and the various protoflight-level component tests identified in Table 4.1-10 and described herein.

The central cylinder shall be subject to a thorough protoflight-level static-load test program. Applied loads encompassing all critical launch events shall be applied to the protoflight cylinder to verify the capability of the cylinder to accommodate critical axial, lateral and bending loads identified.

Displacement gauges and/or strain gauges shall be used to monitor structural performance and to provide data for correlating with analytic predictions.

The protoflight north or south panels and battery panels shall be subject to protoflight-level static out-of- plane bending tests. These tests shall verify the overall integrity of the panels and the heat pipe-to-heat pipe adhesive bonds.

The protoflight earth deck antenna support structure shall be subject to a fixed-base sine vibration test to protoflight acceleration levels. Applied base motion shall induce accelerations and internal loads which shall envelop predicted loads from all critical events. The appropriate load and acceleration levels shall be achieved using a low frequency dwell and/or sweep test. Accelerometers shall be used to monitor dynamic response. The support structure shall also be subjected to five thermal conditioning cycles.

Acceptance tests shall be performed on critical structural components to verify

workmanship before their integration into the structure subsystem. Acceptance tests shall be performed on critical strut assemblies, which shall be loaded to acceptance load levels to verify proper workmanship quality.

4.12 MECHANISMS AND PYROTECHNIC EQUIPMENT

Paragraph 4.12.1 describes the pyrotechnic equipment design. Paragraphs 4.12.2 and 4.12.3 collectively address all mechanisms.

4.12.1 PYROTECHNIC DESIGN

The mechanisms and the pyrotechnic equipment qualification status and test plans and the protoflight and acceptance tests shall be summarized in Tables 4.1-11 and 4.1-12, respectively.

PYROTECHNIC CUTTERS

A dual pyrotechnic rod cutter shall be used for the release of all deployable structures. The cutter shall be actuated by two independent pyrotechnic initiators. *

The cutters shall be procured in a single lot. A representative sample shall be selected from this lot, exposed to the required environments and then shall be functionally tested. The functional tests shall consist of cutting margin tests at high and low temperatures for each functional interface.

Unit lot acceptance tests shall be performed on the remainder of the samples to confirm that materials, workmanship, fit and function are acceptable for flight use. Acceptance tests shall be nominal cutting tests at both high and low temperatures evenly distributed among

all applications. The cutters are accepted when they have passed all the nondestructive tests and when the test cutters have successfully completed the destructive tests. The dual rod cutter test plan is shown in Table 4.1-12.

PYROTECHNIC INITIATOR

The dual rod cutter shall be activated by two independent pyrotechnic initiators. These initiators shall be physically and functionally equivalent to the NASA Standard Initiator (NSI).

The initiators shall be manufactured and procured in a single lot. All units from this lot shall be nondestructively tested and inspected. A representative sample shall be selected from this lot, exposed to the required environments, and functionally tested.

The functional tests shall consist of firing the initiator into a fixed volume (10 cc) and measuring the pressure versus time. The firings shall be done at ambient and cold temperatures. The peak pressure, as well as the unit-to-unit variation, shall be evaluated for acceptability.

The deliverable units shall be acceptable for flight use once the nondestructive tests, inspections, and the lot acceptance functional tests have been successfully completed. The test plan for the pyrotechnic initiator shall be shown in Table 4.1-12.

4.12.2 REFLECTOR MECHANISMS

QUALIFICATION

The main reflector hinges were developed and qualified on the Tempo program. The holddown mechanisms were qualified on the Superbird, Intelsat VII, and Tempo programs. The qualification status and test plan shall be summarized in Table 4.1-11.

ACCEPTANCE TESTING

Acceptance tests of the holddown mechanisms and the hinges shall be summarized in Table 4.1-11.

a. HOLDDOWN MECHANISMS. The holddown mechanisms shall be tested at the spacecraft level as noted in Table 4.1-11.

b. HINGES. Each hinge set shall be performance tested at ambient conditions. These tests shall include torque margin, deployment, proof load, and post-load deployment and torque margin.

4.12.3 SOLAR SAIL MECHANISM

Testing for the solar sail shall be defined in Table 4.1-11.

ACCEPTANCE TESTING

Acceptance tests of the holddown mechanisms and the hinges shall be summarized in Table 4.1-11.

a. HOLDDOWN MECHANISMS. The holddown mechanisms shall be tested at the spacecraft level as noted in Table 4.1-11.

b. HINGES. Each hinge set shall be performance tested at ambient conditions. These shall include torque margin and deployment tests.

4.12.3 DAPM/TAAPM
TBD

TABLE 4.1-1. ANTENNA UNITS/SUBSYSTEM SUMMARY TEST MATRIX

*

TABLE 4.1-2A. ANTENNA UNITS/SUBSYSTEM SUMMARY TEST MATRIX

*

TABLE 4.1-2B. REPEATER HIGH POWER SECTION UNIT/SUBSYSTEM SUMMARY TEXT MATRIX

*

TABLE 4.1-3. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX TC&R TRANSPONDER

*

TABLE 4.1-4. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX -- ADCS

*

TABLE 4.1-5. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX -- PROPULSION

*

TABLE 4.1-6. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX -- SOLAR ARRAY

*

TABLE 4.1-7. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX -- ELECTRICAL POWER

*

TABLE 4.1-8. SATELLITE CONTROL ELECTRONICS UNIT/SUBSYSTEM SUMMARY TEST MATRIX

*

TABLE 4.1-9. UNIT AND SUBSYSTEM SUMMARY TEST MATRIX -- THERMAL

*

TABLE 4.1-10. STRUCTURE UNIT/SUBSYSTEM SUMMARY MATRIX

*

TABLE 4.1-11. MECHANISMS UNIT/SUBSYSTEM SUMMARY TEST MATRIX

*

TABLE 4.1-12. PYROTECHNIC EQUIPMENT/SUBSYSTEM SUMMARY TEST MATRIX

*

SECTION 5 -- SPACECRAFT ASSEMBLY AND INTEGRATION

The assembly and integration processes planned for each spacecraft are summarized in this section. The sequence implied by the following paragraphs may not be the actual sequence of assembly.

The objective of the assembly operations and integration test, conducted during this phase is to ensure that all spacecraft subsystems have been installed properly, that their electrical interconnections are correct and troublefree, and that all installed subsystems are operable.

5.1 GENERAL SPACECRAFT ASSEMBLY AND INTEGRATION OPERATIONS

The following tasks are performed as appropriate during or prior to the spacecraft assembly and integration operations.

5.1.1 HARNESS CONTINUITY AND HIPOT

Harness fabrication and assembly are performed on panel mockups. The panel mockups shall provide spatial placement of the connectors and harness. The completed harnesses are continuity and hipot tested and delivered for assembly and integration onto the spacecraft.

5.1.2 BOX FLATNESS AND MASS PROPERTIES

Spacecraft units and components are delivered for spacecraft assembly with flatness and mass property data. The unit mounting panels, including the repeater panels with heat pipes, are measured for flatness during the manufacturing process.

5.1.3 ELECTRICAL GROUNDING CHECKS

Electrical grounding measurements are performed on all active units during integration. These tests are measure from a designated point on the unit structure to the spacecraft single point ground or panel ground point. Interpanel grounding is also verified as the structure is assembled during integration. Thermal blanket grounding measurements are made at initial installation and are repeated if the blanket has been removed and reinstalled.

5.2 PROPULSION, EARTH PANEL, ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM (ADCS) DECK, AND CENTRAL CYLINDER ASSEMBLY AND INTEGRATION

*

5.2.1 EARTH PANEL

*

5.2.2 ADCS DECK

*

5.2.3 ANTI-EARTH DECK

*

5.2.4 CENTRAL CYLINDER

*

5.2.5 BUS MODULE

*

5.3 BUS MODULE INTEGRATION

*

5.3.1 ELECTRICAL POWER INTEGRATION
*

5.3.2 SPACECRAFT CONTROL ELECTRONICS INTEGRATION
*

5.3.3 ADCS INTEGRATION AND POLARITY TESTS
*

5.4 NORTH AND SOUTH PANEL ASSEMBLY AND INTEGRATION
*

5.4.1 INSPECTION OF NORTH AND SOUTH REPEATER PANELS
*

5.4.2 REPEATER COMPONENT ASSEMBLY
*

5.4.3 ELECTRICAL INTEGRATION
*

5.4.4 PANEL RF TESTING
*

5.4.5 COMM MODULE ASSEMBLY AND INTEGRATION
*

5.4.5.1 REFLECTION COEFFICIENT MEASUREMENTS
*

5.4.5.2 REPEATER SUBSYSTEM TESTS
*

5.4.5.3 RADIATED EMC TEST
*

5.4.5.4 SADA INTEGRATION
*

SECTION 6 -- SPACECRAFT TEST

The protoflight and flight test sequence for the spacecraft is shown in Figure 6.1-1. Tests that are performed only on the protoflight model shall be noted as "PFM Only." The order of the tests as shown in Figure 6.1-1 may be changed as mutually agreed.

6.1 INTEGRATED SYSTEM TEST 1A

The initial Integrated System Test (IST-1) is performed to verify specified operation of the spacecraft subsystems prior to application of environmental tests. This test provides a reference baseline of test data to which subsequent performance test results will be compared during and after environmental tests.

Because the antennas are not installed on the spacecraft until after the thermal vacuum test, the IST-1 is broken into two parts designated IST-1A and IST-1B. IST-IB is conducted after the antennas are installed subsequent to the thermal test. IST-1A consists of initial alignments of subsystem support module (SSM) equipment a propulsion functional test and the performance test.

Tables 6.1-1 through 6.1-4, Spacecraft Protoflight and Acceptance Test Matrices, describe the system level tests to be performed on the various subsystems during the IST-1A and subsequent system tests. Shown vertically on the left of each matrix are the major activities in the test sequence. Shown horizontally at the top of each matrix, organized by subsystem, are the measurements to be performed during the indicated activities. The places in the sequence where these test measurements are made are denoted by an X, or other symbol as defined in footnotes. Tables 6.1-5 through 6.1-13, at the end of this section, contain descriptions of the spacecraft test configurations. The test configurations are also keyed to the system test matrices.

6.1.1 INITIAL SPACECRAFT ALIGNMENTS
*

FIGURE 6.1-1 SPACECRAFT TEST FLOW (PFM AND FM)

*

TABLE 6.1-1. SATELLITE TEST MATRIX

*

TABLE 6.1-1. SATELLITE TEST MATRIX (CONTINUED)

*

TABLE 6.1-1. SATELLITE TEST MATRIX (CONTINUED)

*

TABLE 6.1-1. SATELLITE TEST MATRIX (CONTINUED)

*

*

6.1.2 PROPULSION SUBSYSTEM FUNCTIONAL TEST

*

6.1.3 INITIAL PERFORMANCE TEST

*

6.1.4 GROUND EQUIPMENT COMPATIBILITY (PFM ONLY)

*

6.2 THERMAL VACUUM TEST

*

6.2.1 PRE-THERMAL VACUUM PERFORMANCE TEST

*

6.2.2 PROTOFLIGHT SPACECRAFT THERMAL TESTING

*

FIGURE 6.2-1. PROTOFLIGHT THERMAL VACUUM PROFILE

*

*

6.2.3 FLIGHT ACCEPTANCE SPACECRAFT THERMAL TESTING

*

FIGURE 6.2-2. THERMAL VACUUM ACCEPTANCE TEST PROFILE

*

6.2.4 POST THERMAL PERFORMANCE TEST
*

6.3 INTEGRATED SYSTEM TEST-1B

Interated Systems Test-1B (IST-1B) is conducted after antenna installation and initial alignment.

6.3.1 BASELINE ANTENNA INSTALLATION AND ALIGNMENTS
*

6.4 MANUAL ANTENNA DEPLOYMENT TESTS
*

6.5 SOLAR ARRAY INSTALLATION AND PARTIAL DEPLOYMENT

6.5.1 SOLAR ARRAY INSTALLATION
*

6.5.2 SOLAR ARRAY PARTIAL DEPLOYMENT
*

6.6 PREPARATION FOR DYNAMICS TESTS
*

6.6.1 PFM SINE VIBRATION TEST
*

SINE VIBRATION (FM)
*

6.6.2 ACOUSTIC NOISE TEST
*

6.7 DEPLOYMENT TESTS (EED INITIATED)

EED initiated deployment tests include a demonstration of the complete spacecraft deployment sequence with the spacecraft antennas and solar panels stowed in their launch configuration and the spacecraft powered in the appropriate flight configuration. These tests are performed following the dynamic test phase without reconfiguration of the spacecraft. At the beginning of the test sequence the spacecraft antennas and solar panels will be stowed in their launch configuration.

This sequence of tests shall be performed once on all flight spacecrafts, including, the protoflight spacecraft. The spacecraft response to the deployment shall be monitored by spacecraft telemetry.

6.7.1 ANTENNA AND SOLAR SAIL PYRO RELEASE
*

6.7.2 SOLAR ARRAY PYRO RELEASE
*

6.7.3 SOLAR ARRAY REMOVAL AND TEST OPERATIONS
*

6.8 FINAL INTEGRATED SYSTEM TEST (IST-2)

IST-2 test will be performed to demonstrate satisfactory performance after completion of the environmental tests. The IST-2 will consist of the following tests:

a. Alignment verification

b. CATR

c. Final Performance Test

d. Ground Equipment compatibility test (PFM only)

e. Fit check (if required)

6.8.1 POST DYNAMIC ALIGNMENT VERIFICATION
*

6.8.2 CATR
*

PREPARATIONS FOR COMPACT ANTENNA TEST RANGE (CATR)
*

CATR TEST SETUP
*

SPACECRAFT TESTS
*

6.8.3 RADIATED ELECTROMAGNETIC COMPACTIBILITY TESTS (PFM-ONLY)
*

RADIATED EMISSIONS
*

FIGURE 6.8-1. COMPACT ANTENNA RANGE TEST CONFIGURATION

*

RADIATED SUSCEPTIBILITY
*

6.8.4 FINAL PERFORMANCE TEST
*

6.9 FINAL OPERATIONS

6.9.1 PROPULSION GLOBAL HELIUM LEAK TEST AND FINAL PERFORMANCE TEST
*

6.9.2 FLIGHT BATTERY INSTALLATION
The flight battery will be installed on the spacecraft and a functional test will be performed.

6.9.3 MASS PROPERTIES
The final mass properties measurements conducted at this time include the following:

a. Mass (weight)

b. X, Y and Z center of mass

c. MOI about the X, Y and Z-axes.

6.9.4 FINAL THRUSTER ALIGNMENT
*

6.9.5 SOLAR ARRAY OPERATIONS/STOW
*

6.9.6 PROPULSION EED INSTALLATION
*

6.9.7 ANTENNA AND SOLAR SAIL OPERATIONS/STOW

*

6.9.8 PREPARATION FOR SHIPMENT

A preshipment review will be held to verify the readiness of the spacecraft to be shipped to the launch site. When readiness has been verified, the spacecraft will be put into its shipping configuration and will be placed in its environmentally controlled shipping container.

TABLE 6.1-5. REPEATER AND ANTENNA SUBSYSTEM MEASUREMENT DESCRIPTIONS

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TABLE 6.1-5. REPEATER AND ANTENNA SUBSYSTEM MEASUREMENT DESCRIPTIONS (CONTINUED)

*

TABLE 6.1-5. REPEATER AND ANTENNA SUBSYSTEM MEASUREMENT DESCRIPTIONS (CONTINUED)

*

TABLE 6.1-5. REPEATER AND ANTENNA SUBSYSTEM MEASUREMENT DESCRIPTIONS (CONTINUED)

*

TABLE 6.1-5. REPEATER AND ANTENNA SUBSYSTEM MEASUREMENT DESCRIPTIONS (CONTINUED)

*

TABLE 6.1-6. TT&C SUBSYSTEM MEASUREMENT DESCRIPTIONS

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TABLE 6.1-6. TT&C SUBSYSTEM MEASUREMENT DESCRIPTIONS (CONTINUED)

*

TABLE 6.1-7. ADCS MEASUREMENT DESCRIPTIONS

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TABLE 6.1-7. ADCS MEASUREMENT DESCRIPTIONS (CONTINUED)

*

SECTION 7 -- LAUNCH BASE TESTS

7.1 LAUNCH BASE OPERATIONS SEQUENCE

The launch base operations sequence is presented in order to place in context the spacecraft test operations that shall be performed at the launch base.

Spacecraft test operations shall be conducted in the Payload Processing Facility (PPF), the Hazardous Processing Facility (HPF) and the Launch Complex (LC). (These are general designations; specific designations will differ from site to site.)

The spacecraft sequential launch flowchart shown in Figure 7.1-1 shall depict, in block form, each of the major spacecraft-related events occurring at the launch base. The sequential launch flow shall be divided into three section: PPF, HPF, and LC. Launch base activity shall begin with site activation and the receipt and unloading of electrical and mechanical ground support equipment (EGSE/MGSE) and spacecraft at the PPF. This shall be followed by initial EGSE/MGSE validation and spacecraft validation tests to demonstrate that the hardware has not been degraded by transportation from Palo Alto. At the completion of the PPF activities, the spacecraft shall be transported to the HPF for oxidizer and fuel services, spacecraft closeout encapsulation and preparation for transport to the LC. There shall be a launch preparation option that performs fairing/spacecraft encapsulation in the launch center. The option, option 2, shall increase the launch mass capability. This document shall assume that the spacecraft shall be encapsulated in the Technical Center, option 1, and modified if required. At the LG the payload shall be received and mated to the launch vehicle. The spacecraft/launch vehicle interface shall be tested, the payload batteries are charged and the spacecraft shall be prepared for the launch terminal countdown.

7.2 SPACECRAFT LAUNCH BASE TEST AND INTEGRATION

The spacecraft shall undergo a series of inspections and tests from the time it arrives at the launch base through launch. The launch base system test matrix (Table 7.2-1), shall identify the spacecraft validation tests that shall be performed at the launch site. The performance measurements conducted on the spacecraft/payload subsystems shall be the same as defined in the test measurement descriptions in Section 6. Launch base unique tests shall be described in the following paragraphs.

7.2.1 PAYLOAD PROCESSING FACILITY TEST OPERATIONS

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FIGURE 7.1-1. SPACECRAFT SEQUENTIAL LAUNCH FLOW (TYPICAL)

*

*

7.2.2 HAZARDOUS PROCESSING FACILITY OPERATIONS

HPF shall be used specifically for hazardous operations such as spacecraft fuel/oxidizer service, encapsulation and launch vehicle stage mate, test, and integration. All operations in the HPF shall be considered hazardous in nature and personnel access shall be strictly controlled and limited.

*

7.2.3 ON-PAD OPERATIONS

During the payload on-pad operations (spacecraft plus adapter) the payload shall undergo a set series of functional and interface tests to verify the payload configuration and shall be prepared to support terminal launch countdown.

*

SECTION 8 -- STORAGE AND POST-STORAGE TEST

This section shall present the plan for long-term storage of the spacecraft. It

describes the plan and procedures to be implemented, if required, and includes specific schedules, milestones, and callup notice time requirements. Details of the spacecraft storage configuration, preparation, storage activity, and poststorage operations shall be presented along with identification of storage support facilities and equipment.

8.1 GENERAL REQUIREMENTS

The storage of the spacecraft and its associated flight units will be accomplished during the storage period using facilities, equipment, and procedures that meet the following requirements.

The requirements for short-term and long-term storage shall be identified in this plan. Short-term storage is defined as storage for a period of less than 6 months and shall be used for short waiting periods between end-of-acceptance test and start of launch operations. Long-term storage shall be defined as a preplanned storage period of 6 months or more.

8.1.1 ENVIRONMENTAL CONDITIONS

*

8.1.2 ACCESS CONTROL

Throughout the entire storage period, limited and controlled access to the spacecraft and flight units not stored on the spacecraft shall be required. Each of these items shall be stored in a controlled access area where only a limited number of certified personnel shall be allowed entrance by prior approval. Access log books shall be maintained for the spacecraft storage area and containers.

8.1.3 MONITORING

The storage conditions for each spacecraft and flight component shall be monitored on an established and regular basis. Although temperature and humidity conditions will be recorded continuously, monitoring must be performed by an assigned responsible and cognizant person to verify requirements are being met, and if required to initiate corrective action. Monitoring will include recording of data and anomalies.

8.1.4 DOCUMENTATION

The following, documentation will be maintained during the storage period for spacecrafts and their associated units and support equipment:

a. Spacecraft Log Book. A spacecraft log will be maintained by SS/L in chronological order during the storage period to account for all handling, monitoring, testing, and inspection operations performed on the spacecraft.

b. Test Procedures. Detailed test procedures will be prepared for the storage of the spacecraft and flight hardware units. These procedures will detail the requirements, the step-by-step preparation, and the storage activity including monitoring for each separate item stored. Data sheets will be included in the test procedures to record test conditions, inspection and test data, and poststorage operations.

8.2 FACILITIES AND EQUIPMENT

The facilities and equipment required to prepare, store, monitor, and test the spacecrafts and their associated components for the periods required are identified in the following paragraphs.

8.2.1 FACILITIES

Facilities at SS/L in Palo Alto, California will be used to store the spacecrafts and their various components and support equipment as detailed in subsection 8.3. Table 8.2-1 presents a summary description of each of the facilities, which can be used for this purpose.

8.2.2 STORAGE EQUIPMENT

The following spacecraft MGSE required:

a. Spacecraft Handling Dolly. The spacecraft handling dolly permits the spacecraft to be store vertically or horizontally. This assembly will be stored within the spacecraft protective cover.

b. Spacecraft Vertical Workstand. The spacecraft vertical workstand is also capable of storing the spacecraft in the vertical position.

Table 8.2-1. Storage Facilities

*

c. Spacecraft Shipping Container. For short-term storage, the spacecraft may be stored in its shipping container, if available. Alternatively, it may be stored in the SS/L high bay. Plastic sheeting taped in place may be used to minimize particulate contamination if stored for a few months is envisioned.

d. Spacecraft Storage Protective Covers (Long Term). Protective covers of sheet metal aluminum construction will be fabricated to be used in protecting the spacecraft from particulate contamination during long-term storage. The covers will be sized to fit over the spacecraft while installed on the handling dolly in the vertical position. Internal to the cover will be a basket in which desiccant will be placed prior to spacecraft storage to ensure dry air within the cover.

e. Other Storage Containers. Protective storage containers will be provided for other items stored apart from the spacecraft, such as the solar array.

8.3 STORAGE OPERATIONS

The storage operations to be performed on the spacecraft are described within this section. These details include callup notice schedule, the spacecraft mechanical and electrical configuration preparation of the spacecraft and its components for storage, and the in-process storage activity. Additionally, storage details are provided for the GSE. All post-storage operations are detailed in subsection 8.4.

The in-process storage monitoring and test activity for the spacecraft are detailed in paragraph 8.3.4. The in-process monitoring and test operations for individual flight units not stored, or with the spacecraft, are detailed in the storage description for each unit. Table 8.3-1 presents the matrix for storage monitoring, maintenance, and test schedules for the spacecraft and associated flight components plus GSE.

8.3.1 SPACECRAFT CONFIGURATION FOR STORAGE

The spacecraft will complete its planned assembly, integration, and acceptance test through final functional before being put into storage (refer to Figure 7.1-1). The solar array will complete its final electrical and deployment tests, but will not be installed on the spacecraft for storage. The battery will be stored separate from the spacecraft.

8.3.2 SPACECRAFT PREPARATION FOR SHORT-TERM STORAGE

Short-term storage is defined as a period of storage which is projected to last for less than 6 months. For such storage, the spacecraft may be located in the Building 18 high bay. If the storage period is expected to be a few months, the spacecraft will be covered with RCS-2400 plastic sheeting taped in place to minimize particulate contamination. Alternatively, if available, the spacecraft may be stored in its shipping container. If so, all cleanliness, purge, desiccant, and other preparations normally associated with installation of the spacecraft in the shipping container will be made. Other spacecraft preparations for storage will be the same as described in paragraph 8.3.3.

8.3.3 SPACECRAFT PREPARATION FOR LONG-TERM STORAGE

For long-term storage, the spacecraft will be stored in Building 18 on its handling dolly in a vertical position. An aluminum protective cover will be placed over the spacecraft to protect it from particulate contamination.

TABLE 8.3-1. STORAGE MONITORING MATRIX

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8.3.3.1 SPACECRAFT PREPARATION

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8.3.3.2 STORAGE CONTAINER PREPARATION

*

8.3.3.3 SPACECRAFT INSTALLATION INTO PROTECTIVE COVER

*

8.3.3.4 FINAL STORAGE PREPARATION

*

8.3.4 SPACECRAFT MONITORING

*

8.3.5 FLIGHT BATTERY STORAGE

Batteries can be stored trickle-charged at -10o C without adverse effect or detectable aging. It is planned to complete the production of the flight batteries on a schedule that is compatible with their earliest projected need date. The batteries will be cold stored until needed.

8.3.6 SOLAR ARRAY STORAGE

Each solar array assembly will have completed its subsystem and system-level acceptance test before being stored. Each solar array wing, will be stored in its shipping container. The container will be purged and desiccant installed at the time of sealing, the container. After each 12-month period the desiccant will be changed and the container will be purged and resealed. No other in-process tests will be performed.

8.3.7 GROUND SUPPORT EQUIPMENT

MGSE and EGSE used for the program will, in most cases, be general purpose equipment which is usable on many spacecraft programs. If the equipment used for the spacecraft is in use on another program at the time of the spacecraft storage, storage of the GSE will not be necessary. If GSE store is necessary, the EGSE will be stored in the same area as the spacecraft, or in a similar area. MGSE will be stored in a suitable secure and environmentally protected storage facility.

8.4 POST-STORAGE OPERATIONS

Post-storage operations for the spacecrafts in long-term storage will commence upon receipt of a callup notice. The required notification period baseline to launch data is described in Paragraph 8.4.1. Component preparation for each item separately stored or not completed is detailed in paragraph 8.4.2. Details of removal of the spacecraft from storage and startup of its assembly, integration, and acceptance test activity are described in subsequent paragraphs.

8.4.1 CALLUP SCHEDULE

A minimum of 3 months notice is needed prior to the scheduled launch date when calling up the spacecraft from long-term storage. This minimum 3 months is required to provide adequate time to remove the spacecraft, flight units, and GSE from storage and complete the assembly and test of the spacecraft.

8.4.2 UNIT PREPARATION

Upon receipt of callup notice for a spacecraft, the following specific activities will take place to remove each of the flight units from storage and to prepare for use. All activities will be conducted in accordance with established and preapproved procedures and work orders. The sequence of component preparation is not critical in that parallel operations will be initiated.

a. Solar Array Assembly. The solar array assembly will be removed from its storage container and a thorough mechanical inspection performed. For arrays stored long-term, electrical functional test including a flash test will be performed. The assembly will then be subjected to several deployment tests to verify its flight readiness. Upon review and acceptance of all mechanical and electrical data, the unit will be prepared for installation onto the spacecraft.

b. Flight Batteries. Checkout and conditioning of the flight batteries will begin immediately upon receipt of the callup notice.

c. MGSE. All MGSE required to support one spacecraft will be brought out of storage and to Building 18 airlock, where it will be thoroughly cleaned and routine service maintenance performed. All lifting slings and devices will be proof-tested. All mating surfaces to the spacecraft will be thoroughly inspected before first use.

d. EGSE. EGSE that has been stored for spacecraft will be set up in the spacecraft test configuration. All measuring instruments will be checked to see that the calibration is current and according to the SS/L calibration schedule. The EGSE will be validated according to the spacecraft EGSE validation procedure.

8.4.3 SPACECRAFT PREPARATION

The spacecraft will be removed from the protective cover and inspected for dust contamination. The OSRs will be cleaned and wipe samples taken from various thermal surfaces and analyzed. After the mechanical and cleanliness inspection is completed and documented, the spacecraft will be ready to enter the spacecraft integration and test activity described in paragraph 8.4.4.

8.4.4 SATELLITE INTEGRATION AND TEST ACTIVITY

The satellite test requirements upon removal are divided into three categories: storage periods of one to three months, storage period of three to six months, and storage periods of greater than six months. The following paragraphs provide details of the required operations. For all cases, it is assumed that the satellite has completed the final performance tests and has been assembled to the point of "callup" to prepare for shipment to the launch base (ready for flight battery installation).

8.4.4.1 ONE TO THREE MONTH SATELLITE POST STORAGE OPERATIONS

The following operations are required (in addition to the normal "callup" activities) to prepare the spacecraft for shipment to the launch base:

a. Perform a health test of all three momentum wheels and the DIRA.

b. Proceed with the normal preparations for shipment, starting with flight battery installation.

8.4.4.2 THREE TO SIX MONTH SATELLITE POST STORAGE OPERATIONS
The following operations are required (in addition to the normal "callup" activities) to prepare the spacecraft for shipment to the launch base:

a. Perform a complete command functional test (both sides).

b. Perform a health test on all momentum wheels, DIRA and sensors.

c. Proceed with the normal preparations for shipment, starting with flight battery installation.

Note: These operations include those specified in 8.4.4.1.

8.4.4.3 GREATER THAN SIX MONTH SATELLITE POST STORAGE OPERATION
The following operations are required (in addition to the normal "callup" activities) to prepare the spacecraft for shipment to the launch base:

a. Complete the satellite final performance test to include the following:

1. Communications Subsystem
P in to Saturate (Gain Transfer)
Output Power
Frequency Response (Linear)

2. TC&R and ADCS Subsystems. As specified in the final performance test per 6.1- 2, Satellite Protoflight and Acceptance Test Matrix

3. Electrical Power and Propulsion Subsystems. As specified in the final performance test per 6-1, Satellite Protoflight and Acceptance Test Matrix.

4. SCE, Terminal and Mechanisms Subsystems. As specified in the final performance test per 6-1, Satellite Protoflight and Acceptance Test Matrix.

Note: The final performance test includes those tasks specified in 8.4.4.1 and 8.4.4.2.

b. Proceed with the normal preparations for shipment starting with flight battery installation.

SECTION 9 -- IN-ORBIT TEST

9.1 PURPOSE OF TESTS
The purpose of in-orbit testing is to verify that the performance of the satellite, consisting of the communications payload and the bus, has not degraded during launch and orbit raising. This will be achieved by comparing in-orbit test data with predictions based on ground test data. It is not the purpose of in-orbit testing to test the satellite, its subsystems, or units against performance specifications.

In-orbit testing will also accomplish the following:

a. Satellite Biases. In-orbit test data will be used to establish the nominal biases of the attitude sensors and any antenna pointing mechanisms.

b. Satellite Operations. In-orbit testing will verify that operations, attitude performance, and stationkeeping performance are consistent with planned mission operations design.

c. Telemetry, Tracking and Command (TT&C) Earth Station Compatibility and Calibration. In-orbit testing will verify the compatibility of the satellite with the TT&C station(s) used during IOT. The range and angle calibration of the TT&C station(s) used during the on-station IOT period will be evaluated during IOT, if different than the TT&C stations used during orbit raising.

d. Redundancy. IOT will verify the operational status of both primary and redundant units.

e. Constellation Verification - TBD.

9.2 MAJOR ASSUMPTIONS
In-orbit testing will be based on the following major assumptions:

a. The satellite is tested near its nominal 24 hour in-service orbit.

b. There are no restrictions on bus or payload testing resulting from conflicts with other spacecraft in the orbital location for the satellite under test. Responsibility for resolving such conflicts

(e.g. command interference, payload traffic interference, collision avoidance, etc.) resides with Purchaser.

c. There are no restrictions on bus or payload testing resulting from limitations of Purchaser provided support including Purchaser's ground equipment as may be provided in accordance with the Statement of Work (SOW).

d. Purchaser is responsible for providing, operating, and maintaining the on-station TT&C earth stations that are used for IOT after orbit raising.

SECTION 9 -- IN-ORBIT TEST

9.1 GENERAL

The purpose of in-orbit test (IOT) is to verify that the performance of the spacecraft has not degraded during launch. For the communications payload, IOT begins after the spacecraft is on station and all deployments are complete. For the bus subsystems, IOT begins at the first acquisition of signal (AOS) following separation of the spacecraft from the launch vehicle. Bus subsystem tests will be integrated into the orbit-raising sequence of events and conducted on a noninterference basis. Bus subsystem functions that are not verified during orbit raising will be performed after station acquisition. All redundant units will be exercised to verify proper operation.

9.2 REPEATER PAYLOAD TESTING

The repeater payload will be tested using procedures similar to those for ground test. Data taken during the repeater payload IOT will be compared to the ground test data wherever possible.

9.2.1 REPEATER TRANSPONDER TESTING

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9.2.2 REPEATER ANTENNA MAPPING

*

9.3 BUS SUBSYSTEMS TESTING

Bus subsystems will be tested by activating each unit, subsystem or function by ground command and monitoring telemetry data for predicted values. Listed below are the functions/units to be tested along with a brief description of the test method to be used. Redundancy testing, will be limited to the specifically indicated tests, and will be conducted only after the spacecraft is in synchronous orbit and on station.

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*

CD RADIO DARS SYSTEM

EXHIBIT E

CD-RADIO DYNAMIC SIMULATOR SPECIFICATION

21 JULY 1998
FINAL

Prepared for
CD RADIO INC.
1180 Avenue of the Americas
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1.0 DYNAMIC SIMULATOR

Space Systems/Loral shall develop and provide an attitude dynamic spacecraft simulator for the CD-RADIO spacecraft. * The simulator shall be capable of operating with the CD Radio highly inclined elliptical orbits with periods of 24 hours; the orbits are phased 120o apart. The simulator shall be able to simulate attitude and orbit control functions of a real spacecraft in all phases of the spacecraft life including various attitude control system failures.

This simulator shall be suitable for use for validation of flight control procedures, ground station operator training for both normal operations (such as maneuvers) and contingency operations (such as loss of lock), validation of the ground station software and spacecraft command sequences, anomaly investigations, and attitude recovery training. The simulator shall be configurable to different spacecraft orbit, attitude, and subsystem initial conditions for specific operator training scenarios.

1.1 SIMULATOR GENERAL CHARACTERISTICS

The design of the simulator shall provide for the following basic elements:

- Three independent spacecraft simulators.
- A '3D' graphical display showing the orbit and attitude and antenna motions of all three spacecraft in the appropriate orbit constellations, including projected antenna transmit beams.
- The '3D' graphical display will be driven by data provided by the three spacecraft simulations.

Each of the spacecraft simulations will provide:

- Simulation start up, initialization and control via a Graphical User Interface (GUI).
- Attitude dynamics simulation with all important internal and external disturbance torques.
- Spacecraft subsystem modeling including:
  - -- Attitude determination & control with high fidelity sensor & actuator models
  - -- Four wheel system and yaw steering
  - -- Steerable antennas and pointing algorithms
  - -- Propulsion subsystem
  - -- Dynamic power with non-linear elements for solar array and batteries
  - -- Dynamic thermal model
  - -- Communications payload model
  - -- Mechanisms, including deployments
  - -- Telemetry (normal & dwell) generation and output & link modeling
  - -- Command processing
- Anomaly and failure modeling and injections
- Orbits simulation including eclipse modeling
- Command and telemetry processing
- Post simulation plotting

1.2 HERITAGE PRODUCTS

*

1.3 REAL-TIME SIMULATION COMPUTER & PERIPHERALS

Each dynamic spacecraft simulator is a real-time interactive system consisting of a single PC type computer with dual Pentium II processors running at least 400 MHz with 64 Mbytes of memory and a minimum of a 4 GB harddrive. This computer will be housed in a server style floor standing tower. The real-time simulation computer provides for high fidelity modeling of the spacecraft environment, dynamics, sensors and actuators as well as ADCS failure models. Also modeled will be the T&C subsystem and link model, orbital dynamics, the power subsystem, the thermal subsystem, and elements of the communications payload. These models will enable the user to simulate/practice all attitude and orbit control functions of a real spacecraft in all phases of the spacecraft life. These modeled elements communicate with the modeled SCE CPU via an emulated 1553b data interface as in the actual spacecraft. In addition, the operator interface is implemented on the real-time computer. The operator interface is further described in a later section.

The real-time simulation computer will have these peripheral devices:

- Standard keyboard
- Standard mouse
- 20 inch high resolution color monitor (SVGA at 1280xl024)
- A 3.5" floppy disk drive
- CD-ROM drive (8x or better)
- A cartridge disk drive of approximately 1 Gb capacity
- A laser printer/plotter with 600 dpi

1.3.1 TOP-LEVEL BLOCK DIAGRAM

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1.4 GROUND STATION INTERFACE

The real-time simulation computer will be configured to provide telemetry and command interfaces to the user ground equipment. Each of the command and telemetry interfaces can be built to communicate with the ground system via one of the following interfaces to be specified by the customer:

- Ethernet (10base-T, 100base-T, FDDI)
- RS-232
- PCM
- RS-422 / RS-485
- IEEE-488
- USB

1.5 SIMULATOR MODELING

The spacecraft simulator modeling includes the following elements:

- ADCS processor emulation
- Attitude dynamics modeling
- Propulsion subsystem
- T&C subsystem
- Orbit dynamics
- Power subsystem
- Thermal subsystem
- Communications payload
- Failure models

1.5.1 ADCS PROCESSOR EMULATION

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1.5.2 ATTITUDE DYNAMIC MODELING

*

1.5.3 PROPULSION MODEL

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1.5.4 T&C SUBSYSTEM MODEL

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1.5.5 ORBIT & EPHEMERIS MODEL

*

1.5.6 EMULATION OF THE SECOND SPACECRAFT SCE PROCESSOR

*

1.5.7 DYNAMIC POWER MODEL

*

1.5.8 DYNAMIC THERMAL MODEL

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1.5.9 PAYLOAD MODEL

*

1.5.10 FAILURE MODELS

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1.6 SIMULATOR USER INTERFACE

The simulator user interface will be implemented on the real-time simulation computer and presents the simulator operator with an easy to use menu and icon based graphical user interface. All the simulator functionality and controls are accessible through the menus. In addition, some commonly used functions are available at a button bar. This interface allows the operator to configure, monitor and control the dynamic simulator including the initiation of the various simulator failures. The user interface also provides for the management, set-up, editing and saving of multiple database sets. Spacecraft commands and telemetry display will be available from this interface. Commanding can be done as single commands, time tag- commands or commands files. There are a variety of display pages available including raw and some formatted telemetry (engineering

units), non-telemetered simulation variables (such as 'true' yaw), orbit information and event log display. It will be possible for the user to define new spacecraft data display screens that can be selected from the simulator menus. Spacecraft telemetry data and other selected nontelemetry data (such as yaw rate) can be displayed in a stripchart form. It will be possible to display more than one page at once.

1.7 POST-PROCESSING PLOTTING

Off-line plotting software will be non-real-time software that runs on the real-time simulation computer and enables screen and laser printer plotting of pre-specified simulation variables, both telemetry and nontelemetry, after a simulation run has been completed. The plot data is obtained from disk files created by a data storage task during simulation execution. It is possible for the simulation operator to select which variable to store from a large list and to select at which rate to store the selected variables with one of four rates: 16 Hz, 4 Hz, 1 Hz and .25 Hz. The data storage task can store at least five (5) days' worth of the entire spacecraft telemetry data, and selected non-telemetered variable (such as true yaw). What variables are stored for each simulation run is user selectable from a pre-set list through the user interface. The plotting interface will be an easy to use Graphical User Interface similar to the Simulator User Interface.

1.8 '3D' GRAPHICAL DISPLAY SYSTEM

This is a detailed graphical display, on a separate workstation, driven by data from the three spacecraft simulators which can show in real-time the following:

- The 3 spacecraft constellation with all three spacecraft.
- For each spacecraft the attitude and rates relative to the orbit, Earth, Sun & Moon.
- Antenna pointing for each spacecraft.
- Sun lighting effects on each spacecraft including eclipses.
- 3D Orbit geometry perspective.
- Sensor fields of view for each spacecraft.
- Vectors to the Earth, Moon & Sun for each spacecraft.
- Thruster locations and firings for each spacecraft.
- Solar array position for each spacecraft

These are shown using a 3D representational display of a fully solid rendered spacecraft model. The spacecraft can be viewed from any perspective at any time. Particularly useful views are from the Sun and from the Earth. This is very useful for visualizing the spacecraft attitude and motions during events such as loss of lock and Earth Acquisitions. Additionally the sensor fields of view can be visualized and their interactions with their targets (Earth, Sun) can be viewed. This display will be driven in real-time from the real-time simulation computer but currently cannot be driven from actual spacecraft telemetry.

1.9 DESIGN REVIEWS

There will be two formal design reviews of the dynamic simulator held at SS/L. A dynamic simulator preliminary design review and a critical design review shall be held during the design and development phases. The PDR shall cover Spacecraft Simulator Requirements Specification, the software and hardware architecture of the simulator (including input output descriptions), the simulator modeling, and the development schedule. The CDR shall provide additional detailed software modeling information and software descriptions, and test plan. Data packages associated with each review will be delivered approximately ten (10) calendar days prior to the start of the review.

1.10 SIMULATOR TEST AND VALIDATION

There will be three formal tests of the dynamic simulator conducted at a CD Radio specified site. These tests are:

1. Initial installation test which occurs after the initial simulator shipment.
2. Intermediate installation test which occurs after the first simulator software upgrade.
3. Final installation test which occurs after the second and final simulator upgrade.

These tests will be defined in an Installation Test Plan and Procedures document. A draft of this test plan will be available at PDR.

In general, the initial installation test will consist of tests of the nominal ADCS and TT&C simulator models and functions. The intermediate test will also include tests of the power functions and model as well as the simulator failure models. The final installation test will also include tests of the thermal model and fractions.

The validation of the tests will be based on several methods and sources:

- Engineering judgment
- Flight data from previous similar spacecraft (if available)
- Simulation results generated during spacecraft control system design (good for basic behavior)
- Inspection (for example many user interface requirements are validated via inspection)
- Rate table test results (good for sensor validation data)
- Bench test and closed loop test results (limited usefulness)

It is important to note that in all cases engineering judgment is required in the simulator validation process.

1.11 DOCUMENTATION

Several documents are associated with the development and delivery of the simulator. These documents are:

- The SIMULATOR SYSTEM REQUIREMENTS DOCUMENT that defines the simulator functional, performance and interface requirements. This document will be provided as part of the PDR package.
- PDR and CDR data packages
- SIMULATOR/GROUND CONTROL SYSTEM INTERFACE CONTROL DOCUMENT (ICD)
- The INSTALLATION TEST PLAN AND PROCEDURES document details how the simulator requirements are to be verified is available approximately one (1) month prior to start of installation.

The following documents will be delivered prior to simulator training.

- USER GUIDE AND MAINTENANCE MANUAL including descriptions of the simulator screens and controls, simulator physical packaging and intra-simulator interfaces with wire lists.
- SIMULATOR PRODUCT SPECIFICATION which is an 'as built' document
- Listing of the delivered databases.
- Vendor documents of any off-the-shelf hardware and software incorporated into the simulator.

1.12 DELIVERY & INSTALLATION

SS/L will deliver and install the CD-RADIO Dynamic Simulator at its CONUS TT&C facility. There will be a sequence of deliveries that includes the initial simulator delivery and two subsequent software upgrades.

1. The simulator will be shipped prior to September 1, 1999. The simulator installation, initial installation test and the simulator training will be completed within three (3) weeks of shipment. This version of the simulator is based on the build 2 of the flight firmware and will include all of the hardware deliverables and will contain initial versions of the various spacecraft subsystem models except thermal.

2. The simulator software upgrade to an intermediate version will be shipped three (3) months after the release of build 3 of the flight software. The intermediate version installation and test will be completed within three (3) weeks of the shipment. This version will include the power model and the simulator failure models.

3. The simulator software upgrade to its final version will be shipped three (3) months after the release of the final flight software. The final version installation and test will be completed within three (3) weeks of the shipment. The final version will include the thermal model.

1.13 TRAINING

A training course in the operation and maintenance of the simulator would be provided at installation site after the initial simulator installation and test. The training course will be a five (5) day course that consists of classroom and simulator hands-on instruction. The classroom instruction will utilize the following material:

- Course specific handouts
- The simulator users manual
- The spacecraft T&C list

The simulator hands-on instruction is intended to provide simulator operators with training on the basics of running the simulator at the simulator control console as well as running of a set of representative simulator scenarios. It is assumed that operators to be trained on the simulator will already be familiar with spacecraft operations and the spacecraft T&C list. This course will not provide instruction on the operation of the spacecraft itself.

1.14 WARRANTY

SS/L provides a one (1) year warranty for the dynamic simulator, except for the commercially purchased software whose warranty shall be limited to the applicable supplier furnished warranty, if any. This warranty shall start upon completion of simulator installation and test. During the warranty period, CD Radio shall provide SS/L with any simulator anomaly reports for analysis. Based on these analyses, SS/L shall correct, at its cost, any discovered deficiencies of required performance determined to be covered by this warranty provision. Repairs or replacement of simulator during this warranty period shall be at SS/L's sole discretion and may include:

- Software corrections, including modifications and validations,
- Updates of documentation and configuration item data list, or
- Generation and delivery of new software releases.

LUCENT TECHNOLOGIES / CD RADIO
RECEIVER INTEGRATED CIRCUITS AGREEMENT*

THIS AGREEMENT is made by and between Lucent Technologies Inc., a Delaware corporation, acting through its Microelectronics Group, having an office at Two Oak Way, Berkeley Heights, New Jersey 07922 ("Lucent") and CD Radio, Inc., a Delaware corporation, having its principal place of business at 2175 K Street NW, Washington, DC, 20037 ("CD Radio"). The effective date of this Agreement is the later of the dates of execution by the respective parties, as set forth below herein.

IN CONSIDERATION OF the mutual covenants set forth hereinbelow, the parties agree to the following terms and conditions:

PART 1: BUSINESS TERMS

1 BACKGROUND

This is an agreement between the Microelectronics Group of Lucent Technologies Inc. ("Lucent") and CD Radio Inc. ("CD Radio") to develop a systems engineering specification for the communications link of a Satellite Digital Audio Radio Service (S-DARS), and a specification for a set of integrated circuits ("ICs") for such a receiver ("chip set"). Upon the mutual acceptance of the chip set specification by CD Radio and Lucent, Lucent would then fabricate and deliver a prototype of the proposed receiver to verify the communications link performance and thereafter design and manufacture first prototypes and then production chip sets. The foregoing development plan is based upon Lucent's current understanding of CD Radio's needs. It is Lucent's understanding that the objective of the project is to develop a chip set for a low cost, addressable satellite receiver for CD Radio's broadcasts. The details given herein are a baseline, with further details to evolve as the project proceeds.

2 THREE PROJECT PHASES

The Lucent part of the project will be completed in three phases:

1. authorship and delivery of a systems engineering document and the development of a chip set specification;

2. fabrication and delivery of a prototype receiver using existing components from one or more integrated circuit ("IC") vendors; and

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* This agreement is subject to a confidential treatment request. The confidential portions have been omitted from this Form 10-Q and have been replaced by asterisks (*). The confidential portions have been filed separately with the Commission as provided pursuant to Rule 24b-2 under the Securities Exchange Act of 1934.

3. the design, layout, fabrication, and delivery of prototype ICs and, after approval by CD Radio, production devices for use in the consumer electronics original equipment manufacturer's ("CE-OEM's") prototypes and production units.1

Lucent's IC development would facilitate the implementation by CD Radio of four potential products:

(a) A radio including S-DARS capability for installed car sound systems. The antenna unit would be hard-wired to the rest of the receiver;

(b) A "Plug 'n' Play" ("PnP") adapter for a subscriber's tape cassette car sound system; and

(c) A PnP adapter for a subscriber's compact disk ("CD") car sound system.

(d) *

Bringing these products to market requires a division of labor between Lucent, CD Radio, and the CE-OEM. This agreement gives the roles and responsibilities of each.

In large measure, the chip sets for all four potential products are congruent and can be pursued in parallel. However, the products identified in subsections (b), (c) and (d) above require some extra effort in a few areas.

3 STATEMENT OF WORK

3.1 PHASE 1 - SYSTEMS ENGINEERING

The first task of Phase 1 shall be for Lucent and CD Radio to define and agree

on an overall system level specification.

The deliverables from the systems engineering phase are the communications link systems engineering document, chip set specification, a non-exclusive software license for a link simulator (runs slower than real time on a software platform such as SIMULINK), a link emulator (runs in real time on technical DSP hardware such as SPACE), and applicable documentation.

The documents, simulator, and emulator can be considered a prototype of a portion of the earth station transmitter. This will enable CD Radio's studio/earth station contractor to build a mission-critical version of the encoder that will connect both a) digital audio feeds from the studios/content providers and b) receiver command and control output from CD Radio's customer center to c) the satellite up-link transmitter.

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1/ There may be more than one CE-OEM. For the sake of brevity, in this Agreement we will take CE-OEM to mean "consumer electronics original equipment manufacturer(s)".

Note that the Lucent systems engineering work will not cover satellite tracking, telemetry and control, nor the studios, nor the design and positioning of terrestrial repeaters, nor the generation of receiver commands for activation, billing, and deactivation of subscriber's accounts at CD Radio's customer center.

At a minimum, the emulator will provide a baseband to baseband emulation. The extent to which actual RF up-link and space hardware can be incorporated into the emulator will depend on the level of cooperation provided by CD Radio's transmitter and satellite manufacturers.

CD Radio shall test, review, and approve the work in Phase 1. After such review and approval, Lucent shall not be responsible in the case that the communications link does not meet CD Radio's need. Upon completion of Phase 1 Lucent will provide a quotation on chip set NRE and schedule and preliminary quotation of unit price.

3.2 PHASE 2 - PROTOTYPE RECEIVER

To verify the systems engineering concepts, a prototype receiver will be built. Lucent will obtain and assemble existing parts from one or more component vendors. The prototype receiver will enable early verification of the air interface specification and receiver design, but may contain parts that are higher in cost/power/size than the chip sets in a production receiver. Lucent will make the prototype receiver available to a CE-OEM for engineering into a product at CD Radio's request. Making the prototype receiver into a product may require the CE-OEM to modify the design to lower the implementation cost and/or size and/or power. In such a case, Lucent agrees to grant a royalty-bearing, non-exclusive license, on commercially reasonable terms, to CD Radio and/or the CE-OEM under any issued patent owned by Lucent (to the extent Lucent has a right to grant such license) which is infringed by such design. No further payment by CD Radio is necessary if such patent rights are already exhausted in the sale by Lucent to CD Radio and/or the CE-OEM of a Lucent integrated circuit. Such a patent license will be limited to the specific field of use in which the Lucent integrated circuits are intended to be used, namely CD Radio's satellite digital audio broadcasting service and its associated terrestrial repeaters. Specifically, the license will forbid the use of such patents in the field of wholly terrestrial broadcasting.

CD Radio and its CE-OEM shall test, review, and approve the work in Phase 2. After such review and approval, Lucent shall not be responsible in the case that the communications link does not meet CD Radio's need.

After approval, the chip set design will proceed to Phase 3, as detailed below.

3.3 PHASES 1 AND 2 - PAYMENT SCHEDULE

Lucent will perform these two phases and charge CD Radio quarterly on a time and materials basis. CD Radio approves a charge for such time and materials up a maximum of $1,300,000, payable to Lucent:

On signing of this Agreement *;

On completion of Phase 1 *; and

On completion of Phase 2 *.

Any funds not charged shall be refunded to CD Radio at the conclusion of Phase 2. If completion of Phases 1 and 2 exceeds this budget, Lucent will seek further approval from CD Radio. Such approval shall be sought as soon as Lucent becomes aware of any need for additional funds.

3.4 IC DEVELOPMENT AND PROTOTYPE PRODUCTION

The development work for Phase 3 will be performed by Lucent and charged to CD Radio quarterly on a time and materials basis. The below stated fees are for the design and development of the integrated circuit chip set and for 1,000 pre-production chip sets. These preliminary target design and development fees are based on our current understanding of the project. They may change once Phases 1 and 2 are completed.

Non-recurring engineering fees due total $8,000,000, triggered by pre-production milestones detailed below. The fee cover both the engineering work and 1000 pre-production chip sets.

MILESTONE	PAYMENT DUE
Go Ahead for Phase 3	*
Design Inspection 1	*
Design Inspection 2	*
Firmware Sign-off	*
Prototype ICs	*
Deliver 1000 pre-production chip sets	*
TOTAL NRE FEES	$8,000,000

Any funds not charged shall be refunded to CD Radio at the conclusion of each milestone. If completion of Phase 3 exceeds this budget, Lucent will seek further approval from CD Radio. Such approval shall be sought as soon as Lucent becomes aware of any need for additional funds.

3.5 DESIGN HAND-OFF REQUIREMENTS

CD Radio shall review Phase 3 of the project at Design Inspection 1, Design Inspection 2, and Firmware Sign-off meetings. Review and approval by CD Radio at these three points plus signature of the post-layout mask sign off sheet (including prototype IC acceptance criteria) shall constitute the Design Hand-Off Requirements mentioned below in Part 3 of this Agreement.

3.6 PRODUCTION IC PRICING

Definitive production IC pricing is unknown at this time. However, Lucent believes it is commercially reasonable to achieve CD Radio's objective of not more than a $50 selling price per chip set, based on the information available today. At or before the completion of Phase 2, Lucent and CD Radio will establish a definitive pricing plan for commercially produced quantities of the chip set, based on the method outlined in Part 3, Section 12. Based on the outcome of this pricing plan, the period of exclusivity outlined in Section 6.0 will be determined.

CD Radio intends to use the jointly owned chip specification to seek competitive bids on the chip set and to use any responses for the purposes of comparison with the price based on the method outlined in Part 3, Section 12.

4 ENGINEERING RISK

Lucent shall not be held liable by CD Radio or its subsidiaries, affiliates, OEM suppliers, subcontractors and customers, nor by any of their officers, shareholders, employees, representatives, agents, attorneys and any other such persons if the engineering objectives involved in this project are not met, so long as Lucent's engineering work has been performed in a professional manner in accordance with generally understood industry standards.

5 SCHEDULE

A chip development project would normally commence after Phases 1 and 2 are complete, namely after Feb 28th, 1999. In previous projects such an effort takes between * and * months to deliver IC prototypes, depending on complexity and how well matched the project is to existing Lucent macrocells. Assuming * months is realistic, this means that IC prototypes would be available *.

In this case, given the need of CD Radio to meet its service launch date of Dec 1st, 1999, Lucent will attempt an accelerated schedule, where several methods are explored to make receivers available earlier than would normally be the case.

The methods, to be explored in parallel, are:

1) Assess the practicality of the CE-OEM making the receiver prototype developed in Phase 2 into a product for a Dec 1st, 1999 service launch.

2) Accelerate Phases 1 and 2 to complete them by Jun 15th 1998 and Jan 15th 1999, respectively.

3) Accelerate Phase 3 to 10 months from 15 months

4) Commence some Phase 3 tasks in parallel with Phases 1 and 2. This shortens the part of the chip set development that occurs after completion of Phases 1 and 2. The part of Phase 3 that has to occur after Phases 1 and 2 is a minimum of 8 months.

If all four methods are successful, CD Radio would have receivers based on the Phase 2 prototypes for its Dec 1st, 1999 service launch, and prototype ICs for a low cost Phase 3 receiver delivered to the CE-OEM for system integration Sep 15th, 1999. However, no assurances can be given by Lucent that these methods will be successful in meeting these dates.

6 ONE WAY EXCLUSIVITY AND GUARANTEED MINIMUM PURCHASE

CD Radio and its CE-OEM shall make Lucent their exclusive supplier of CD Radio's S-DARS receiver chip sets, for a limited period, as described below.

Nothing in this Agreement prevents Lucent from supplying the same or similar chips incorporating any of CD Radio's IPRs to any other of its present or future customers, including but not limited to CD Radio's competitor(s), so long as such customers have a license agreement with CD Radio and any applicable royalty is paid to CD Radio (as discussed under Intellectual Property below). Use of existing CD Radio IPR by Lucent in serving non-CD Radio customers in the S-DARS application area is contingent on CD Radio deciding to license any such IPR as may be used in such ICs. Use of existing CD Radio IPR by Lucent in serving the designated CE-OEM is hereby granted royalty free during the exclusivity period described below. Use of existing CD Radio IPR by Lucent in serving any CD Radio customers after the exclusivity period has ended is hereby granted royalty free.

The exclusivity arrangement shall be defined by the table below. The pricing in the table does not constitute a quote. The start date shall be the date CD Radio commences commercial operations, specifically, the date that the 1,000th receiver built from the production chip sets is sold.

Initial Production Unit Selling Price	Exclusivity period (months)
*	*
*	*
*	*
*	*
*	*
*	*

CD Radio may cancel the exclusivity arrangement if Lucent fails to deliver to orders prototype ICs within fifteen (15) months from the date of the go ahead payment for Phase 3.

Thereafter, CD Radio may cancel any exclusivity remaining if Lucent fails to deliver on orders a minimum of one (1) million production chip sets during the twelve (12) months following the start date, with a minimum of 75,000 in any given month.

Thereafter, CD Radio may cancel any exclusivity remaining if Lucent fails to deliver on orders a minimum of 450,000 chip sets in any given month.

Notwithstanding the above three (3) paragraphs, CD Radio shall not have the right to cancel the exclusivity arrangement if Lucent halts delivery due to non-payment of Lucent invoices for previously delivered services or products relating to this project. Furthermore, the purchase orders shall be placed with due consideration for Lucent's fabrication logistics and manufacturing lead time as agreed prior to the commencement of Phase 3.

If CD Radio or the CE-OEM does not order and pay for a minimum of 1,000,000 delivered chip sets within the exclusivity period, CD Radio will compensate Lucent in the amount of $2,000,000 minus $2 per chip set actually ordered, delivered and paid for.

7 TERMINATION FOR CONVENIENCE

Either party may terminate this Agreement without cause upon six (6) months written notice to the other party. Upon termination of this Agreement without cause, neither party shall be liable to the other, either for compensation or for damages of any kind or character whatsoever, whether on account of the loss by Lucent or CD Radio of present or prospective profits on sales or anticipated sales, or expenditures, investments or commitments made in connection therewith, or on account of any other cause or thing whatsoever, except that termination shall not prejudice or otherwise affect the rights or liabilities of the parties with respect to any indebtedness then owing by either party to the other.

8 CONSUMER ELECTRONICS ORIGINAL EQUIPMENT MANUFACTURER (CE-OEM)

CD Radio shall delegate to the CE-OEM the following roles and responsibilities:

- printed circuit board design;
- specification, procurement and integration of:
- discrete active components, such as transistors, diodes, varactors, light emitting diodes etc.;
- passive components such as resistors, capacitors, inductors, filters, crystal oscillators etc.;
- keypad and display;
- antennae;

- commodity ICs such as memories, CD transmitter, FM transmitter, and power ICs; and
- power supply and power supply management including any solar cells, batteries, battery management, capstan generators, smoothing and voltage regulation;
- field testing in a variety of vehicles and under a variety of conditions;
- mechanical engineering;
- electromagnetic interference and compatibility, and shielding;
- audio coupling to a tape head, or FM band transmitter, signal generator for input to a subscriber's CD car sound system;
- making the product suitable for use by the majority of consumers, including:
- user interface hardware and firmware;
- ease of installation, set up and use; and
- consumer information booklet;
- micro-controller unit (MCU) and digital signal processor (DSP) firmware development and integration;
- packaging, marketing and selling of receivers; and
- handling of receivers returned by consumers, if any.
- CD Radio shall oversee the CE-OEM and monitor its performance.

PART 2: TERMS AND CONDITIONS APPLYING TO PHASES ONE AND TWO PURSUANT TO THIS AGREEMENT

1 BINDING EFFECT

This Agreement is comprised of Parts 1, 2, and 3. The terms set forth in Parts 1 and 2 shall govern Phases 1 and 2, while the terms set forth in Parts 1 and 3 (as Part 3 may be amended by the parties before initiation of Phase 3) shall govern Phase 3, if Phase 3 is initiated by CD Radio in its sole discretion. In either case, Part 1 is incorporated by reference and the terms set forth in Part 1 shall prevail in the event of any conflict.

2 CONFIDENTIALITY

2.1 All information furnished or disclosed by one disclosing party to the other receiving party which is marked with a restrictive notice or otherwise tangibly designated as proprietary (hereinafter "Information") shall be deemed the property of the disclosing party and shall be returned to the disclosing party upon request. Unless such Information: (a) was previously known to the receiving party free of any obligation to keep it confidential, or (b) has been or is subsequently made public by the disclosing party or a third party under no obligation of confidentiality, or c) is independently developed by the receiving party, then the receiving party shall, for a period ending three (3) years after the conclusion of this Agreement, use the same degree of care, but no less than a reasonable standard of care, as it uses with regard to its own proprietary information to prevent disclosure, use or publication thereof. Except as set forth in section 2.2 below, information furnished hereunder may be used by either party only for performance under this Agreement and may be used for other purposes only upon such terms and conditions as may be mutually agreed upon in writing.

2.2 Neither party shall disclose any of the terms and conditions of this Agreement without the prior written consent of the other party. Notwithstanding the foregoing, Lucent agrees that CD Radio may disclose a summary of the material terms and conditions of this agreement in its reports, registration statements and other documents required to be filed with the Securities and Exchange Commission and as otherwise may be required by the rules and regulations of the SEC or any other applicable regulatory agencies. To the extent practicable, CD Radio will afford Lucent a reasonable opportunity to review and comment on any such public disclosure prior thereto and shall consider in good faith any proposed modification of such disclosure suggested in writing by Lucent a reasonable period of time prior to the time public disclosure is required to be made by CD radio. At the request of Lucent, CD Radio will apply for confidential treatment of any portions of this Agreement which Lucent designates as being a "trade secret" within the meaning of the Freedom of Information Act and will diligently pursue obtaining an exemption from any such disclosure requirements.

2.3 The parties agree that their obligations under this Section 2.0 shall survive and continue after any termination of this Agreement.

3 OWNERSHIP OF INTELLECTUAL PROPERTY

3.1 All intellectual property developed or created prior to the effective date of this Agreement ("Existing Intellectual Property") is and shall remain the property of the party who made, developed or created or presently owns such Existing Intellectual Property and, unless otherwise expressed in this Agreement, no license is implied or granted herein to any Existing Intellectual Property by virtue of this Agreement. The parties acknowledge and agree that, as between them, any new intellectual property that is jointly developed or created during Phases 1 and 2 and after the effective date of this Agreement ("New Intellectual Property") shall be the joint property of the parties and each party shall be free to use and exploit such jointly owned New Intellectual Property without accounting in any way to the other party. In particular, the systems engineering documents and the chip set specification jointly developed under Phases 1 and 2 will be jointly owned by Lucent and CD Radio.

3.2 The IPR in the software simulator and emulator, and the prototype receiver developed in Phases 1 and 2 will be solely owned by Lucent, but CD Radio shall be granted a royalty-free license to use such software simulator, emulator and prototype in the course of development of CD Radio's S-DARS.

4 TERMINATION OR CHANGE

CD Radio shall not terminate, suspend performance, reschedule or cancel any work undertaken hereunder, in whole or in part, without Lucent's prior written consent, which consent shall not be unreasonably withheld, and upon terms that will compensate Lucent for any loss or damage resulting from such action.

5 LICENSES AND RIGHTS

No title or other ownership rights in any licensed products or any copies thereof shall pass to CD Radio by virtue of any performance hereunder. CD Radio agrees that it will not alter any notices on, prepare derivative works based on, or reproduce, reverse engineer, disassemble or de-compile any software embodied in licensed products or recorded in the purchased products furnished hereunder.

6 TERMS OF PAYMENT

CD Radio shall pay any amounts invoiced pursuant to the schedule and amounts set forth in Part 1 pertaining to Phases 1 and 2 within thirty (30) days from the date of Lucent's invoice. Delinquent payments are subject to an interest charge at the rate of one and one-half percent (1 1/2%) per month, or portion thereof (but not to exceed the maximum lawful rate).

7 TAXES

Any tax or related charge that Lucent shall be required to pay to or collect for any government upon or with respect to services rendered hereunder shall be billed to CD

Radio as a separate item and paid by CD Radio, unless a valid exemption certificate is furnished by CD Radio to Lucent.

8 EXPORT CONTROL

CD Radio acknowledges that technical information transmitted in connection herewith may be subject to export restrictions under applicable law, including the U.S. Department of Commerce Export Administration Regulations ("Regulations"), and CD Radio agrees to comply fully with same. CD Radio assures Lucent that it will not transmit, sell, transfer or convey any products, technical information or software, or goods produced through the use of same, to

any country, or citizen or resident of a country, other than the United States without first securing the written consent, if required, of the U.S. Department of Commerce.

9 LIMITATION OF LIABILITY

NOTWITHSTANDING ANY OTHER PROVISION HEREOF, EXCEPT AS MAY ARISE OUT OF INTENTIONAL MISCONDUCT OR GROSS NEGLIGENCE, LUCENT SHALL NOT BE LIABLE FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES OR FOR LOST PROFITS, SAVINGS OR REVENUES OF ANY KIND, WHETHER OR NOT LUCENT HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THIS PROVISION SHALL SURVIVE FAILURE OF AN EXCLUSIVE REMEDY.

10 ASSIGNMENT

Except to any entity that succeeds it as the result of a strategic merger, acquisition, or other corporate reorganization, CD Radio shall not assign this Agreement or any rights or obligations hereunder without the prior written consent of Lucent, which shall not be unreasonably withheld. Any such attempted assignment without Lucent's consent shall be void and ineffective.

11 NON-WAIVER

No course of dealing or failure of either party to strictly enforce any term, right or condition of this Agreement shall be construed as a waiver of such term, right or condition. If these terms and conditions conflict with terms and conditions of a purchase order or procurement document issued by CD Radio, the terms and conditions contained herein shall govern. Lucent's acceptance of CD Radio's order is conditioned upon CD Radio's acceptance of these terms and conditions in writing. Lucent's failure to object to provisions contained in any communication from CD Radio shall not be deemed a waiver of the provisions herein.

12 NO POWER TO BIND LUCENT TECHNOLOGIES

CD Radio specifically assures Lucent that it will not extend, directly or indirectly, any warranty or representation in the name of Lucent or purport to bind Lucent in any way.

13 TERMINATION FOR CAUSE

13.1 Either party may initiate termination of this Agreement for cause by giving to the other party sixty (60) days prior written notice specifying the reason for termination, which termination shall occur unless such reason for termination is cured within such sixty (60) day period. A right to terminate under this section shall arise upon the happening of any of the following events:

13.1.1 a party becomes the subject of a bankruptcy petition filed in a court in any jurisdiction, whether voluntary or involuntary; or

13.1.2 a receiver or a trustee is appointed for all or a substantial portion of a party's assets; or

13.1.3 a party makes an assignment for the benefit of its creditors; or

13.2 a party fails to perform substantially any material covenant, obligation, representation or warranty under this Agreement including but not limited to the timely payment of any fees or other charges specified under this Agreement.

14 USE OF TRADEMARKS

The parties recognize each other's rights in their respective trademarks, service marks, trade names and logos. Except as permitted by United States trademark law and except as expressly provided herein, nothing in this Agreement shall imply the grant by one party to the other of a license to use (i) any trademark, service mark, trade name or logo of that party or any of its affiliates in connection with advertising, licensing, marketing or any other use, or (ii) any trademark, service mark, trade name or logo that is confusingly similar to a name or mark used by that party or any of its affiliates.

15 FORCE MAJEURE

Except with respect to CD Radio's obligation to make timely payments when due, neither party shall be held responsible for any delay or failure in performance of any part of this Agreement to the extent such delay or failure is caused by fire, flood, explosion, war, strike, embargo, government requirement, civil or military authority, act of God, nature or the public enemy, inability to secure material or transportation facilities, act or omission of carriers or any other causes beyond its reasonable control.

16 CHOICE OF LAW

The construction, interpretation and performance of this Agreement shall be governed by the substantive laws, but not the conflicts of law, of the State of New York. The U.N. Convention on Contracts for the International Sales of Goods shall not apply hereto.

17 NOTICES

Unless otherwise provided, any notice required or permitted hereunder shall be given in writing and shall be deemed effectively given upon: (i) personal delivery to the party to be notified; (ii) seven (7) days after deposit in the mail, by registered or certified mail, postage prepaid, return receipt requested, (iii) on the day following facsimile transmission, with confirmed transmission; or (iv) on the second day following deposit with a reputable overnight courier service, in any case addressed to the party to be notified at the address indicated for such party on the first page hereof, or at such other address as such party may designate by ten (10) days' advance written notice to the other party.

18 PARTIAL INVALIDITY

If any paragraph, provision, or clause thereof in this Agreement shall be found or be held to be invalid or unenforceable in any jurisdiction in which this Agreement is being performed, the remainder of this Agreement shall be valid and enforceable and the parties shall negotiate, in good faith, a substitute, valid and enforceable provision which most nearly effects the parties' intent in entering into this Agreement.

19 COUNTERPARTS

This Agreement may be executed in two or more counterparts, all of which, taken together, shall be regarded as one and the same instrument.

20 SECTION HEADINGS

The section headings contained in this Agreement are for reference purposes only and shall not affect in any way the meaning or interpretation of this Agreement.

21 RELATIONSHIP OF PARTIES

The parties to this Agreement are independent contractors. There is no relationship of agency, partnership, joint venture, employment or franchise between the parties. Neither party has the authority to bind the other or to incur any obligation on its behalf.

22 DISPUTE RESOLUTION

22.1 If a dispute arises out of or relates to this Agreement, or its breach, and if such dispute cannot be settled through good faith negotiations within thirty (30) days, the parties agree to submit the dispute to a sole mediator selected by the parties or, at

any time at the option of a party, to mediation by a mediator selected by the American Arbitration Association ("AAA"). The parties agree to make good faith efforts to resolve disputes by mediation within thirty (30) days. If not thus resolved, it shall be referred to a sole arbitrator selected by the parties within thirty (30) days of the mediation, or in the absence of such selection, to AAA arbitration which shall be governed by the United States Arbitration Act. The mediator or arbitrator selected by the parties shall be knowledgeable in the law and technology and the rules and regulations of the AAA. Such mediation or arbitration shall be non-binding on the parties. In the event such dispute is not resolved either by mediation or arbitration, then either party may initiate suit in the federal or state courts in the State of New York.

22.2 The mediation or arbitration, if any, shall be held in New York City. The requirement for mediation or arbitration shall not be deemed a waiver of any right of termination under this Agreement and the mediator or arbitrator is not empowered to act or make any award other than based solely on the rights and obligations of the parties prior to any such termination.

22.3 The mediator or arbitrator may not limit, expand or otherwise modify the terms of this Agreement.

22.4 Each party shall bear its own expenses but those related to the compensation and expenses of the mediator or arbitrator shall be borne equally.

22.5 The mediator or arbitrator shall not have authority to award punitive, exemplary or other damages in excess of compensatory damages and each party irrevocably waives any claim thereto. The award shall be made within two (2) months after selection of the mediator or arbitrator and may be entered in

any court.

22.6 The parties, their representatives, other participants and the mediator and arbitrator shall hold the existence, content and result of mediation or arbitration in confidence.

23 ENTIRE AGREEMENT

Except for any written agreement between the parties relating to confidentiality of proprietary information, the terms and conditions contained in this Agreement supersede all prior oral or written understandings between the parties and

shall constitute the entire Agreement between the parties with respect to the subject matter of this Agreement. This Agreement shall not be modified or amended except by a writing signed by CD Radio and Lucent.

LUCENT TECHNOLOGIES INC.	CD RADIO INC.
- ----------	----------
(Signature)	(Signature)
- ----------	----------
(Name Printed)	(Name Printed)
- ----------	----------
(Title Printed)	(Title Printed)
- ----------	----------
(Date)	(Date)

PART 3: TERMS AND CONDITIONS APPLYING TO PHASE THREE PRODUCTION PURSUANT TO THIS AGREEMENT

1 AGREEMENT

This Agreement, effective as of the date of latest execution by a party hereto shown hereon, applies to one or more products (hereinafter "Device(s)") that are identified in Lucent's Business Terms to which these terms and conditions are attached and any additional Agreement that references this Agreement, (hereinafter "Agreement"). As used herein, "Agreement" refers to these terms and conditions and those parts of Part 1: Business Terms (the "Business Terms") that refer to Phase 3 of the project. This Agreement, together with the Business Terms, supersedes all prior oral or written understandings between the parties, and constitutes the entire agreement between the parties, with respect to all transactions relating to the subject matter of the Business Terms. In the event of a conflict between the applicable Business Terms and these terms and conditions, the terms and conditions of the Business Terms shall prevail. Additional or differing terms appearing on any purchase order or other procurement document do not apply. This Agreement may not be modified or amended except by a writing signed by both parties.

2 CHANGE OF BUSINESS TERMS

Proposed prices, fees and charges are valid only for the parameters or other particulars relating to the Device as stated in the Business Terms. If any changes in such parameters or particulars become necessary, including but not limited to revision or redefinition of the specification or variations in quantities, functional description, package type, or testing requirements, upon mutual agreement the parties may revise such prices by amendment to the Business Terms. Other proposed fees and charges are valid only for the respective particulars stated in the Business Terms. The parties may also amend the Business Terms with respect to any of such indicated fees and charges to make adjustments for changes in CD Radio's requirements. Any such amendments to the Business Terms shall reference the Business Terms and shall be further identified by their respective dates and shall be signed by both parties.

3 PROTOTYPE IC APPROVAL

Within ninety (90) days after receipt of prototype ICs for any Device covered by this Agreement, CD Radio may return any claimed non-conforming prototype ICs to Lucent with a written rejection statement specifying the alleged failure or failures of the prototype ICs to meet the acceptance criteria as provided in the mask order sign off sheet or mutually agreed modifications thereof (the "Acceptance Criteria"). If CD Radio does not return the prototype ICs with a written rejection statement within such ninety (90) day period, then the design and prototype ICs shall be deemed to have been approved by CD Radio and development work shall be deemed to have been completed by Lucent.

If any prototype IC does not meet the Acceptance Criteria and is rejected by CD Radio, Lucent shall use commercially reasonable efforts to replace it with one which does comply with the Acceptance Criteria. Lucent shall not, however, be obligated to replace any non-complying prototype ICs of which it has not been notified within ninety (90) days of shipment of same to CD Radio. If Lucent, within ninety (90) days after receipt of CD Radio's timely written rejection report, is unable to supply CD Radio with conforming prototype ICs, then either party may by written notice to the other terminate this Agreement as to such Device. Provided CD Radio has fulfilled all "Design Hand-Off Requirements," as defined in the Business Terms, if so terminated, unless otherwise provided in the Business Terms, all moneys paid by CD Radio to Lucent with respect to such Device will be refunded in full within thirty (30) days. Such refund of moneys shall be CD Radio's sole and exclusive remedy and Lucent's entire liability with respect to non-conforming prototype ICs.

In the event that delivered prototype ICs comply with the Acceptance Criteria, but do not function in CD Radio's application (e.g., logic design error, change in required function, etc., not attributable to Lucent), CD Radio shall pay all charges incurred for the development of the Device and then CD Radio and Lucent may negotiate a mutually agreeable redesign schedule and price.

4 ORDERS

No order for production quantities of the Device shall be placed by CD Radio or accepted by Lucent unless and until CD Radio has approved the prototype ICs for the Device, paid all fees then due under the Business Terms and made any other payments due to Lucent under any order based on this Agreement. All orders for the design of the Device, for changes, for technical assistance, for production quantities of the Device or for any other service by Lucent relating to this Agreement shall be in writing, shall reference the Business Terms by its number and date and any current amendments thereto by their respective dates, and shall be signed by CD Radio. Lucent shall acknowledge all orders in writing.

5 RESCHEDULING OF ORDERS

CD Radio may reschedule an order pursuant to the following schedule:

Days.....Time between date of reschedule request and current factory promise date.

DAYS	RESCHEDULE
Within 30 days (0-30)	No rescheduling
31 days to lead-time	One time reschedule by up to 90 days beyond factory promised date is permitted with no further reschedule or cancellation.
Beyond lead-time	Reschedules and cancellations without limits.

PULL-IN WITHIN AGREED DELIVERY DATE

CD Radio request date ("RD") may be pulled in as desired by CD Radio.

Lucent will make reasonable efforts to meet the new RD.

If improvement of the acknowledged date is possible, a new acknowledged date will be issued.

If improvement cannot be made, the current acknowledged date will be retained; in all cases, the requested pull-in date will be maintained with the order history in the event an improvement can be made at a later date.

6 CANCELLATION OF ORDERS

Should CD Radio cancel any order which has been acknowledged and a shipping date assigned, either in whole or in part, such cancellation shall be upon terms and conditions that will compensate Lucent for any loss or damage resulting from such cancellation. Notwithstanding the foregoing, Lucent shall use its best efforts to mitigate any loss or damage resulting from such cancellation. Lucent shall not be obligated to permit a cancellation if a reschedule has been previously negotiated at CD Radio's request.

Compensation by CD Radio for production quantities of the Device shall be according to the following schedule:

Days.....Time between date of cancellation and current factory promise date.

Liability.....Liability is the percentage of aggregate purchase price of the canceled portion of the order.

DAYS	PERCENT OF LIABILITY

0 to lead-time	100
Greater than lead-time	0

7 WARRANTY

Lucent warrants the Device as a production item ("Item"), but not related services or prototypes of any such Items, to be free from defects in material and workmanship and to be in conformance with the written specification contained in the Business Terms and amendments thereto, if any, and referenced in an order by CD Radio. With respect to prototype ICs, Lucent shall use commercially reasonable efforts to ensure freedom from defects and conformity with written specifications, if any. If any defect in material or workmanship or failure to conform to such specification ("Defect") is suspected in any such Items, CD Radio, after obtaining a Returned Material Authorization Number from Lucent, shall ship suspected defective samples of the Items to Lucent, following Lucent's instructions regarding the return. No product will be accepted for repair, replacement, credit or refund without the written

authorization of and in accordance with Lucent's instructions, which authorization and instructions shall not be unreasonably withheld or delayed. Lucent shall analyze the failures, making use, when appropriate, of technical information provided by CD Radio relating to the circumstances surrounding the failures. Lucent will verify whether any Defect appears in the Items. If Lucent determines that the returned products are not defective, CD Radio may seek evaluation by a competent and disinterested third party approved by Lucent (which approval shall not be unreasonably withheld). If such third party determines that the returned products are not defective, CD Radio shall pay Lucent all costs of handling, inspection, repairs and transportation at Lucent's then prevailing rates. Lucent shall, at Lucent's option, either credit or refund the purchase price or repair or replace the defective product with the same or equivalent product without charge at Lucent's manufacturing or repair facility provided: (i) CD Radio notifies Lucent in writing of the claimed Defect within thirty (30) days after CD Radio knows or reasonably should know of the claimed Defect and (ii) Lucent's and/or the disinterested third party's examination of the Items discloses that the claimed Defect actually exists. In the event of a replacement, Lucent shall ship the replacing Items FOB point of origin, freight prepaid to CD Radio's destination. Any replaced Item shall become Lucent's property. The method of disposition of any replaced Items will be as mutually agreed by both parties in writing. Lucent shall not be responsible for de-installation or reinstallation of any Item or for the expenses thereof. Repairs and replacements covered by the above warranty are warranted to be free from defects as set forth above. Inspection and acceptance of Items by CD Radio and/or payment therefor shall not relieve Lucent of responsibilities hereunder.

The above warranty does not apply to, and Lucent makes no warranties with respect to products that: are software programs (except for software programs Lucent developed and incorporated into the Device), experimental products or prototypes (all of which are provided "AS IS") or to Items which have been subjected to misuse, neglect, accident or abuse or operating or environmental conditions that materially deviate from the parameters established in applicable specifications; or have been improperly installed, stored, maintained, repaired or altered by anyone other than Lucent; or have had their serial numbers or month and year of manufacture or shipment removed, defaced or altered. This warranty does not extend to any system into which a Device is incorporated. This warranty applies only to CD Radio and its successors and may not be assigned or extended by CD Radio to any of its customers or other users of the Items. Lucent will not accept returns from CD Radio's customers or users of CD Radio's products.

EXCEPT AS STATED IN THE SECTION ENTITLED WARRANTY, LUCENT, ITS SUBSIDIARIES AND AFFILIATES, SUBCONTRACTORS AND SUPPLIERS MAKE NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIM ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CD RADIO'S SOLE AND EXCLUSIVE REMEDY SHALL BE LUCENT'S OBLIGATION TO REPAIR OR REPLACE OR CREDIT OR REFUND AS SET FORTH ABOVE.

8 PROPRIETARY RIGHTS IN TECHNICAL INFORMATION

Unless otherwise agreed in writing, CD Radio-supplied design information relating to the Device, as incorporated in circuit design information, test vectors, test tapes, and special requirements specifications shall remain the property of CD Radio. CD Radio hereby authorizes Lucent to use such information and results solely and exclusively for the design, manufacture and sale of the Device to CD Radio and in providing related production services. The systems engineering documents and the chip set specification jointly developed under Phases 1 and 2 will be jointly owned by Lucent and CD Radio. Lucent retains all ownership rights in Lucent's processing information, mask works, mask sets, macro cells, and the like used in design, production or in filling orders placed by CD Radio hereunder. CD Radio has no rights in or to such processing information, mask works, mask sets, macro cells, and the like.

If and to the extent CD Radio in its sole discretion, during the term of this

Agreement, reaches any agreement with a third party to license intellectual property rights that are solely CD Radio's in the field of digital broadcasting, it shall either: (a) negotiate with Lucent the grant of a non-exclusive license to such intellectual property rights (with royalty terms dependent on the agreement reached with the third party or parties) or (b) provide in such third-party license (or licenses) for the grant of a sublicense (with the terms of the sublicense to be as set forth in the third-party license or exhibit thereto), in both cases for the purpose of permitting Lucent to make, have made, use, lease, sell and import chip sets and receivers for the purposes of commercializing digital broadcasting. In either case (license or sublicense), Lucent shall be limited to supplying such Devices only to authorized CD Radio licensees.

IPR developed by Lucent under Phase 3, as detailed herein, will be owned exclusively by Lucent.

9 INTELLECTUAL PROPERTY INDEMNITY

Lucent will indemnify and hold harmless CD Radio from and against any claim by a third party against CD Radio alleging that any Device furnished under this Agreement directly infringes any patent, copyright or trademark of such third party. Lucent shall have the obligation, at its own expense, to defend or settle all such claims, subject to CD Radio's reasonable participation, at its own expense, in the conduct of any such proceeding or settlement. Lucent shall reimburse CD Radio for any costs incurred at Lucent's written request relating to such claim and shall pay damages and costs assessed by final judgment against CD Radio, or resulting from settlement, and attributable to such claim.

In addition, Lucent will have the right, at any time and at its option and expense to: (i) procure for CD Radio the right to continue using such Device; (ii) replace or modify any such Device provided or to be provided to render it free of the infringement, while maintaining equivalent functionality and complete compatibility

with CD Radio's products; or (iii) require return of such Device and refund the purchase price.

Lucent's obligations hereunder are conditioned upon: (i) CD Radio giving Lucent written notice within thirty (30) days of any such claim asserted against it; (ii) Lucent having complete control of the defense and settlement thereof, subject to CD Radio's reasonable participation and consent (in the case of settlement or litigation decisions affecting CD Radio); (iii) CD Radio cooperating fully with Lucent, at Lucent's expense, to facilitate the defense or settlement of such claim; and (iv) CD Radio's substantial compliance with the material terms of this Agreement.

Notwithstanding the foregoing, Lucent shall have no obligation to defend or settle any claim, and CD Radio shall indemnify and save harmless Lucent and its suppliers and affiliated companies from all costs, expenses, liabilities and claims, for any such claim: (i) arising from Lucent's compliance with CD Radio's specifications, designs or instructions; or (ii) relating to any Device furnished hereunder in combination with item(s), whether or not furnished by Lucent, even if such combination results from the Device's necessary or inherent use or the use for which the device is purchased.

The sale of any Device by Lucent shall not in any way confer upon CD Radio, or upon anyone claiming under CD Radio, any license (expressly, by implication, by estoppel or otherwise) under any patent claim of Lucent or others covering or relating to any combination, machine or process in which such Device is or might be used, or to any process or method of making such Device.

THE FOREGOING STATES THE SOLE AND EXCLUSIVE REMEDY AND OBLIGATION OF THE PARTIES HERETO FOR INFRINGEMENT OR OTHER VIOLATION OF ANY INTELLECTUAL PROPERTY RIGHTS ARISING OUT OF THIS AGREEMENT AND IS IN LIEU OF ALL WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, IN REGARD THERETO.

10 NONDISCLOSURE

During performance of this Agreement, the parties may disclose or furnish to each other proprietary marketing, technical, or business information, including, without limitation, products and/or software ("information"), relating to the subject of this Agreement.

Information provided in tangible form shall be clearly marked as proprietary. With respect to any devices, any technical information, including but not limited to circuit layout, design, or software, embedded in any such device is proprietary information notwithstanding the absence of any proprietary marking on such device. Information provided orally will be considered proprietary, if the disclosing party says it is proprietary at the time of oral disclosure and summarizes it in a proprietary writing provided to the other party within 20 (twenty) days of the oral disclosure.

The receiving party shall: (a) hold information in confidence using the same degree of care as it normally exercises to protect its own proprietary information; (b) restrict disclosure and use of information to employees (including any contractors or consultants) with a need-to-know, and not disclose it to any other parties; (c) advise those employees, contractors and consultants of their obligations with respect to the information; (d) not copy, duplicate, reverse engineer or decompile information; (e) use the information only in furtherance of performance under this Agreement; and (f) upon expiration or termination of this Agreement, return all information to the disclosing party or at the request of the disclosing party, destroy such information.

The receiving party shall have no obligation to keep confidential information that: (a) was previously known to it free of any confidentiality obligation; (b) was independently developed by it; (c) is or becomes publicly available other than by unauthorized disclosure; (d) is disclosed to third parties by the disclosing party without restriction; or (e) is received from a third party without violation of any confidentiality obligation.

If a party is faced with legal action or a requirement under government regulations to disclose or make available proprietary information received hereunder, such party shall forthwith notify the furnishing party and, upon request of the latter, cooperate in contesting such action or requirement at the requesting party's expense. Neither party shall be liable for damages for any disclosure or unauthorized access pursuant to legal action or government regulations or for inadvertent disclosure, access, or use if the customary degree of care as it uses with respect to its own proprietary information has been exercised and if, upon discovery of such inadvertent disclosure, access, or use the furnishing or receiving party has endeavored to prevent any further (inadvertent or otherwise) disclosure or use.

Obligations imposed by this Section 10 shall survive for a period of five (5) years after termination or expiration of this Agreement.

11 TERM OF AGREEMENT

The term of this Agreement as related to any specific Device covered by this Agreement shall expire at the end of the purchase period specified in the Business Terms and any agreed extensions thereto. Lucent reserves the right to discontinue the supply of any Device(s) hereunder, subject to providing CD Radio six (6) months written notice of discontinuation, during which period CD Radio may place orders for reasonable quantities calling for delivery within lead-time of the Device, and subject to the immediate termination of the exclusivity period provided for in Part 1, if such period has not already concluded.

12 PRICE AND PAYMENT TERMS

Lucent and CD Radio will collect market price data on ICs with comparable functions and volumes to the ICs in the chip set, for example, ICs used in IS-95 cellular telephones. Both parties will work together to estimate the difference in value the

actual ICs have with respect to the open market ICs. After allowances are made for differences in function and performance, the price Lucent charges for the chip sets shall not exceed that of comparable ICs at comparable cumulative volume. Lucent will take the NRE fees paid by CD Radio into account when calculating the chip set selling price in this way.

The price for each unit of the Device shall be as set forth in Appendix 1 (+) hereto, as may be amended from time to time by mutual agreement of the parties. CD Radio shall pay the invoiced amount within thirty (30) days from the date of Lucent's invoice. Payment terms for all design and development activities of Lucent are as specified in the Business Terms. Lucent may exercise an option to assess an interest charge of up to one and one-half percent (1 1/2%) per month on all amounts which are not timely paid (but not to exceed the maximum lawful rate). CD Radio hereby grants to Lucent a purchase money security interest in the product to secure the purchase price of the product until the purchase price is paid in full. CD Radio agrees to execute and deliver all documents reasonably requested by Lucent to perfect and maintain Lucent's security interest. Orders are subject to a maximum outstanding credit limit (measured counting all outstanding invoices, whether or not past due, combined with the value of all accepted orders) as reasonably determined by Lucent. Lucent may refuse to accept purchase orders, if such acceptance would result in CD Radio exceeding such credit limit. The amount of credit or terms of payment may be changed or credit withdrawn by Lucent at any time upon reasonable advance notice to CD Radio. Each shipment shall constitute an independent transaction and CD Radio shall pay for same in accordance with the specified payment terms. Lucent will invoice CD Radio upon shipment. If shipments are delayed by CD Radio, Lucent may invoice CD Radio when Lucent is prepared to ship. Lucent may invoice CD Radio immediately upon termination or cancellation of any order. Prices shall be quoted and invoices shall be rendered and paid in United States currency.

13 DELIVERY, TITLE, RISK OF LOSS AND TRANSPORTATION

Unless otherwise agreed to by Lucent in writing as part of the Business Terms or any amendment thereto referenced by CD Radio in an order, (a) delivery terms on shipments to any point in the United States shall be F.O.B. point of origin, and (b) delivery terms on shipments to any point outside of the United States shall be pursuant to Incoterms 1990 (FCA, country of export). Where, in order to meet CD Radio's requests, Lucent ships or packs the Device or other materials in other than its normal manner for shipment, additional billing may be rendered. risk of loss shall pass to CD Radio upon delivery.

14 PRODUCT CHANGES

Lucent may at any time make changes in the Devices (i) that do not materially affect physical or functional interchangeability or performance or (ii) when required for purposes of safety. In the case of (ii), Lucent shall ensure that such changes do not

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(+) Appendix 1 hereto does not currently exist and is not expected to be created in the future.

adversely affect the functionality of the Device or its compatibility with CD Radio's products. No changes by Lucent may result in any price increase.

15 MANUFACTURING FACILITY

Notwithstanding anything contained herein to the contrary, Lucent reserves the right to manufacture the Device in any Lucent-qualified facility. Lucent also reserves the right to transfer production from one qualified facility to another or to manufacture at multiple qualified facilities.

16 EXCLUSIVE REMEDIES AND LIMITATIONS OF LIABILITY

A. For purposes of the exclusive remedies and limitations of liability set forth in this section, Lucent shall be deemed to include Lucent Technologies Inc., its subsidiaries and affiliates and the directors, officers, employees, agents, representatives, subcontractors and suppliers of all of them; and "Damages" shall be deemed to refer collectively to all injury, damage, loss or expense incurred.

B. Lucent's entire liability and CD Radio's exclusive remedies against Lucent for any damages caused by any Device defect or failure, or arising from the performance or non-performance of any work, regardless of the form of action, whether in contract, tort, including negligence, strict liability or otherwise, except as may arise from intentional misconduct or gross negligence, shall be:

1 For infringement, the remedies set forth in the section entitled Intellectual Property Indemnity;

2 For failure to deliver conforming prototypes, CD Radio's sole and exclusive remedy and Lucent's entire liability shall be CD Radio's right to a refund of moneys paid by CD Radio as provided in Section 3 of this Part 3. For any other failure of the Device or work performed, the remedies stated in the section entitled Warranty;

3 For delays in delivery of production quantities, Lucent shall have no liability unless the delivery is delayed by more than thirty (30) days by causes not attributable either to CD Radio or to conditions beyond Lucent's reasonable control, in which case CD Radio shall have the right, as its sole remedy, to cancel the order without incurring cancellation charges;

4 For bodily injury or death to any person proximately caused by Lucent, CD Radio's right to proven direct damages; and

5 For claims other than set forth above, Lucent's liability shall be limited to direct damages that are proven, in an amount not to exceed one hundred thousand ($100,000) dollars.

C. Notwithstanding any other provision of this Agreement, Lucent shall not be liable for incidental, indirect, special, exemplary or consequential damages or for lost profits, savings or revenues of any kind, whether or not Lucent has been advised of the possibility of such damages. This provision shall survive failure of an exclusive remedy.

17 CD RADIO'S DESIGNATED EMPLOYEES ON SELLER'S PREMISES

CD Radio's personnel shall, while on any location of Lucent or any of its affiliates, comply with rules and regulations with regard to safety and security at such location. Lucent shall inform such personnel of such rules and regulations. CD Radio shall have full control over such personnel and shall be

entirely responsible for their complying with such rules and regulations. CD Radio agrees to indemnify and save Lucent and any of its affiliates harmless from any claims or demands, including the costs, expenses and reasonable attorney's fees incurred on account thereof, that may be made by (i) anyone for injuries to persons or damage to property resulting from the acts or omissions of CD Radio's personnel or (ii) CD Radio's personnel under Worker's Compensation or similar laws. CD Radio agrees to defend Lucent and its affiliates, at Lucent's request, against any such claim or demand.

18 EXPORT CONTROL

The parties acknowledge that any products, software, and technical information (including, but not limited to, services and training) provided under this Agreement are subject to U.S. exports laws and regulations and any use or transfer of such products, software, and technical information must be authorized under those regulations. The parties agree that they will not use, distribute, transfer, or transmit the products, software, or technical information (even if incorporated into other products) except in compliance with U.S. export regulations. If requested by Lucent, CD Radio also agrees to sign written assurances and other export-related documents as may be required for Lucent to comply with U.S. export regulations.

19 ASSIGNMENT

Except for Lucent's right to assign this Agreement to any of its affiliates and CD Radio's right to assign this Agreement to any entity that succeeds it as the result of a strategic merger, acquisition, or other corporate reorganization, neither party shall have the right to assign this Agreement except upon the prior written consent of the other and any such purported assignment shall be void and ineffective.

20 IDENTIFICATION

Except as permitted by United States trademark law and except as expressly provided herein, neither Lucent nor CD Radio shall use any identification of, or reference to, any code, drawing, specification, trade name, trademark, trade device, insignia, service mark, symbol, or any abbreviation, contraction, or simulation thereof, of the other party in any advertising or promotional efforts without such other party's prior approval.

21 EXCUSE OF PERFORMANCE

Except with respect to CD Radio's obligation to make timely payments when due, neither party shall be held responsible for any delay or failure in performance of any part of this Agreement to the extent such delay or failure is caused by fire, flood, explosion, war, strike, embargo, government requirement, civil or military authority, act of God, nature or the public enemy, inability to secure material or transportation facilities, inadequate yield of products despite Lucent's reasonable efforts, act or omission of carriers or any other causes beyond its reasonable control. After conclusion of the exclusivity period provided for in Part 1, Lucent may, in the event of any such circumstance, allocate in a fair and reasonable manner, taking into account Lucent's contractual commitments, its available production output among itself and its other customers, including at Lucent's option those not under contract.

22 NON-WAIVER

No course of dealing or failure of either party to strictly enforce any term, right or condition with respect to any transaction or order hereunder shall be construed as a waiver of such term, right or condition.

23 TAXES

Any tax or related charge which Lucent shall be required to pay to or collect for any government upon or with respect to services rendered or the sale, use or delivery of the Device or other materials shall be billed to the CD Radio as a separate item and paid by CD Radio, unless a valid exemption certificate is furnished by CD Radio to Lucent.

24 CHOICE OF LAW

The construction, interpretation, and performance of this Agreement and any transaction hereunder shall be governed by the substantive laws, but not the conflicts of law rules, of the State of New York. The U.N. Convention on Contracts for the International Sales of Goods shall not apply to the sale of product hereunder.

25 MEDICAL AND LIFE SUPPORT APPLICATIONS

Lucent does not recommend the use of any Devices for medical or life support applications wherein a failure or malfunction of the Device may directly threaten life or cause injury and Lucent will not knowingly sell its Devices for such use except pursuant to a written exception to this policy granted on a

case-by-case basis. No warranty is made with respect to any such medical or life support use of any Device.

26 DISPUTES

26.1 If a dispute arises out of or relates to this Agreement, or its breach, and if such dispute cannot be settled through good faith negotiations within thirty (30) days, the parties agree to submit the dispute to a sole mediator selected by the parties or, at

any time at the option of a party, to mediation by a mediator selected by the American Arbitration Association ("AAA"). The parties agree to make good faith efforts to resolve disputes by mediation within thirty (30) days. If not thus resolved, it shall be referred to a sole arbitrator selected by the parties within thirty (30) days of the mediation, or in the absence of such selection, to AAA arbitration which shall be governed by the United States Arbitration Act. The mediator or arbitrator selected by the parties shall be knowledgeable in the law and technology and the rules and regulations of the AAA. Such mediation or arbitration shall be non-binding on the parties. In the event such dispute is not resolved either by mediation or arbitration, then either party may initiate suit in the federal or state courts in the State of New York.

26.2 The mediation or arbitration, if any, shall be held in New York City. The requirement for mediation or arbitration shall not be deemed a waiver of any right of termination under this Agreement and the mediator or arbitrator is not empowered to act or make any award other than based solely on the rights and obligations of the parties prior to any such termination.

26.3 The mediator or arbitrator may not limit, expand or otherwise modify the terms of this Agreement.

26.4 Each party shall bear its own expenses but those related to the compensation and expenses of the mediator or arbitrator shall be borne equally.

26.5 The mediator or arbitrator shall not have authority to award punitive, exemplary or other damages in excess of compensatory damages and each party irrevocably waives any claim thereto. The award shall be made within two (2) months after selection of the mediator or arbitrator and may be entered in any court.

26.6 The parties, their representatives, other participants and the mediator and arbitrator shall hold the existence, content and result of mediation or arbitration in confidence.

THE PARTIES, agreeing to the above terms and conditions, including by reference all terms and conditions contained in the Business Terms, and intending to be legally bound thereby, have caused the signatures of their respective authorized representatives to be affixed below on the date so written.

LUCENT TECHNOLOGIES INC.	CD RADIO INC.
- ----------	----------
(Signature)	(Signature)
- ----------	----------
(Name Printed)	(Name Printed)
- ----------	----------
(Title Printed)	(Title Printed)
- ----------	----------
(Date)	(Date)