READ INSTRUCTIONS CAREFULLY BEFORE PROCEEDING

(1) LOCKBOX # 358210

FEDERAL COMMUNICATIONS COMMISSION

REMITTANCE ADVICE

PAGE NO. 1 OF 1

APPROVED BY OMB 3060-0589

SPECIAL USE

FCC USE ONLY

SECTION A - PAYER INFORMATION

(2) PAYER NAME (if paying by credit card, enter name exactly as it appears on your card): Lockheed Martin Corporation

(3) TOTAL AMOUNT PAID (dollars and cents): $ 425,225.00

(4) STREET ADDRESS LINE NO. 1: 6801 Rockledge Drive

(5) STREET ADDRESS LINE NO. 2:

(6) CITY: Bethesda

(7) STATE: MD

(8) ZIP CODE: 20817

(9) DAYTIME TELEPHONE NUMBER (Include area code): (301) 897-6000

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

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

SECTION B - APPLICANT INFORMATION

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

39/40/41/42/43-SAT-P/LA-98

(12) STREET ADDRESS LINE NO. 1

(13) STREET ADDRESS LINE NO. 2

(14) CITY

(15) STATE

(16) ZIP CODE

(17) DAYTIME TELEPHONE NUMBER (Include area code)

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

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

SECTION C - PAYMENT INFORMATION

	FCC CALL SIGN/OTHER ID	PAYMENT TYPE CODE (PTC)	QUANTITY	FEE DUE FOR (PTC) IN BLOCK 20	FCC USE ONLY
A	(19A)	(20A) B N Y	(21A) 5	(22A) $ 85,045.00	
	(23A) FCC CODE 1		(24A) FCC CODE 2		
B	(19B)	(20B)	(21B)	(22B) $	
	(23B) FCC CODE 1		(24B) FCC CODE 2		
C	(19C)	(20C)	(21C)	(22C) $	
	(23C) FCC CODE 1		(24C) FCC CODE 2		
D	(19D)	(20D)	(21D)	(22D) $	
	(23D) FCC CODE 1		(24D) FCC CODE 2		

SECTION D - TAXPAYER INFORMATION (REQUIRED)

(25) PAYER TIN [redacted]

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

SECTION E - CERTIFICATION

(27) CERTIFICATION STATEMENT

I, Mel R. Brashears (PRINT NAME), Certify under penalty of perjury that the foregoing and supporting information are true and correct to the best of my knowledge, infomation and belief. SIGNATURE [signature]

SECTION F - CREDIT CARD PAYMENT INFORMATION

(28) MASTERCARD / VISA

MASTERCARD/VISA ACCOUNT NUMBER:

EXPIRATION DATE: MONTH YEAR

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

AUTHORIZED SIGNATURE

DATE

COPY

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December 22, 1997

VIA COURIER

Federal Communications Commission
International Bureau - Satellites
P.O. Box 358210
Pittsburgh, PA 15251-5210

Payment Code: BNY

Re: Application of Lockheed Martin Corporation for Authority to Launch and Operate a Global Satellite Communications System in Geostationary Orbit - Stop Code: 0800

Ladies and Gentlemen:

Transmitted herewith, on behalf of Lockheed Martin Corporation ("Lockheed Martin"), are an original and nine copies of an application for authority to launch and operate the Astrolink-Phase II™ System, a state-of-the-art constellation of five (5) geostationary satellite orbit ("GSO") space stations interconnected by intersatellite links. The Astrolink-Phase II™ System, which will utilize Ka-band frequencies to provide communications globally in the Fixed-Satellite Service, will complement and augment the capabilities of Lockheed Martin's previously-licensed Astrolink™ System.

Accompanying this application are: (1) an FCC Form 159; and (2) a check payable to the FCC in the amount of $425,225.00 to cover the applicable FCC filing fee.

Should any questions arise with regard to this filing, kindly communicate with the undersigned.

Very truly yours,

Raymond G. Bender, Jr.
Counsel for Lockheed Martin Corporation

RGB/db
Enclosures

FCC 312
Main Form

Approved by OMB 3060-0678

Est. Avg. Burden Hours Per Response: 10 Hrs.

FCC Use Only
File Number:
Call Sign:

FEDERAL COMMUNICATIONS COMMISSION
APPLICATION FOR SATELLITE SPACE AND EARTH STATION AUTHORIZATIONS

PAYOR AND FILING FEE INFORMATION

a. Payor Name: Lockheed Martin Corporation				b. Daytime Telephone Number: (301) 897-6000
c. Mailing Street Address or P.O. Box: 6801 Rockledge Drive				d. FCC Account Number: 0952693884
e. City: Bethesda		f. State: MD	g. Zip Code: 20817	h. Country Code (if not U.S.A.):
i. Payment Type Code: BNY	j. Quantity: 5	k. Fee Due for Payment Type Code in (i): $85,045.00	l. Total Amount Paid: $425,225.00	FCC Use Only

APPLICANT INFORMATION

1. Legal Name of Applicant: Lockheed Martin Corporation		2. Voice Telephone Number: (301) 897-6000
3. Other Name Used for Doing Business (if any):		4. Fax Telephone Number: (301) 897-6083
5. Mailing Street Address or P.O. Box: 6801 Rockledge Drive ATTENTION: Mel R. Brashears	6. City: Bethesda 7. State / Country (if not U.S.A.): MD	8. Zip Code: 20817
9. Name of Contact Representative (If other than applicant): Raymond G. Bender, Jr., Esq.		10. Voice Telephone Number: (202) 776-2758
11. Firm or Company Name: Dow, Lohnes & Albertson		12. Fax Telephone Number: (202) 776-2222
13. Mailing Street Address or P.O. Box: 1200 New Hampshire Avenue, N.W., Suite 800 ATTENTION: Raymond G. Bender, Jr., Esq.	14. City: Washington 15. State / Country (if not U.S.A.): DC	16. Zip Code: 20036

CLASSIFICATION OF FILING

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

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

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

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

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

TYPE OF SERVICE

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

[X] a. Fixed Satellite [ ] b. Mobile Satellite [ ] c. Radiodetermination Satellite [ ] d. Earth Exploration Satellite [ ] e. Other (please specify) ______

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

[ ] a. Common Carrier [X] b. Non-Common Carrier

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

[ ] a. Using U.S. licensed satellites [ ] b. Using Non-U.S. licensed satellites

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

[ ] a. Connected to the Public Switched Network [ ] b. Not connected to the Public Switched Network

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

[ ] a. C-Band (4/6 GHz)
[ ] b. Ku-Band (12/14 GHz) [X] c. Other (Please specify) Ka-band (30/20 GHz), extended C-band (4/6 GHz, TT&C), V-band (above 40 GHz, ISLs), and ISLs at 22/23 GHz and 32/33 GHz

TYPE OF STATION

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

[ ] a. Fixed Earth Station [ ] b. Temporary-Fixed Earth Station [ ] c. 12/14 GHz VSAT Network [ ] d. Mobile Earth Station [X] e. Space Station [ ] f. Other Specify ______

If space station applicant, go to Question 27.

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

[ ] a. Transmit/Receive [ ] b. Transmit-Only [ ] c. Receive-Only N/A

PURPOSE OF MODIFICATION OR AMENDMENT

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

N/A

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

ENVIRONMENTAL POLICY

28. Would a Commission grant of any proposal in this application or amendment have a significant environmental impact as defined by 47 CFR 1.1307? [ ] YES [X] NO
If YES, submit the statement as required by Sections 1.1308 and 1.1311 of the Commission's rules, 47 C.F.R. §§ 1.1308 and 1.1311, as Exhibit A to this application.

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

ALIEN OWNERSHIP

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

BASIC QUALIFICATIONS

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

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

Lockheed Martin hereby seeks authority to launch and operate five (5) geostationary satellites to provide Fixed-Satellite Services to businesses and consumers around the globe. A further description of the proposed system and services is included in the narrative portion of this application.

CERTIFICATION

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

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

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

*See Exhibits L and M.

43. Typed Name of Person Signing	44. Title of Person Signing
Mel R. Brashears	President and Chief Operating Officer Space & Strategic Missiles Sector, Lockheed Martin Corporation
45. Signature	46. Date
Mel R. Brashears	December 19, 1997

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

APPLICATION OF

LOCKHEED MARTIN CORPORATION

FOR THE

ASTROLINK-PHASE II™ SATELLITE COMMUNICATIONS SYSTEM

BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

DECEMBER 19, 1997

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

In the Matter of	)	
	)	
LOCKHEED MARTIN CORPORATION	)	
	)	File No.
Application For Authority to Launch and Operate a Global Ka-band Satellite Communications System in Geostationary Orbit	)	
	)	

ASTROLINK-PHASE II™ COMMUNICATIONS SYSTEM APPLICATION

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1200 New Hampshire Avenue, N.W.
Washington, D.C. 20036-6802
(202) 776-2000

December 19, 1997

EXECUTIVE SUMMARY

Lockheed Martin Corporation ("Lockheed Martin") hereby requests authority to launch and operate a satellite communications system comprised of five state-of-the-art geostationary satellite orbit ("GSO") fixed-satellite service ("FSS") satellites. The proposed satellite system—the Astrolink-Phase II™ System—will interconnect with and augment the capabilities of Lockheed Martin's Astrolink™ System, a Ka-band GSO FSS system licensed by the Commission to provide worldwide coverage using a constellation of nine satellites located in five separate orbit locations.

The Astrolink-Phase II™ System will operate using two gigahertz of Ka-band spectrum in each direction of transmission in accordance with U.S. and international frequency allocations and the Commission's Ka-band plan. The system will offer a broad array of digital communications services, including voice, data, and video, via the most advanced satellite and ground terminal technology available. Lockheed Martin plans to operate the proposed satellite system on a non-common carrier basis.

The Applicant

Lockheed Martin, a diversified $27 billion advanced-technology company, is a leader in the design, development, and production of aerospace, communications, and other advanced-technology systems. Since 1958, Lockheed Martin has developed, built, launched, and/or operated over 650 communications and other spacecraft. Lockheed Martin's recent satellite communications programs include NASA's Advanced

Communications Technology Satellite ("ACTS") and spacecraft missions for INTELSAT, Inmarsat, EchoStar, IRIDIUM®, the U.S. Department of Defense, and others. Lockheed Martin also has extensive experience in the design, development, installation, and operation of satellite communications ground systems. The planned acquisition of Northrop Grumman Corporation during 1998 will further enhance Lockheed Martin's position as a leading, broad-based technology company, with nearly 230,000 employees worldwide.

The Astrolink-Phase II™ System

Astrolink-Phase II™ will greatly expand the capabilities of Lockheed Martin's licensed Astrolink™ System. The Astrolink-Phase II™ System supplements the capacity of the Astrolink™ System and augments Astrolink™'s global reach by adding five new orbit locations. Key features of the Astrolink-Phase II™ System include:

- A constellation of five advanced GSO FSS satellites complementing the worldwide coverage of the Astrolink™ System;
- Inter-satellite links ("ISLs") providing direct satellite-to-satellite communication, thereby avoiding the need for double-hop connectivity, increasing system level reliability, and providing seamless global connectivity;
- Local inter-satellite links ("LISLs") to interconnect the Astrolink-Phase II™ satellites with closely spaced satellites of other compatible networks, such as Lockheed Martin's proposed Q/V-band satellite system;
- Very high spectral efficiency achieved by the use of high performance multiple spot-beam satellite antennas and low threshold digital coding and modulation schemes;
- Very high system capacity with each satellite capable of supporting a total of between 8,000 and 12,000 simultaneous full duplex 384 kbps circuits;

- A broad array of voice-to-video communications services with data-rates ranging from 16 kbps to 10.4 Mbps; and
- Small and inexpensive ground terminals, with antennas as small as 65 cm in diameter.

Planned Services

Deployment of the Astrolink-Phase II™ System will expand the broad range of high-quality, flexible and reliable telecommunications capabilities of the Astrolink™ System. The use of small, inexpensive ground terminals permits cost-effective applications in many emerging markets, including group work, telecommuting, workforce training, distance learning, and telemedicine applications. The wide range of data-rates available to Astrolink™ System users will bring low-cost broadband services directly to urban and remote locations alike, and open up new possibilities for essential high-speed data applications. Astrolink-Phase II™ will further expand global information networks by virtue of the fully interconnected worldwide coverage of the entire Astrolink™ System. All Astrolink-Phase II™ services will be available to users as "capacity on demand," which will make using the system cost-effective for customers with low utilization requirements, and for those who need continuous, high-capacity communication links.

Public Interest Considerations

Deployment of the Astrolink-Phase II™ System will promote important public interest objectives. First, the Astrolink-Phase II™ System will address the growing demand for advanced communications capacity in the U.S. and international marketplace. Second, Astrolink-Phase II™ will serve as a core component of the Global Information

Infrastructure. Third, licensing of the Astrolink-Phase II™ System will assure competition in the growing market for satellite-based telecommunications services. Fourth, implementation of the Astrolink-Phase II™ System will foster important U.S. economic goals and will help maintain U.S. leadership in commercial satellite communications technology.

Lockheed Martin is legally, technically, and financially qualified to implement the Astrolink-Phase II™ System and requests that the Commission grant this space station application on an expedited basis so that the benefits of the Astrolink-Phase II™ System will be realized as rapidly as possible.

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Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the Matter of **LOCKHEED MARTIN CORPORATION** Application For Authority to Launch and Operate a Global Ka-band Satellite Communications System in Geostationary Orbit	))))))))	File No.

ASTROLINK-PHASE II™ COMMUNICATIONS SYSTEM APPLICATION

Lockheed Martin Corporation ("Lockheed Martin") hereby submits its application for authority to launch and operate the Astrolink-Phase II™ System—a geostationary satellite orbit ("GSO") fixed-satellite service ("FSS") communications network that will augment the capabilities of Lockheed Martin's previously licensed Astrolink™ System. The Astrolink-Phase II™ System will utilize Ka-band spectrum allocated to GSO FSS to provide a wide range of communications services to businesses and consumers around the world.

1. INTRODUCTION

1.1. NAME AND ADDRESS OF APPLICANT

The applicant for authority to launch and operate the Astrolink-Phase II™ System is:

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1.2. CORRESPONDENCE

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1.3. AUTHORIZATION REQUESTED

This application requests FCC authorization to launch and operate, on a non-common carrier basis, a satellite communications system comprised of five GSO space stations in five orbit locations. Lockheed Martin proposes to provide FSS services utilizing two gigahertz of uplink and two gigahertz of downlink spectrum in the Ka-band. Specifically, the Astrolink-Phase II™ System will utilize the 17.8-19.3 GHz and 19.7-20.2 GHz bands for space-to-Earth communications links, and the 27.85-29.1 GHz and 29.25-30.0 GHz bands for Earth-to-space links. These frequencies have been allocated by the Commission for GSO FSS operations, either on a primary or secondary basis.

Lockheed Martin also requests authority to operate inter-satellite links ("ISLs") and local inter-satellite links ("LISLs") in a total of three gigahertz of ISL spectrum. The proposed ISLs will be used to interconnect adjacent Astrolink™ or Astrolink-Phase II™ satellites, while the LISLs will interconnect Astrolink-Phase II™ satellites with closely spaced satellites of other compatible networks, such as Lockheed Martin's proposed Q/V-band system. Lockheed Martin proposes to perform tracking, telemetry, and control functions in extended C-band frequencies.

1.4. INFORMATION CONTAINED IN THIS APPLICATION

This application contains all of the information required for a space station authorization as specified in Part 25 of the Commission's Rules and Appendix B of the

Commission's *1983 Processing Order*.[1] Consistent with Commission policy and precedent, Lockheed Martin understands that it will have an opportunity to amend or modify this application if the Commission adopts additional policies or modifies existing rules governing satellite services in the Ka-band.

1.5. LOCKHEED MARTIN HISTORY AND BACKGROUND

One of the world's largest aerospace and defense companies, Lockheed Martin has more than 190,000 employees and had $27 billion in sales in 1996. Through its numerous advanced-technology businesses, Lockheed Martin has developed extraordinary technological strength across a wide range of areas, including all types of spacecraft, launch vehicles, and surface- and space-based information and communications systems. On July 3, 1997, Lockheed Martin announced an agreement to acquire Northrop Grumman Corporation. The closing of that transaction in 1998 will further enhance Lockheed Martin's position as a leading, broad-based technology company, with nearly 230,000 employees worldwide. In 1997, the two companies will have combined estimated revenues of $37 billion. The acquisition is consistent with Lockheed Martin's long-term growth strategy to expand core businesses and move into closely related emerging markets.

Since the late 1950s, Lockheed Martin has supplied over 650 communications, earth observation, planetary exploration, and other spacecraft to government and non-government customers around the world. Recent Lockheed Martin satellite

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[1] *Filing of Applications for New Space Stations in the Domestic Fixed-Satellite Service*, Memorandum Opinion and Order, 93 FCC 2d 1260 (1983) ("*1983 Processing*

communications programs include NASA's Advanced Communications Technology Satellite ("ACTS"), as well as spacecraft missions for INTELSAT, Inmarsat, EchoStar, Iridium®, the U.S. Department of Defense, and others.

In addition, Lockheed Martin has extensive experience in other space and communications businesses. For example, the company's space launch programs include Titan IV; Atlas; the Athena family and other Lockheed Martin launch vehicles; and, in conjunction with two of Russia's leading aerospace organizations, Khrunichev and Energia, the Proton M launch vehicle, which is currently under development. Lockheed Martin also has an extensive background in the design, development, installation, and operation of satellite communications ground networks.

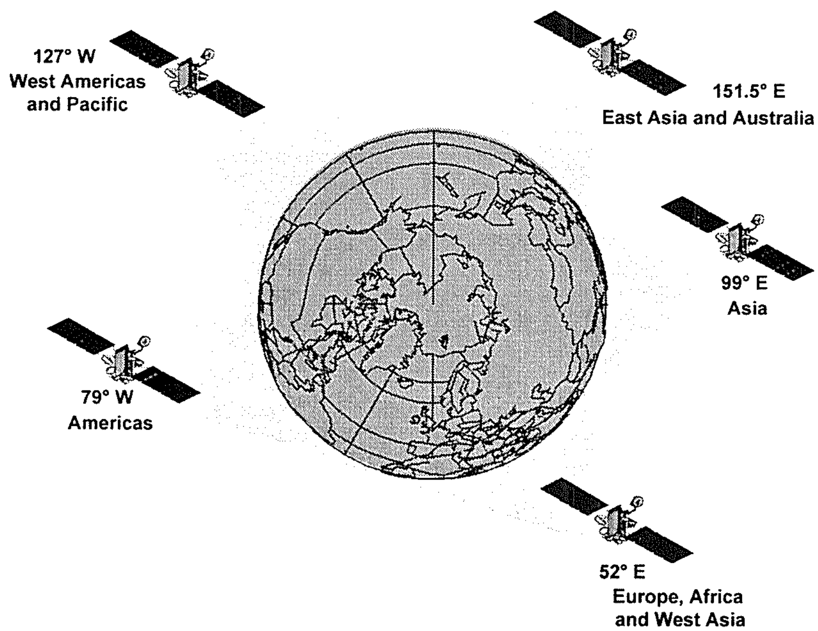
Finally, Lockheed Martin is the licensee of the Astrolink™ System, a GSO FSS system authorized by the Commission to provide advanced broadband communications services in the Ka-band. In addition, Lockheed Martin has an application pending before the FCC for authority to launch and operate an ultra-broadband satellite communications network that will utilize Q-band and V-band spectrum to provide a wide range of communications services to the public. Based on this experience, Lockheed Martin is uniquely positioned to implement the proposed Astrolink-Phase II™ System described in this application.

Order").

2. SYSTEM OVERVIEW

As shown in Figure 2-1, Lockheed Martin will deploy a constellation of five advanced GSO satellites to augment the capability of the Astrolink™ System to provide broadband communications capacity around the world. The Astrolink-Phase II™ satellites, as part of the Astrolink™ System, will be capable of meeting the communications needs of users on a continuous basis or as capacity on-demand.

Figure 2-1 - Astrolink-Phase II™ Constellation



Lockheed Martin's Astrolink-Phase II™ System will provide a combination of point-to-point and point-to-multipoint FSS services to meet a wide variety of user needs. By providing a broad range of satellite communications services, the proposed system will respond to the rapidly growing demand for communication services in the United States and around the globe. Lockheed Martin's proposed system will achieve these objectives by employing state-of-the-art satellite and ground segment technology.

Key features of the Astrolink-Phase II™ System include:

- **On-board Asynchronous Transfer Mode ("ATM") standards-based switching.** ATM is a data transport technology that supports transmission of data, voice, video, and multimedia applications in an integrated and efficient manner. Industry and international standards are rapidly being developed for transmission of most existing data protocols and applications over ATM, including TCP/IP (the standard protocol of the Internet), ensuring interoperability with existing networks and computer equipment. Lockheed Martin is playing a leading role in these standards-setting initiatives.

- **Multiple Spot Beam Satellite Coverage.** The Astrolink-Phase II™ System maximizes spectral efficiency by using up to 88 contiguous spot beams, each with 1° beamwidth. The use of multiple spot beams permits Astrolink-Phase II™ to achieve up to 16 times frequency reuse.

- **A wide range of user terminal antennas as small as 65 cm in diameter, which are low cost and easy to install at customer premises.** User terminals will provide a wide range of standard data interfaces to facilitate interconnectivity between customer premises equipment and the satellite system. The smallest user terminals will provide uplink data-rates of up to 416 kbps and larger user terminals (up to 1.8 meters in antenna diameter) will allow uplink communications up to 10.4 Mbps data-rates. All Astrolink-Phase II™ user terminals will be capable of receiving an aggregate downlink data-rate of approximately 102.4 Mbps.

- **ISLs between adjacent Astrolink™ and Astrolink-Phase II™ satellites.** ISLs between Astrolink-Phase II™ and other Astrolink-Phase II™ or Astrolink™ satellites in adjacent orbit locations will facilitate interconnectivity among all Astrolink™ customers and with existing terrestrial networks around the world, regardless of service area.

- **LISLs between Astrolink-Phase II™ satellites and closely spaced satellites of other compatible systems.** LISLs between Astrolink-Phase II™ satellites and closely spaced satellites of other compatible networks, such as Lockheed Martin's proposed Q/V-band system, will facilitate interconnectivity among users of the various satellite communications networks.

- **Interconnectivity and interoperability with terrestrial networks through a system of gateway earth stations.** These gateway earth stations will provide greater than 100 Mbps connectivity to and from Lockheed Martin's Astrolink-Phase II™ System.

3. MARKET AND SERVICES

3.1. MARKET OVERVIEW

3.1.1. Summary

The Astrolink-Phase II ™ System will provide additional capacity and operational flexibility required to meet the needs of a digital telecommunications marketplace that is growing and changing in character much faster than when the original Astrolink™ application was filed. Since that time demand for digital telecommunications has grown beyond previous forecasts in both the business and consumer markets. This demand is driven in large part by three trends: the rapid advancement of computer technology in processing power, speed, and storage capacity; rapidly declining hardware and software costs; and the widespread acceptance of the computer as a flexible communications tool. Taken together, these trends continue to drive the need for higher capacity networks.

Moreover, Lockheed Martin's current analysis indicates that more demand for satellite bandwidth will be concentrated in major population centers than previously anticipated, particularly in developing regions. The dramatic growth in demand for data telecommunications has not been met with commensurate expansion of terrestrial networks, even in the most densely populated regions. As a result, Lockheed Martin anticipates that the Astrolink™ System will be required to focus additional bandwidth in certain highly populated areas. The additional coverage provided by the Astrolink-Phase

II™ satellites, along with changes proposed in a simultaneously filed application for modification of the original Astrolink™ license, will give the combined system needed flexibility to meet peak demand for bandwidth in high traffic areas.

3.1.2. Demand for Telecommunications Capacity

The most profound increase in demand for telecommunications capacity in the last several years has centered on data communications across public and private networks. At its most basic, this growth arises from the enormous improvements in low-cost computer hardware and software. As computers become simpler to use, more capable of performing complex tasks, and more widely deployed, computer data represents a larger and larger share of human output. And, as computer data begins to substitute for other products (such as printed photographs), processes (such as delivery of text messages) and institutions (such as branch banking), more and more of that data needs to be moved. Thus, the growth in demand for flexible telecommunications capacity is driven in large measure by the exponential growth in processing and storage power available in low-cost computers.

In the past two years the personal computer industry has increased the rate of improvement in processors, memory, and storage devices, resulting in ever more computing power for less money. In 1995, when Lockheed Martin applied for licenses for the original five Astrolink™ satellites, Dataquest estimated that an $1,800 home PC in the year 2000 would have ten times the processing power and twenty times the storage capacity of a 1995 PC. A comparison of Table 3.1.2-1, which was included in the original Astrolink™ application, with Table 3.1.2-2, which reflects computers being marketed in December of 1997, shows that 1995's "computer of the future" is basically available today. However, as shown by the relatively small increase in modem speeds and as discussed below, comparatively little progress has been made in the communications links.

Table 3.1.2-1: What $1800 Will Buy?

From Astrolink™ Application, September 1995

Feature	1995	2000
Processor	Pentium Fifth-generation	Eighth-generation
Speed	60 MHz	600 MHz
Memory	8 megabytes	64 megabytes
Storage	420 megabytes	8320 megabytes
CD ROM Drive	Double-speed	Six-speed
Outside link	Fax modem @ 14,400 bps	Built-in network connections @ up to 100 million bps

Table 3.1.2-2:

Available today[2]

1997
Pentium II (seventh generation)
266 MHz
64 megabytes
4.3 gigabytes
24x variable speed
33,600 bps send 56,600 bps receive

Sources: Wall Street Journal, 1995, and "Washington Business" section of Washington Post, December 15, 1997, p. 4.

Clearly, data processing and storage capabilities are outpacing original forecasts, but the communications link is not keeping up with the rest of the system. The speed with which connectivity has become integral to computers is astounding. In 1995, estimates of World Wide Web ("WWW") users in the United States ranged between one and two million, with expectations of growing to 14 million in the year 2000. In fact, before the end of 1997, WWW users already number roughly 34 million, and the number

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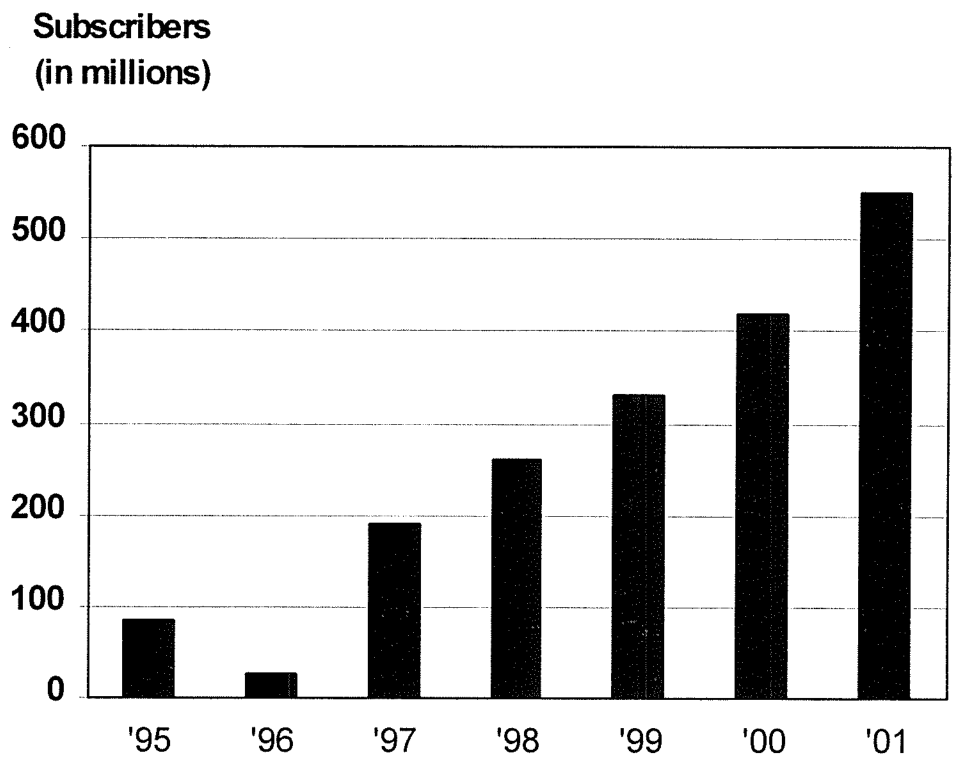
[2] *See* Washington Business, *Washington Post* 4 (Dec. 15, 1997).

is forecast to grow to 65 million in the year 2000. Notably, when Lockheed Martin filed its Astrolink™ application in the fall of 1995, Microsoft had yet to develop an Internet strategy. Today, Microsoft's fourth-generation operating system—to be released in 1998—is being designed with seamless integration of the Internet and other networks as its key feature.

In an environment in which connectivity is an essential feature of computers, the usefulness of new hardware and software will be severely limited unless significantly greater communications capacity is achieved. For instance, voice and video "e-mail" messaging—a novelty today—are likely to permeate corporate networks and the Internet within the next 24 months. Rapidly improving voice command technology will allow users to record voice (or voice and video) messages and send them anywhere in the world simply by speaking naturally into a computer. Widespread use of such applications, which are now made possible through massive processing power, will require much greater bandwidth than the services they replace because voice or video message files are hundreds of times larger than the same words sent as plain text.

Personal computers are not the only devices driving demand for bandwidth. Advances in microprocessor technology are enabling the development of entirely new classes of communications tools designed for productivity and entertainment. Significantly, both the mobile phone and the direct-to-home television industries have experienced rapid market penetration. As shown in Figure 3.1.2-3, Dataquest, Inc. estimates that the world-wide market for mobile phones in 1997 is 190 million and forecasts that the market will grow to 340 million in the Year 2000.

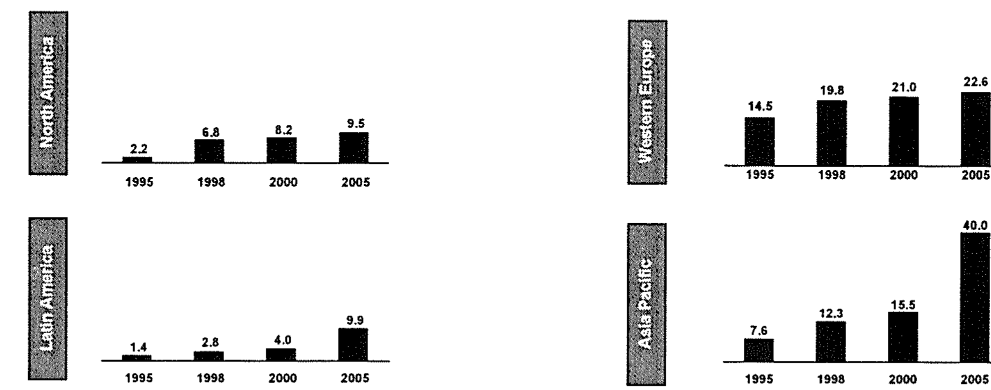
Figure 3.1.2-3 - Total Cellular Phone Market World-Wide



Source: Dataquest, 1997

As shown in Figure 3.1.2-4, Morgan Stanley estimates that the market in selected regions for direct-to-home television services was 25 million in 1995, and forecasts that the market will grow to 82 million.

Figure 3.1.2-4: DTH Penetration in Selected Regions (Millions of Households)

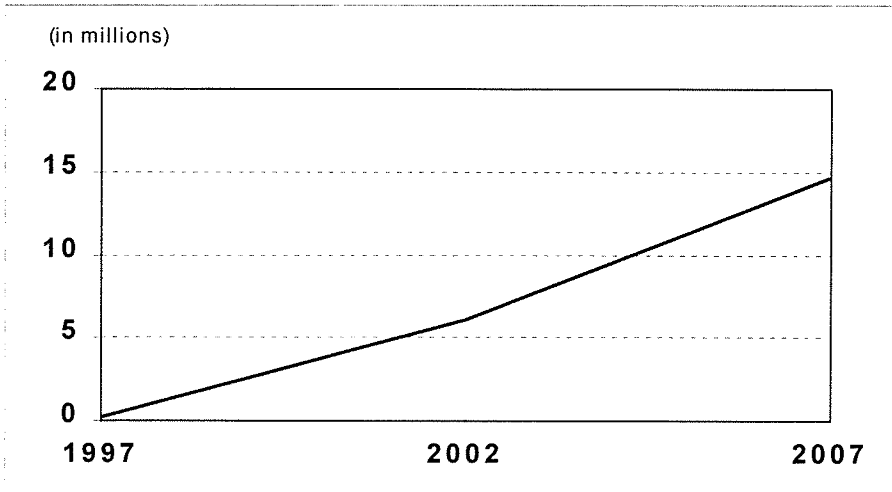


Source: Morgan Stanley; Gemini C4 Lab Analysis
Note: For North America, figures represent only households receiving digital direct broadcast satellite service. Figures reported for all other regions include all analog and digital DTH satellite services.
* Penetration is defined as the number of households served.

These growth rates illustrate a tremendous market willingness to embrace new communication devices in short amounts of time.

Today's small, multi-function cellular telephones and small DBS dishes are forerunners of the myriad products and services that will develop from smaller microprocessors and greater bandwidth. Manufacturers are developing new television devices, like Microsoft's WebTV, to reach new users, and Oracle, Sun, and Netscape are advocating the concept of the Network Computer, which is more of a communications appliance than a personal computer. In addition, the television and computer industries are developing new set-top boxes for broadband communications via cable and satellite. As shown in Figure 3.1.2-5, Paul Kagan Associates Inc. estimates that while 20,000 users access the Internet via television today, that number will grow to 6 million by 2002.

Figure 3.1.2-5: Internet TV Projections



Source: Paul Kagan Associates, 1997

The rapid growth of the Internet (and intranets) are not sources of increased demand, but rather a reflection of it. Hardware improvements have afforded end-users enormous power to consume bandwidth, while software advancement has increased the richness and flexibility of applications, further increasing bandwidth demands. As businesses, institutions, schools, and individuals seek to interconnect with more and more powerful, inexpensive information appliances for ever more practical uses, demand for data transport will only increase. The original Astrolink™ System design anticipated an annualized WWW growth rate of 70%. The actual annual growth rate since 1995 has exceeded 100%. The Astrolink-Phase II™ System is designed to augment the original Astrolink™ System to meet the increased demand for affordable, on-demand broadband connectivity.

3.1.3. Multinational Enterprises and the Broadband Market

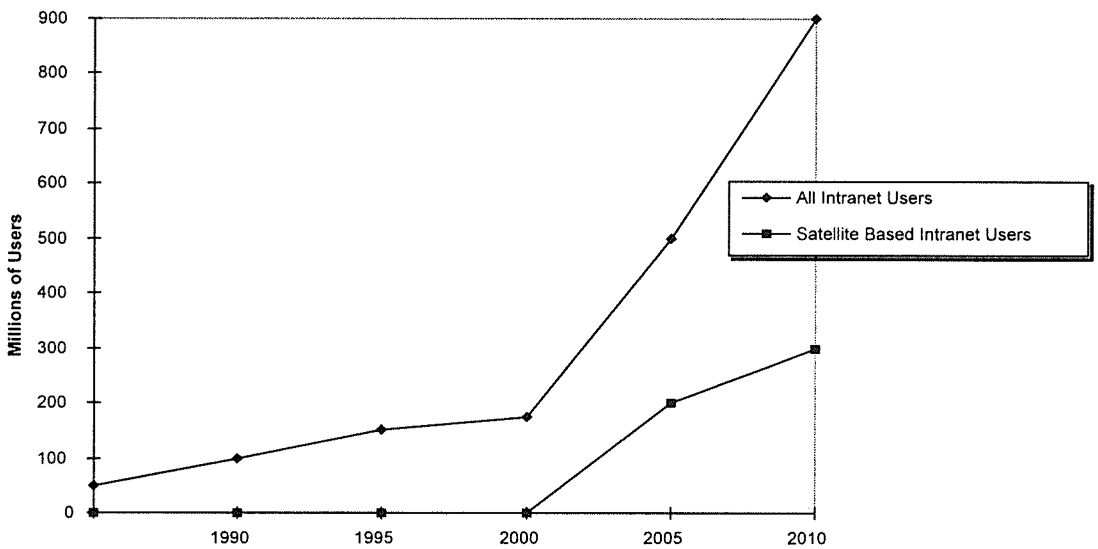
Forecasts reflected in industry reports, ITU data, and Lockheed Martin's independent analysis indicate that the total market for high capacity broadband data transport will grow from $65 billion in 1996 to $471 billion by 2006, a greater than 700% increase over 10 years. A key component of this growth is the increasing demand for broadband connectivity by large multinational enterprises. Figure 3.1.3-1 illustrates the globally dispersed operating environment of the 25 largest global companies.

Figure 3.1.3-1 - Subsidiary and Division Headquarters of the 25 Largest Global Companies

Figure 3.1.3-1 shows that in both developing and developed regions, demand for broadband capacity by large enterprises remains concentrated in certain geographic areas. The Astrolink-Phase II™ System will allow Lockheed Martin to focus additional bandwidth into these high traffic areas in developed and emerging markets. Figure 3.1.3-2 shows the LMT/IDC forecast for demand in corporate intranet connections from 1990

to 2010. A total of 175 million intranet users is estimated by 2000 and by 2005 that number is expected to grow to 500 million. While a portion of this demand will be served by terrestrial services, satellite-based offerings are expected to serve 300 million users by 2010. The Astrolink-Phase II™ System is flexible and versatile enough to meet these and other corporate data communications needs.

Figure 3.1.3-2 - Demand for Intranet Connection



Source: LMT/IDC (1996)

3.1.4. Shortage of Capacity

As discussed above, demand for data transport has greatly outpaced the capability of the existing telecommunications infrastructure -- most of which was never intended to carry primarily data traffic -- leaving much of the potential of more sophisticated customer premises equipment ("CPE") untapped. For example, in a study released June 21, 1996, entitled "Impacts of Internet Traffic on LEC Networks and Switching

Systems," Bellcore found that expanding switching and trunking of the existing PSTN would provide only an interim solution:

> Trunking solutions, however, do not address the central problem of Internet traffic, which is that the Public Switched Telephone Network is not designed to efficiently carry packet data traffic . . . . Any long term solution will necessarily involve a staged migration from the present mode of operation to some data network solution.

However, it is not just the local loop that is falling behind the demand curve. The explosive growth of the Internet and other data networks is driving data transport on undersea cables towards saturation levels. The planned investment for undersea cables will not be able to keep up with the high bandwidth demand for transcontinental traffic and will likely result in capacity shortages as early as 1999. Alternative communications networks that can be widely deployed in a short time and that carry both local and global communications traffic are needed to meet this burgeoning demand.

3.2. PLANNED SERVICES

Lockheed Martin's Astrolink-Phase II™ System will give the combined Astrolink™ System the bandwidth and flexibility needed to meet the demands of a more robust broadband market. The Astrolink-Phase II™ System will launch and operate as an integral part of the Astrolink™ System, and will provide all of the services proposed to be the provided by Astrolink™ System.

The Astrolink™ and Astrolink-Phase II™ Systems are designed to provide on-demand, two-way broadband communications with a wide range of data rates. The combined system provides the following performance and cost advantages to meet the varying communications needs. The Astrolink™ and Astrolink-Phase II™ Systems plan to offer the following services:

- Videoconferencing
- Voice and video messaging
- Telemedicine
- Distance Learning
- Hybrid Networks
- Wireless Backbone for Worldwide Financial and Business Information Databases and Networks
- Workforce Training
- Satellite News Gathering/Other Temporary Communications Links
- Distribution of Software, Music, Scientific Data and Weather Information, etc.
- Telecommuter Connections
- Bandwidth on Demand to Mobile Computer Users
- Global Internet Service
- Monitoring/Data Retrieval
- WAN, LAN and Private Interconnections
- Value-Added Services
- Groupwork

Support for multiple protocols and the Systems' inherent scalability allows users to define their own services and to vary usage levels and applications at will.

The Astrolink™ System, combined with the Astrolink-Phase II™ System, will respond to the rapidly growing need for flexible, high rate, interactive, low-cost communications that connect users wherever demand exists—in homes, offices, government sites, rural villages, and even remote outposts. The Astrolink™ and Astrolink-Phase II™ Systems will offer new opportunities to bring doctors closer to their patients, teachers closer to their students and parents closer to their children. Lockheed Martin's Astrolink™ and Astrolink-Phase II™ seek to extend the promise of the digital revolution to the world.

3.3. NON-COMMON CARRIER STATUS

Lockheed Martin elects to provide all capacity on the proposed Astrolink-Phase II™ System on a non-common carrier basis pursuant to the Commission's *DISCO I*

Order and Section 25.114(c)(14) of the Commission's rules.[3] Lockheed Martin will tailor services to meet the needs of individual customers and expects that capacity on the Astrolink-Phase II™ satellites will be marketed to various telecommunications providers who will, in turn, offer services to end users.

4. TECHNICAL DESCRIPTION

4.1. ORBIT LOCATIONS

The selection of appropriate orbit locations is of paramount importance to the Astrolink-Phase II™ System because the system is designed to supplement the capabilities of Lockheed Martin's previously-licensed Astrolink™ System and to operate in conjunction with Lockheed Martin's proposed Q/V-band satellite system. The Astrolink-Phase II™ orbit locations have been selected to maximize Ka-band coverage capabilities and to permit the efficient use of ISLs between Astrolink™ and Astrolink-Phase II™ satellites. The Astrolink-Phase II™ orbit locations will also permit Lockheed Martin to direct Ka-band capacity from Astrolink™ and Astrolink-Phase II™ satellites to the same service area, providing increased system reliability and additional capacity to respond to changes in telecommunications demand. Additionally, the selected orbit locations will facilitate the eventual use of dual-frequency earth stations to communicate with near-collocated Astrolink-Phase II™ and Q/V-band satellites.

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[3] *Amendment to the Commission's Policies Governing Domestic Fixed Satellites and Separate International Satellite Systems*, Report and Order, 11 FCC Rcd 2429 (1996) ("*DISCO I Order*").

Lockheed Martin seeks five orbit locations for the Astrolink-Phase II™ System. Table 4.1-1 lists the orbit locations selected and the primary coverage areas for each orbit location.

Table 4.1-1 - Proposed Astrolink-Phase II™ System Orbit Locations

Orbit Location	Primary Coverage Area
127°W	West Americas and the Pacific
79°W*	Americas
52°E*	Europe, Africa, West Asia
99°E*	Asia
151.5°E	East Asia, Australasia

*Asterisks denote Astrolink-Phase II™ orbit locations that are within 0.2° of orbit locations requested for Lockheed Martin's proposed Q/V-band system.

Lockheed Martin submitted a timely filed request in the first Ka-band processing round to substitute the 2°E orbit location for the 38°E orbit location that was previously assigned to Lockheed Martin. This request remains pending and Lockheed Martin expects it will be granted in due course. If, however, the Commission does not assign to Lockheed Martin the 2°E orbit location pursuant to the first Ka-band processing round, then Lockheed Martin requests that 2°E be assigned to it as a priority location under this Astrolink-Phase II™ application, in which event Lockheed Martin would forego its request herein for the 127°W location.

Figures 4.1-1(a) to 4.1-1(e), below, show the elevation contours of a user on the earth for the selected orbit locations. Elevation contours are shown at 20° and 30°. The 65 cm user terminal typically will require a minimum of 30° elevation, depending on the link availability required, while 90 cm and larger user terminals and gateway earth stations can operate with minimum elevation angles of 20°.

Figure 4.1-1(a) - 20° and 30° Elevation Contours for Astrolink-Phase II™ Satellite at 127°W

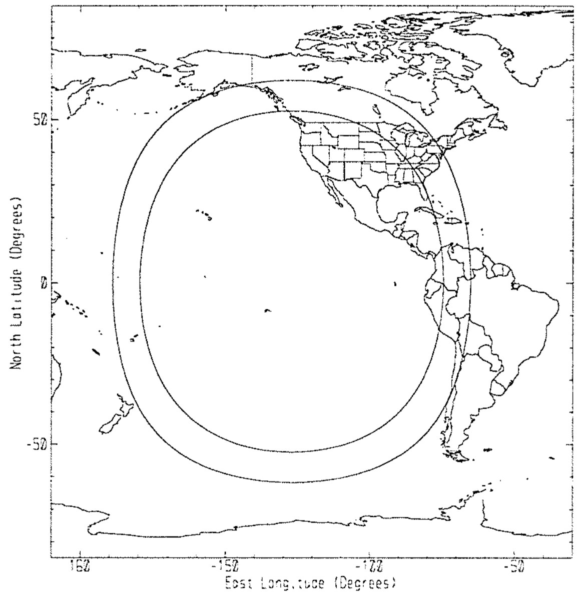


Figure 4.1-1(b) - 20° and 30° Elevation Contours for Astrolink-Phase II™ Satellite at 79°W

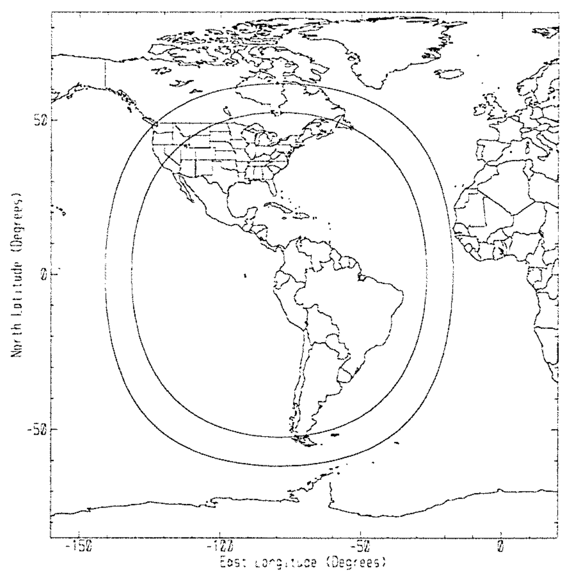


Figure 4.1-1(c) - 20° and 30° Elevation Contours for Astrolink-Phase II™ Satellite at 52°E

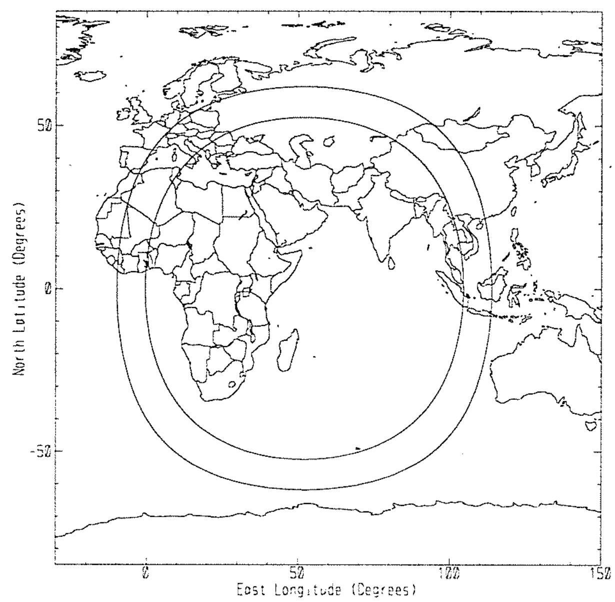


Figure 4.1-1(d) - 20° and 30° Elevation Contours for Astrolink-Phase II™ Satellite at 99°E

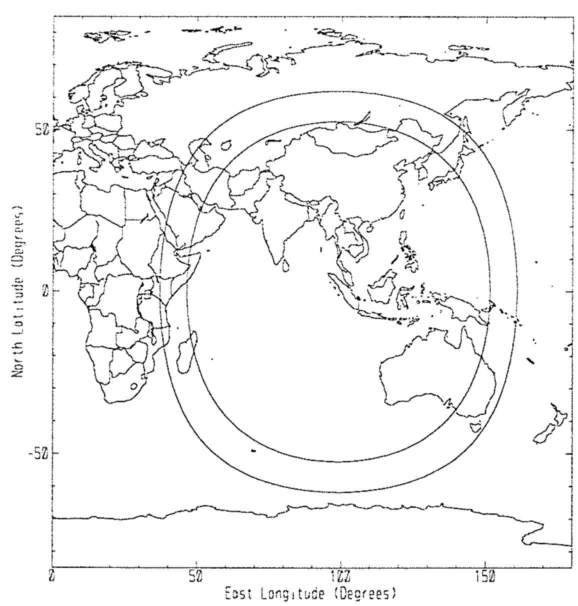
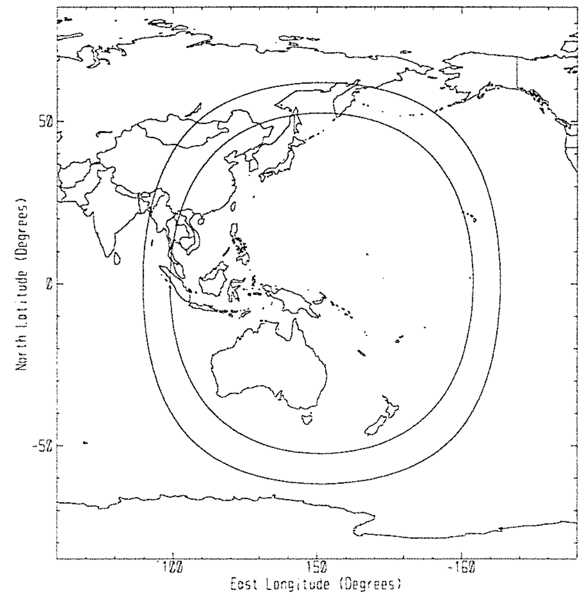


Figure 4.1-1(e) - 20° and 30° Elevation Contours for Astrolink-Phase II™ Satellite at 151.5°E



ISLs connecting Astrolink™ and Astrolink-Phase II™ satellites will ensure full interconnectivity among widely separated Astrolink™ customers around the globe. The use of ISLs will reduce end-to-end signal delay (relative to the use of a double-satellite hop) and will avoid the need for terrestrial turn-around services, thereby promoting spectral efficiency. LISLs will interconnect individual satellites of the Astrolink-Phase II™ system with nearby collocated satellites of other compatible networks, such as Lockheed Martin's Q/V-band system, as well as additional Astrolink-Phase II™ satellites which may be launched in the future to augment system capacity.

For the LISLs to function, however, the satellites should preferably not be so close together that the view direction of the LISL between the spacecraft is occluded by the body of either spacecraft or their respective appendages (such as solar array panels). For this reason Lockheed Martin is requesting an orbital location offset of 0.2° in longitude between the Astrolink-Phase II™ satellites and the Lockheed Martin Q/V-band orbit locations.

As described above, the five orbit locations have been carefully selected to meet the mission requirements of the Astrolink-Phase II™ System in light of the operational characteristics of the Ka-band. For example, high elevation angles from user terminals and gateway earth stations must be maintained in order to minimize the significant propagation impairments resulting from atmospheric and rain effects experienced at Ka-band. The proposed orbit locations will permit a large proportion of the land areas of the Earth to view at least one satellite at sufficiently high elevation angles, will facilitate the Astrolink-Phase II™ System's ability to meet growing demand for telecommunications capacity, will permit Lockheed Martin to provide additional capacity to high-traffic areas, and will allow the Astrolink-Phase II™ System to complement the services provided by other compatible systems such as Lockheed Martin's proposed Q/V-band system through interconnection with LISLs and the use of dual-frequency earth stations. Lockheed Martin plans to use dual-frequency earth stations capable of communicating simultaneously with the Astrolink-Phase II™ satellites and Lockheed Martin's proposed Q/V-band satellites. In view of these requirements, certain Astrolink-Phase II™ orbital locations must be within 1° of the planned Q/V-band orbital slots, although somewhat more flexibility exists with respect to the assignment of other proposed orbit locations. Of course, Lockheed Martin will work with the Commission to develop an appropriate orbital assignment plan for GSO system applicants in the second Ka-band processing round.

4.2. SYSTEM COVERAGE

Astrolink-Phase II™ satellite service link coverage will be composed of multiple spot beams, including up to 64 transmit and receive beams serving user terminals and up to 24 transmit and receive beams serving either large user terminals or gateway earth stations. Each spot beam will have a nominal beamwidth of 1° and a nominal bandwidth of 125 megahertz. The beams will be circularly polarized and up to 32 of the user beams will employ both orthogonal polarizations to double the capacity available to a single coverage area. The remaining beams will employ a single polarization. The coverage plots shown in Figures 4.2-1(a) through 4.2-1(e) illustrate the coverage that the Astrolink-Phase II™ System is capable of providing from each of the selected orbital locations. These figures are representative of both the receive and transmit functions. The Astrolink-Phase II™ System will provide geographically dispersed beam coverage throughout the depicted regions targeted primarily to large population centers and other areas of high traffic demand.

Figure 4.2-1(a) - Beam Coverage from the 127°W Orbit Location

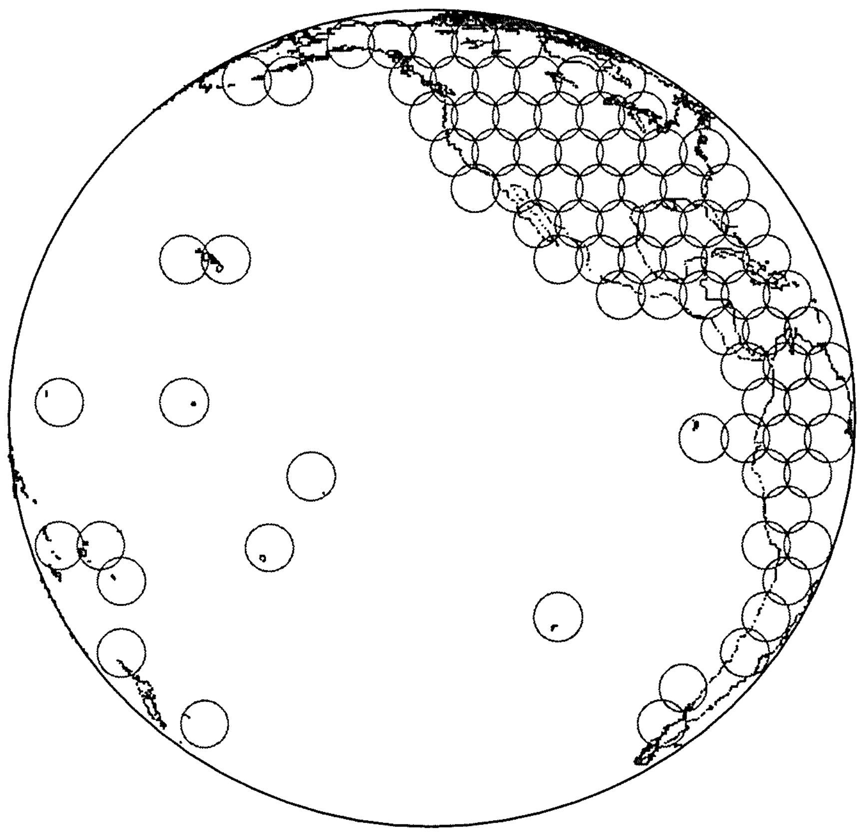


Figure 4.2-1(b) - Beam Coverage from the 79°W Orbit Location

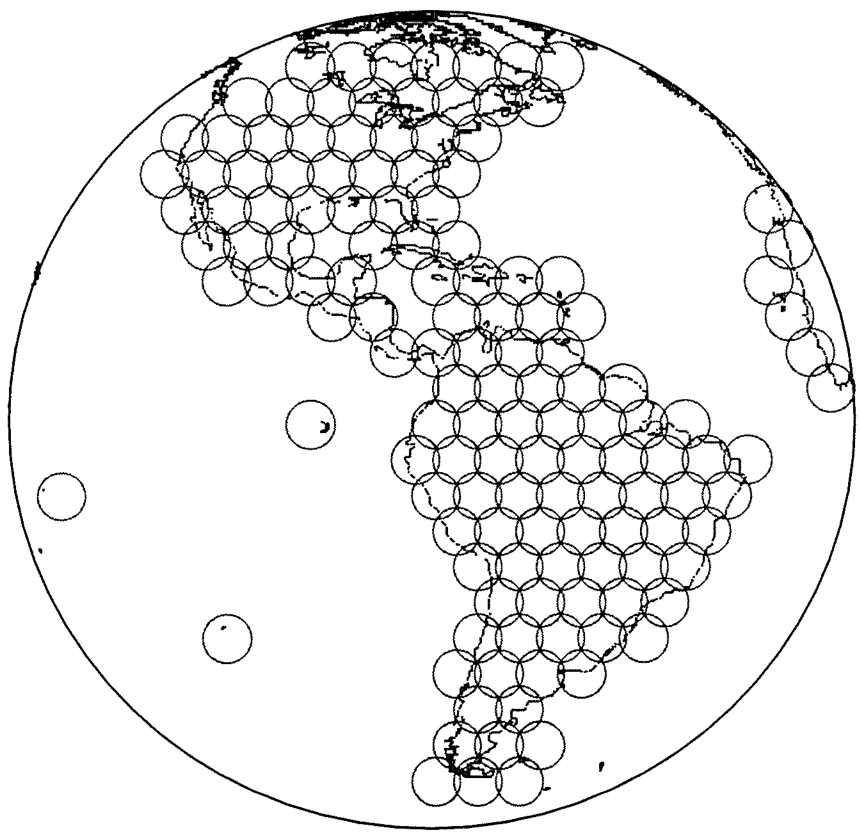


Figure 4.2-1(c) - Beam Coverage from the 52°E Orbit Location

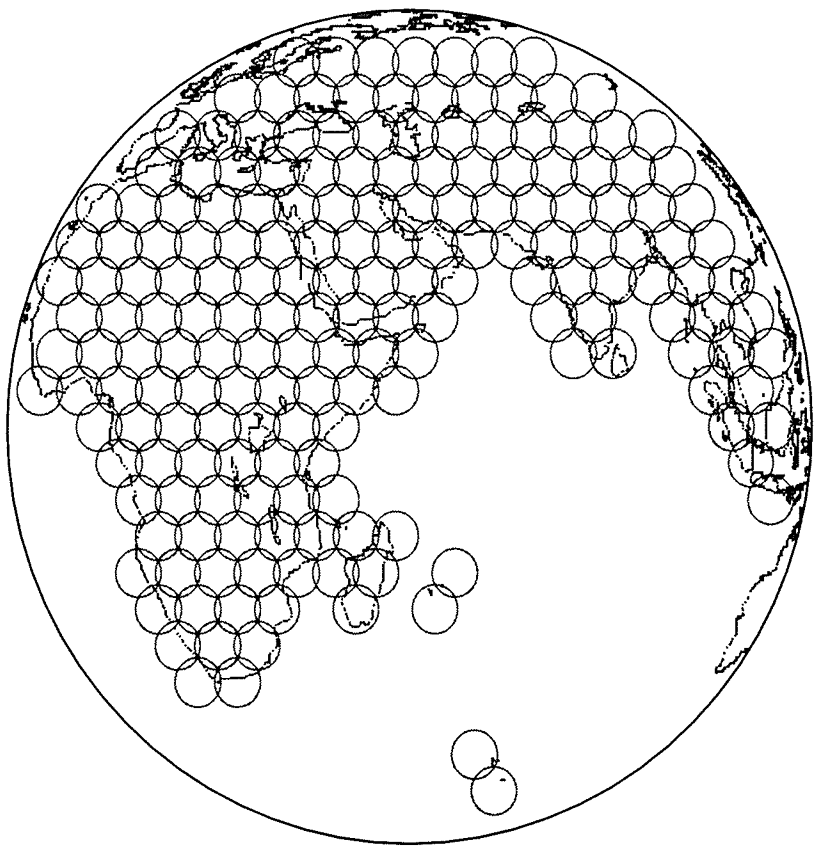


Figure 4.2-1(d) - Beam Coverage from the 99°E Orbit Location

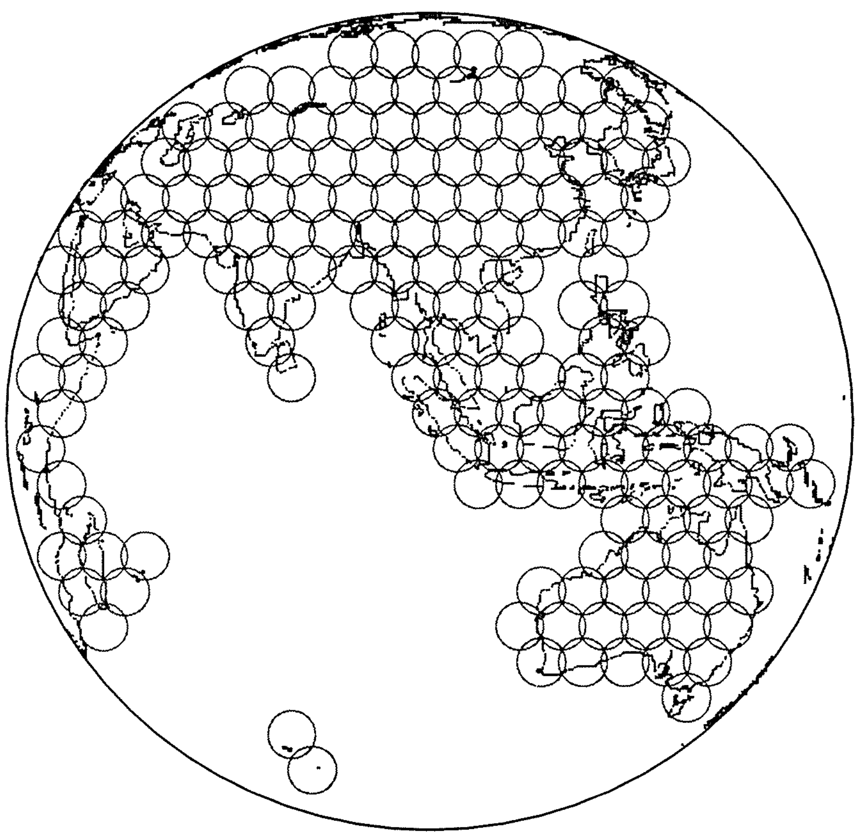
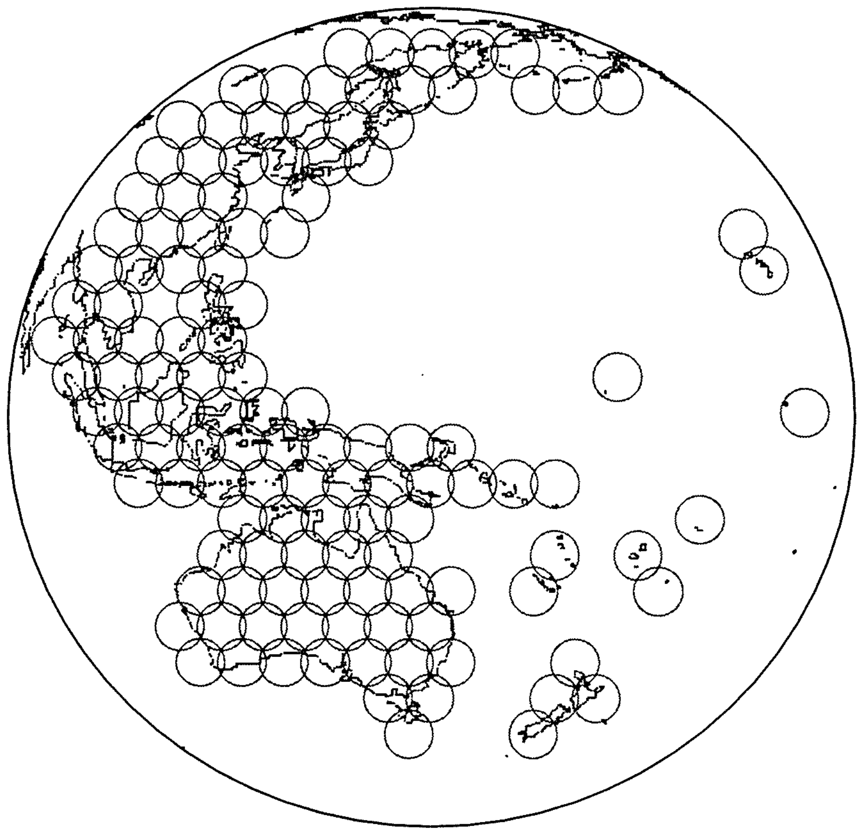


Figure 4.2-1(e) - Beam Coverage from the 151.5°E Orbit Location



Figures 4.2-2(a) and (b) shows the gain contours for a typical coverage beam. These contours are representative of receive and transmit functions for both user and gateway beams at all orbit locations.

Figure 4.2-2(a) - Representative User and Gateway Spot Beam Contours for the 79°W Orbit Location

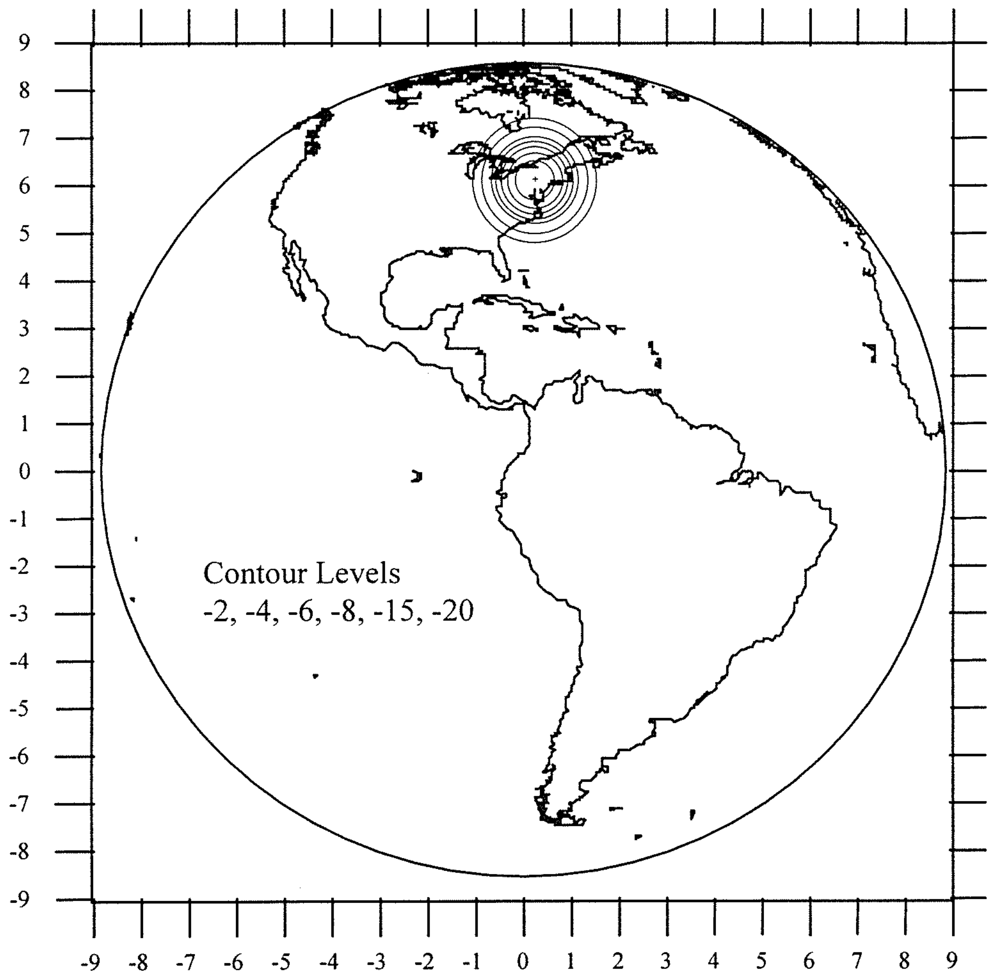
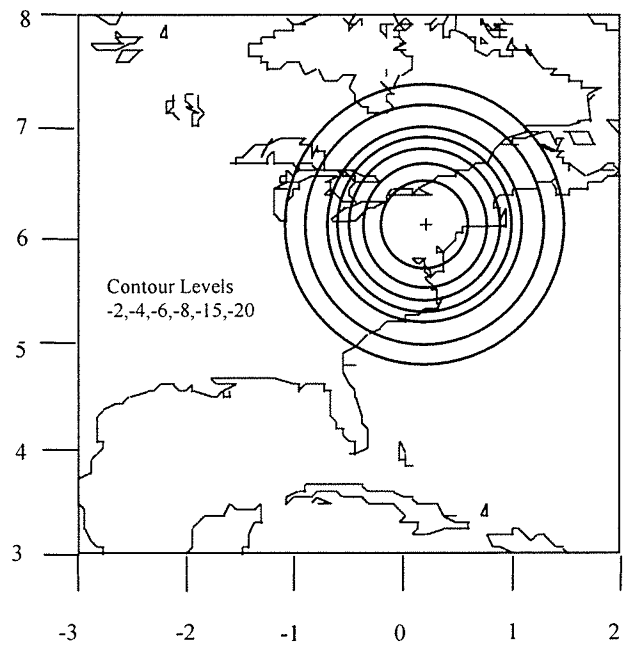


Figure 4.2-2(b) - Representative User and Gateway Spot Beam Contours for the 79°W Orbit Location (Regional View)



4.3. FREQUENCY AND POLARIZATION PLANS

4.3.1. ITU AND FCC ALLOCATIONS

As set forth in Table 4.3.1-1, the 17.8-19.3 GHz band and the 19.7-20.2 GHz band are allocated internationally to FSS (space-to-Earth) on a primary basis, with the lower frequency band also allocated in its entirety on a co-primary basis to the terrestrial fixed and mobile services. Portions of that band are also allocated to the broadcasting satellite, mobile-satellite, Earth exploration-satellite, and space research services on a co-primary or secondary basis. Table 4.3.1-2 shows that the 27.85-29.1 GHz and 29.25-30.0 GHz bands are also allocated to FSS (Earth-to-space), generally on a co-primary basis with terrestrial fixed and mobile services, with portions of the bands allocated on a primary basis to the mobile-satellite service and Earth exploration-satellite service on either a co-primary or secondary basis.

Table 4.3.1-1 - ITU Downlink Allocations

<table>
<tr><th colspan="3">International Allocation to Services
17.8-19.3 GHz and 19.7-20.2 GHz (downlink)</th></tr>
<tr><td>Region 1</td><td>Region 2</td><td>Region 3</td></tr>
<tr><td rowspan="2">17.8-18.1
FIXED
FIXED-SATELLITE
MOBILE</td><td>17.8-17.8
FIXED
FIXED-SATELLITE
BROADCASTING-SATELLITE
Mobile (MOBILE until 4/1/07)</td><td rowspan="2">17.8-18.1
FIXED
FIXED-SATELLITE
MOBILE</td></tr>
<tr><td>17.8-18.1
FIXED
FIXED-SATELLITE
MOBILE</td></tr>
<tr><td>18.1-18.4*</td><td colspan="2">FIXED
FIXED-SATELLITE
MOBILE</td></tr>
<tr><td>18.4-18.6</td><td colspan="2">FIXED
FIXED-SATELLITE
MOBILE</td></tr>
<tr><td>18.6-18.8
FIXED
FIXED-SATELLITE
MOBILE except aeronautical mobile
Earth Exploration-Satellite (passive)
Space Research (passive)</td><td>18.6-18.8
EARTH EXPLORATION-SATELLITE (passive)
FIXED
FIXED-SATELLITE
MOBILE except aeronautical mobile
SPACE RESEARCH (passive)</td><td>18.6-18.8
FIXED
FIXED-SATELLITE
MOBILE except aeronautical mobile
Earth Exploration-Satellite (passive)
Space Research (passive)</td></tr>
<tr><td>18.8-19.3</td><td colspan="2">FIXED
FIXED-SATELLITE
MOBILE</td></tr>
<tr><td>19.7-20.1**
FIXED-SATELLITE
Mobile-Satellite</td><td>19.7-20.1**
FIXED-SATELLITE
MOBILE-SATELLITE</td><td>19.7-20.1**
FIXED-SATELLITE
Mobile-Satellite</td></tr>
<tr><td>20.1-20.2</td><td colspan="2">FIXED-SATELLITE
MOBILE-SATELLITE</td></tr>
</table>

* *See* S5.521 for alternative national allocations.

** *See* S5.524 for alternative national allocations.

Table 4.3.1-2 - ITU Uplink Allocations

International Allocation to Services 27.85-29.1 GHz and 29.25-30.0 GHz (uplink)		
Region 1	Region 2	Region 3
27.85-28.5	FIXED FIXED-SATELLITE MOBILE	
28.5-29.1	FIXED FIXED-SATELLITE MOBILE Earth Exploration-Satellite	
29.25-29.5	FIXED FIXED-SATELLITE MOBILE Earth Exploration-Satellite	
29.5-29.9* FIXED-SATELLITE Earth Exploration-Satellite Mobile-Satellite	29.5-29.9* FIXED-SATELLITE MOBILE-SATELLITE Earth Exploration-Satellite	29.5-29.9* FIXED-SATELLITE Earth Exploration-Satellite Mobile-Satellite
29.9-30*	FIXED-SATELLITE MOBILE-SATELLITE Earth Exploration-Satellite	

* *See* S5.542 for alternative national allocations.

With respect to U.S. non-government spectrum allocations, domestic FSS allocations exist in the 17.8-19.3 GHz and 19.7-20.2 GHz downlink bands, and in the 27.85-29.1 GHz and 29.25-30.0 GHz uplink bands. Portions of these bands are shared with a variety of other services allocated on either a co-primary or secondary basis.[4] As a

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[4] *See* 47 C.F.R. §2.106 (1997) (U.S. Table of Allocations). The U.S. Table of Allocations contains a number of footnotes governing GSO FSS operations in the proposed Astrolink-Phase II™ bands. The most pertinent of these include Footnote U.S. 255, which establishes a pfd limit of -101 dbW/m^2 for FSS downlink transmissions in the 18.6-18.8 GHz band; and Footnote U.S. 334, which requires coordination with government systems in the 17.8-20.2 GHz band. Lockheed Martin's proposed Astrolink-Phase II™ System will comply with these and all other footnotes applicable to FSS operations in the relevant bands.

result of the 28 GHz rulemaking proceeding, the FCC adopted band plans for uplink and downlink frequencies as shown in Table 4.3.1-3 and Table 4.3.1-4.

Table 4.3.1-3 - Uplink Frequency Bands

LMDS fss 850 MHz	**GSO FSS** ngso fss 250 MHz	**NGSO FSS** gso fss 500 5-1	**- TT&C Command and** ng 150 MHz	**MSS FEEDER LINKS & GSO FSS** 250 MHz	**GSO FSS** ngso fss 500 MHz

27.5 28.35 28.60 29.1 29.25 29.5 30.0 GHz

Table 4.3.1-4 - Downlink Frequency Bands

GSO FSS **FIXED** ngso fss 1100 MHz	**NGSO FSS** **FIXED** gso fss 500MHz	**MSS F.L.** **FIXED** gso fss 400 MHz	**GSO/FSS** ngso fss 500 MHz

17.70 18.80 19.30 19.70 20.20 GHz

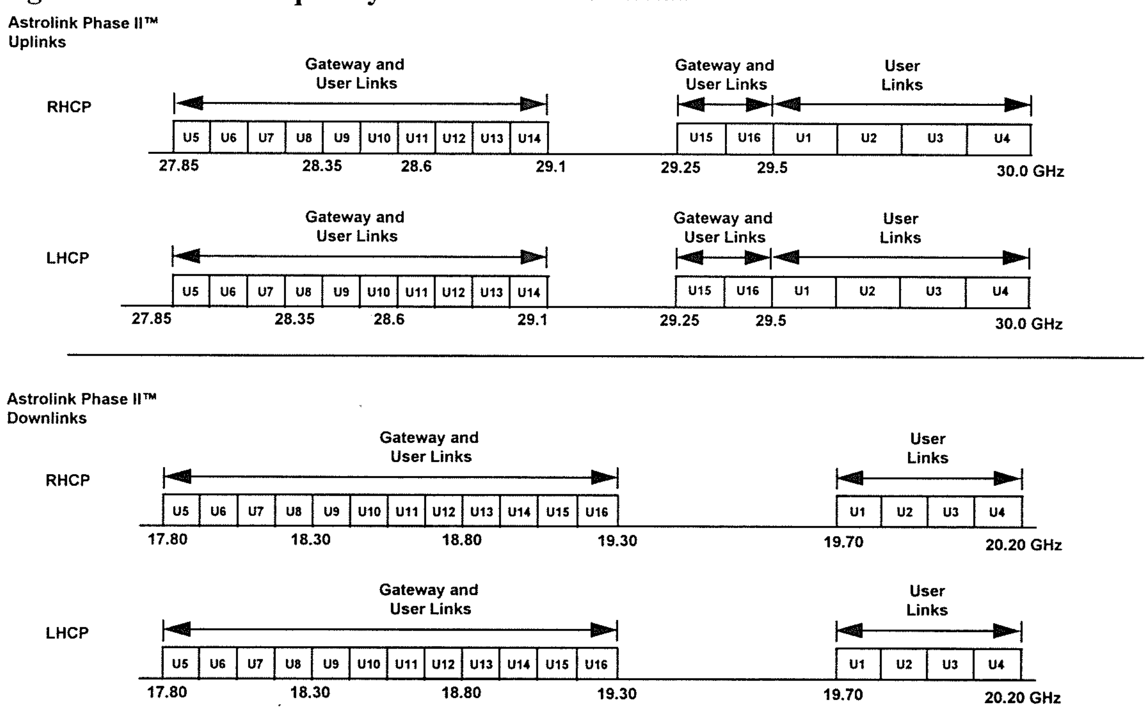
4.3.2. THE ASTROLINK-PHASE II™ FREQUENCY PLAN

4.3.2.1. Service Links

Lockheed Martin seeks to operate service links in two gigahertz of FSS spectrum in the 17.8-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth) and two gigahertz of FSS spectrum in the 27.85-29.1 GHz and 29.25-30.0 GHz bands (Earth-to-space). Because the entire two gigahertz of spectrum in each direction is allocated in the United States and internationally to FSS on either a primary or secondary basis, the proposed services of the Astrolink-Phase II™ System are consistent with relevant domestic and international allocations.

By dividing the requested two gigahertz of service link spectrum into sixteen 125 megahertz channels and using both right hand circular polarization ("RHCP") and left hand circular polarization ("LHCP"), the Astrolink-Phase II™ System will operate with up to 32 separate user channels. Figure 4.3.2.1-1 shows the intended use of the requested spectrum for Astrolink-Phase II™ service links.

Figure 4.3.2.1-1 - Frequency and Polarization Plan



The principal frequency bands for Astrolink-Phase II™ user links, in both the United States and around the world, will be the 29.5-30.0 GHz (uplink) and 19.7-20.2 GHz (downlink) bands. These 500 megahertz bands are unique in the Ka-band range of frequencies because they are not shared with any non-satellite service on a co-primary basis. Therefore, they are ideally suited for use by large numbers of small, ubiquitously deployed user terminals because they do not need to be coordinated with terrestrial services.

The Astrolink-Phase II™ System will provide U.S. and international gateway services primarily in the 28.35-28.6 GHz and 29.25-29.5 GHz (uplink) bands and the 18.3-18.8 GHz (downlink) bands. Where feasible, Lockheed Martin may also use this spectrum for communications with Astrolink-Phase II™ customers using large earth terminals, which can be more readily coordinated with other co-primary users of the bands. As described below, the other requested frequency bands will be used for certain Astrolink-Phase II™ gateway and user terminal operations. In frequencies where GSO FSS operations are secondary to other services, such operations will be constrained by the need to prevent harmful interference to primary users in the band.

In the uplink direction, Lockheed Martin plans to utilize the 27.85-28.35 GHz and 28.6-29.1 GHz bands, which are allocated internationally to FSS on a co-primary basis and designated domestically to GSO FSS on a secondary basis, for certain gateways and user terminal links. In the downlink direction, the Astrolink-Phase II™ System will use the 17.8-18.3 GHz band, which is allocated to GSO FSS on a co-primary basis with terrestrial fixed services, for certain gateway and user terminal downlinks. Lockheed Martin will provide similar services in the 18.8-19.3 GHz band, which has a secondary GSO FSS and primary NGSO FSS and fixed service allocations. Lockheed Martin will carefully deploy Astrolink-Phase II™ services in these frequency bands to ensure that their operation is consistent with co-primary or secondary status, as appropriate. Other portions of this application address the operational procedures that the Astrolink-Phase

II™ System will employ to share spectrum on a co-primary or secondary basis with other services in the relevant bands.

As stated previously, the requested two gigahertz of uplink and downlink spectrum will be divided into sixteen (16) 125 megahertz channels. In the space-to-Earth direction, each of these channels is occupied by a single carrier employing quadrature phase shift keying ("QPSK") modulation. The modulation signal of Astrolink-Phase II™ downlinks consists of time division multiplexed ("TDM") information destined for multiple users or gateways in sequence. A net data-rate of approximately 102.4 Mbps is available on each user downlink carrier and 113.8 Mbps is available on each gateway carrier.[5]

In the Earth-to-space direction, Astrolink-Phase II™ users access the system using a Frequency Division Multiplex/Time Division Multiplex ("FDM/TDM") scheme. In this case, each of the 125 megahertz uplink channels is further subdivided into up to three levels of sub-bands as depicted in Figure 4.3.2.1-2. Utilization of these sub-bands is described in Section 4.5.2, below.

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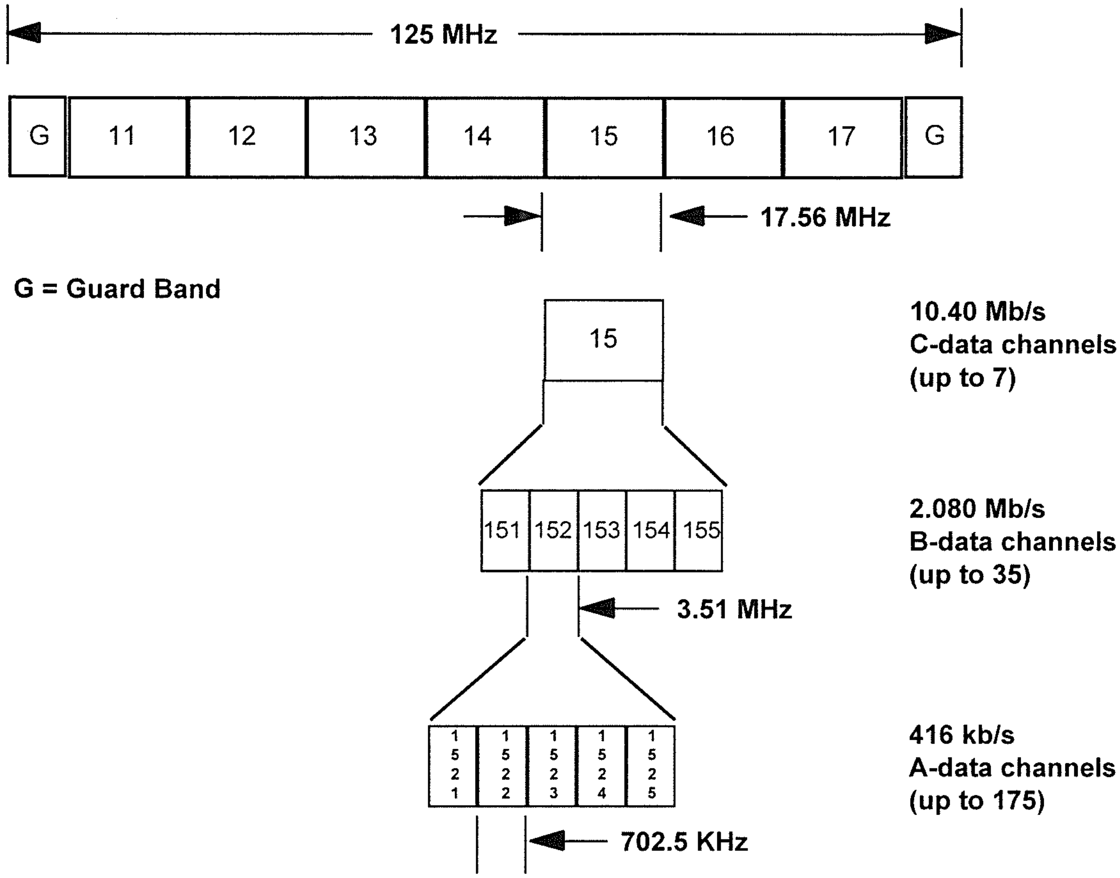
[5] All data-rates quoted are net user data-rates after removal of ATM cell overhead, and adaptive forward error correction ("FEC") coding.

Figure 4.3.2.1-2 – Typical Uplink Service Band Sub-Division Scheme



4.3.2.2. Inter-Satellite Links ("ISLs")

Each of Lockheed Martin's Astrolink-Phase II™ satellites must be able to communicate with other Astrolink-Phase II™ satellites on orbit to pass communications traffic between users served by different satellites. Each satellite will employ a maximum of three transmit/receive ISL beams. Two of the ISL beams will be capable of long range communications and will be used to communicate to and from other Astrolink-Phase II™ or Astrolink™ satellites in other orbital locations. The remaining LISL beam will be designed for short range communications only and will be used to communicate with other compatible satellites located within 1° in longitude, such as satellites of the proposed Lockheed Martin Q/V-band system, in order to provide connectivity between the two networks.

Each of the ISL beams will operate at a data rate of 500 Mbps (net circuit capacity after removal of ATM cell header overhead) in each direction, and will require 600 MHz of frequency spectrum in each direction of transmission. For the long range ISLs, each Astrolink-Phase II™ satellite will utilize a maximum of 0.6 gigahertz x 3 frequencies = 1.8 gigahertz. The short range LISLs will employ considerably lower power transmitters and lower gain antennas. Thus, there will be a significant difference in antenna beamwidth and signal levels, both transmitted and received, between the long range ISLs and the LISLs. For this reason it is proposed to operate the LISLs at another pair of frequencies separate from the long range ISLs, preferably in a different band. The LISLs of all the Astrolink-Phase II™ satellites will operate with the same LISL transmit and receive frequencies. Thus, the entire Astrolink-Phase II™ constellation requires a maximum of 0.6 gigahertz x 5 frequencies = 3.0 gigahertz.

The ISL frequency plan for the long-range ISLs employs three possible frequency channels, with guard band gaps between them. The gaps between the channels , which must be no less than 1.075 GHz, are required to isolate the transmitters from the receivers on the satellite. For the long range ISLs, Lockheed Martin proposes to use either the 54.25-58.2 GHz or 59-64 GHz ISL bands. While the 65-71 GHz ISL band is not Lockheed Martin's preferred ISL spectrum, it could alternatively be used for the Astrolink-Phase II™ System, if the preferred ISL bands are not available.

The LISLs are proposed to operate in lower frequency ISL bands, because their low-power and short-range characteristics enable them to share with other ISL systems.

Therefore, Lockheed Martin proposes to use one 600 MHz LISL channel in the 22.55-23.55 GHz ISL band and the other 600 MHz LISL channel in the 32.0-33.0 GHz ISL band. An alternative, but less attractive option, would be to operate these two LISL channels, with a 1.075 GHz guard band between them, in the 65-71 GHz ISL band.

Lockheed Martin believes that the final ISL channel plan can only be determined after considering the requirements of all ISL systems operating in the bands. Therefore, Lockheed Martin recommends that an informal industry working group be established to develop such a plan.

4.3.2.3. Tracking, Telemetry, and Control ("TT&C")

Due to the high propagation impairment of signals in the Ka-band resulting from atmospheric and weather effects, Lockheed Martin proposes to perform transfer orbit and on-station TT&C functions in a portion of the extended C-band (within 3650-3700 MHz for telemetry functions and within 6425-6525 MHz for command functions).[6] The

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[6] A petition for rulemaking to designate a portion of extended C-band spectrum for TT&C operations of GSO FSS space stations operating in bands above Ku-band has been filed with the Commission. *See Amendment of Parts 2 and 25 of the Commission's Rules to Designate Extended C-band Spectrum for TT&C Functions of GSO FSS Systems Operating in Bands Above Ku-band*, Petition for Rulemaking (Aug. 7, 1997) (filed by Comm, Inc., EchoStar Satellite Corp., GE American Communications, Inc., Hughes Communications Galaxy, Inc., KaStar Satellite Communications Corp., Lockheed Martin Corp., Orion Network Systems, Inc., PanAmSat Licensee Corp., and VisionStar, Inc.). To the extent that these frequencies are not made available for TT&C functions of Ka-band systems, Lockheed Martin hereby reserves the right to request other TT&C frequencies consistent with the Commission's rules.

specific Astrolink-Phase II™ TT&C frequencies are subject to the outcome of coordination with existing users in the band.[7]

4.4. FREQUENCY RE-USE AND SYSTEM CAPACITY

The two gigahertz of Ka-band spectrum requested for the Astrolink-Phase II™ System's communications links will be divided into 125 megahertz channels. Lockheed Martin intends to use the uppermost 500 megahertz of each band (19.7-20.2 GHz for space-to-Earth links and 29.5-30.0 GHz for Earth-to-space links) as the principal Astrolink-Phase II™ user link spectrum, for the reasons set forth in Section 4.3.2.1. Each 500 megahertz band will accommodate four 125-megahertz user terminal channels in each orthogonal polarization, which will be allocated to the Astrolink-Phase II™ satellites' fixed spot beams using a four-cell frequency re-use pattern. This re-use scheme is shown in Figure 4.4-1, with the numbers within each beam indicating the particular 125 megahertz channel allocated to that beam. Note that no adjacent beams have the same channels allocated to them, and that every beam is isolated from a co-frequency beam by at least one beam spacing as indicated by the shaded beams numbered "1" in Figure 4.4-1. This achieves a beam-to-beam isolation for co-frequency, co-polarized beams of greater than 18 dB using the Astrolink-Phase II™ antenna design, thereby providing sufficient isolation to permit frequency re-use without unacceptable interference.

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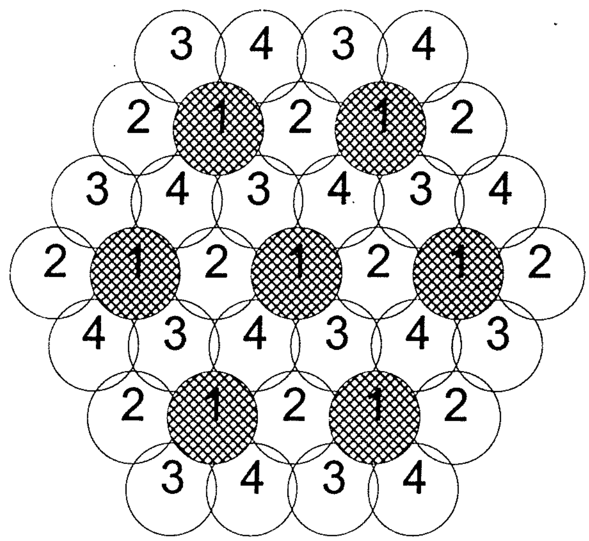
[7] Tentative TT&C frequencies are provided in Table 4.6.3-1.

Figure 4.4-1 - Frequency Re-Use Pattern



Each Astrolink-Phase II™ satellite will support up to 64 simultaneously active user service channels. In the principal 500 megahertz user frequency band, a very high degree of frequency re-use is achieved. Assuming the maximum number of 64 user channels, 32 in each polarization, a total reuse factor of 16 times is achieved. Each Astrolink-Phase II™ satellite can therefore produce an aggregate transmission bandwidth for user beams of up to eight gigahertz in each direction of transmission.

Each Astrolink-Phase II™ satellite will support up to 24 simultaneously active 125 megahertz gateway/user channels. Lockheed Martin proposes to operate these gateway/user links in the 18.3-18.8 GHz band (space-to-Earth) and in the 28.35-28.6 GHz and 29.25-29.5 GHz bands (Earth-to-space). The 500 megahertz downlink band would be subdivided into four 125 megahertz channels, while each of the 250 megahertz uplink bands would be divided into two 125 megahertz channels. To facilitate sharing these bands with other services, only one polarization would be used in each gateway/user beam. Thus, a total frequency reuse of up to six times can be achieved for gateway/user beams. Each Astrolink-Phase II™ satellite can produce an aggregate transmission bandwidth for gateway/user beams of up to three gigahertz.

As discussed in Section 4.3.2.1, Lockheed Martin will use an additional one gigahertz of spectrum in each direction for gateway and user links. The 17.8-18.3 GHz and 18.8-19.3 GHz bands would each be subdivided into four downlink channels, and the 27.85-28.35 GHz and 28.6-29.1 GHz bands would each be subdivided into four uplink channels. These supplemental channels would be used to provide additional gateway/user beam capacity in areas where co-primary sharing or secondary operation is possible. For example, channels in the 27.85-28.35 GHz band could be used in some areas outside of primary LMDS markets, such as rural areas. Additionally, channels in the 28.6-29.1 GHz and 18.8-19.3 GHz bands could be used for services that could share with NGSO satellites.

Lockheed Martin recognizes that all supplemental channels may not be available for use by every Astrolink-Phase II™ satellite, and that selection of active channels would depend on coordination between systems and local sharing scenarios. Because the use of supplemental channels may be constrained by the outcome of coordination or secondary operations, these channels are not relied upon to increase net system capacity. Rather, these supplemental channels permit Lockheed Martin to deploy the Astrolink-Phase II™ System capacity in areas where it can be more fully utilized.

Each Astrolink-Phase II™ satellite supports a total Ka-band transmission bandwidth of up to 11 gigahertz. With the modulation and coding schemes utilized, this Ka-band transmission bandwidth will support the traffic given in Table 4.4-1 below.

Table 4.4-2 - Maximum Ka-Band Traffic Capacity

	Number of Beams*	Per Beam	Per Satellite
User Channels**	44-64	102.4 Mbps	4.5-6.5 Gbps
Gateway Channels**	14-24	113.8 Mbps	1.6-2.7 Gbps
Total	-	-	6.1-9.2 Gbps

* Total number of beams will be optimized.
** Net data rates after removal of ATM headers and other overheads.

4.5. NETWORK PROTOCOL AND TRANSMISSION SCHEMES

4.5.1. NETWORK PROTOCOL

The Astrolink-Phase II™ System is designed to support the TCP/IP standard as well as applications which require a guaranteed quality of service ("QoS") level that are not TCP/IP based, such as MPEG compressed digital video and multimedia. Asynchronous Transfer Mode ("ATM") technology was developed specifically to support transmission of data and multimedia content in an integrated manner, the same applications foreseen for the proposed system. Thus, a network architecture based on the ATM Protocol has been selected for the Astrolink-Phase II™ System.

Industry and international standards are being developed for transmission of nearly every existing data protocol and application via ATM and for interoperability between ATM and other networks, including the Internet.[8] In addition, the small fixed size of ATM cells is well suited for implementing the high-utilization Demand Assigned Multiple Access ("DAMA") "bandwidth on demand" architecture required by the Astrolink-Phase II™ System's large user base.

4.5.2. TRANSMISSION SCHEMES

Each 125 megahertz downlink channel in the Astrolink-Phase II™ System will contain a single QPSK modulated carrier with a time division multiplexed ("TDM") data stream carrying the information to all users assigned to that channel. The downlink data stream employs a powerful proprietary adaptive TDM technique which involves the utilization of two levels of forward error correction coding, one used to communicate with terminals in clear air conditions and the other during periods of rain fade. The additional level of error correcting coding adds robustness to the affected channels to offset the bit error rate degradation due to the rain fade. This adaptive TDM scheme results in very efficient overall utilization of the downlink, as only those terminals affected by rain at any given instant require the additional overhead of the second level of coding. The aggregate net downlink rate supported by each channel is approximately 102.4 Mbps.[9]

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[8] *See* ATM Forum Document af-saa-0049.001, Video on Demand Specification 1.1, and Document af-vtoa-0078.000, Circuit Emulation Service Interoperability Specification 2.0; *see also* Internet Engineering Task Force, Document RFC1932, IP over ATM: A Framework Document.

[9] The data-rates quoted here are net user data-rates after removal of ATM header information, frame sync, and other system overhead.

In the uplink direction, each 125 megahertz channel in the Astrolink-Phase II™ System is subdivided into seven 17.56 megahertz sub-bands. Each of these sub-bands can be subdivided into five 3.51 megahertz second-level sub-bands, which can, in turn, be subdivided into five 702.5 kilohertz third-level sub-bands.

Each of the three sub-band levels corresponds to one of the three Astrolink-Phase II™ standard burst rates utilized by all service uplinks. Each user terminal always communicates at one of these standard burst rates but, by using variable portions of the data frame, can effectively communicate at a net data-rate that can be varied from 16 kbps to the maximum rate for its terminal class in 16 kbps increments. This unique FDM/TDM scheme provides the Astrolink-Phase II™ System with great flexibility in the dynamic assignment of bandwidth among users based on terminal class and quality of service requested, promoting efficient utilization of available satellite capacity and scarce spectrum resources.

Each first level sub-band accommodates an aggregate uplink rate of 20.8 Mbps in clear air conditions and 10.4 Mbps in rain conditions; each second level sub-band accommodates an aggregate uplink rate of 4.16 Mbps in clear air and 2.08 Mbps in rain conditions; and each third level sub-band accommodates an aggregate uplink rate of 832 kbps in clear air and 416 kbps in rain conditions. In use, any given 125 megahertz uplink channel can be subdivided into 7 high data-rate channels, 35 medium data-rate channels, 175 low data-rate channels, or a combination of high, medium and low data-rate channels. Alternately, all seven high data-rate channels can be used simultaneously for gateway services. In each 125 megahertz channel, one or more third level sub-bands will be designated for entry order wire ("EOW") service. The EOW channel is utilized by users to initially request entry into the Astrolink-Phase II™ System.

User terminals will transmit at data-rates between 16 kbps and the maximum rate for the terminal class, depending on the network capacity available. Class A and AA user terminals will be able to transmit at data-rates up to a maximum of 416 kbps. Such data-rates support rural telephony “village telephones,” and small business and individual uses such as desktop videoconferencing and Internet access. Class B user terminals will be able to transmit at data-rates up to a maximum of 2.08 Mbps. These data-rates are suitable for wide area general business applications such as corporate intranets, business Internet access, and high-quality video conferencing. Class C terminals will be able to transmit at data-rates up to a maximum of 10.4 Mbps. These data-rates are suitable for small gateways, wide-area network ("WAN") interconnection of corporate local area networks ("LANs"), and large business users.

All seven of the first level sub-bands can be used simultaneously by Astrolink-Phase II™ gateway earth stations to achieve an aggregate uplink data-rate of 145.6 Mbps.

Each of the Astrolink-Phase II™ user terminals will employ uplink power control in order to minimize the interference to other users in the same channel and to other satellite systems.

4.6. SPACECRAFT DESCRIPTION

4.6.1. GENERAL DESCRIPTION

The technical design proposed for the Astrolink-Phase II™ System takes advantage of the latest design features of Lockheed Martin's flight-proven A2100™ spacecraft and will be closely based on the satellites built for the licensed Astrolink™ System. The modular or "building block" architecture of the A2100™ allows the spacecraft to be configured to the payload's specific requirements, avoiding the cost and risk of new design development. Technology and engineering innovations have resulted in an A2100™ spacecraft platform design with only one-fifth the number of parts of earlier satellites, resulting in easier manufacturing, lower costs, increased reliability, and longer operating life in space. In addition, the A2100™ design effectively applies lightweight, composite structural components and high-efficiency thrusters for stationkeeping to reduce total launch weight dramatically, which means longer-life spacecraft, higher payload capacity, and/or reduced launch cost. Four A2100™ satellites have been launched successfully to date, including EchoStar III, which has a payload capacity similar to that of the Astrolink-Phase II™ System.

Figures 4.6.1-1 and 4.6.1-2 show the spacecraft in its stowed and in-orbit configurations, respectively. Table 4.6.1-1 summarizes the key features of the A2100™ spacecraft platform and subsystems.

Figure 4.6.1-1 - Spacecraft in Stowed Configuration for Launch

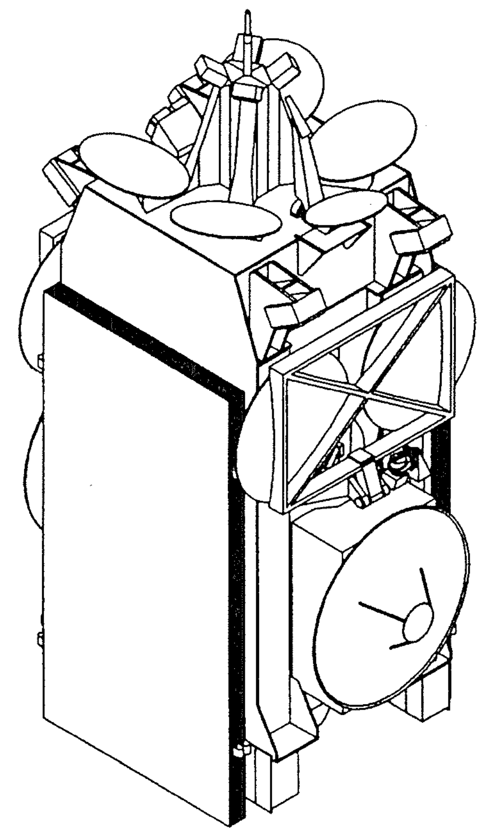


Figure 4.6.1-2 - Spacecraft in Mission Configuration In Orbit

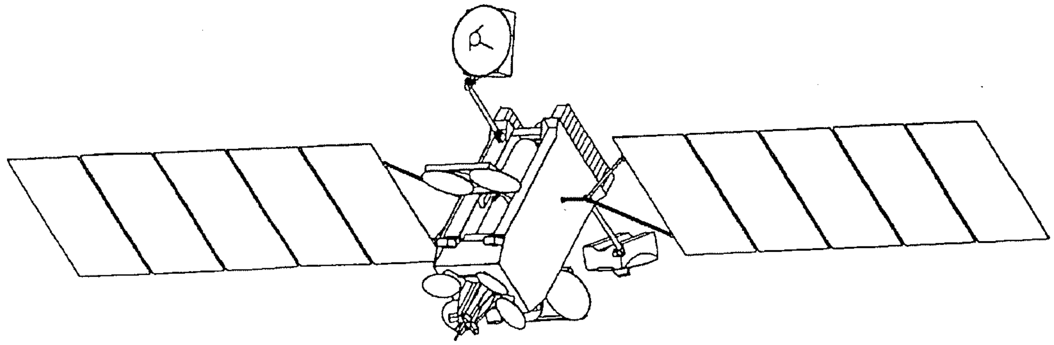


Table 4.6.1-1 - Key Features of the A2100™ Spacecraft Platform and Subsystems

General	**Astrolink-Phase II™ Mission Specific**
Design Life: 15 years	Mission Life: 12 years Platform Reliability (10 years): 0.93
Propulsion	**Attitude Determination and Control Subsystem**
Liquid "Dual-Mode" system provides all propulsive functions - Apogee Insertion: Bipropellant Mode - All other functions: Monopropellant Mode High efficiency bipropellant liquid apogee engine Thruster "Half-Systems" provide full functional redundancy High-performance arcjet thrusters for north/south stationkeeping	3-axis control system with near zero net momentum Continuous sensing and control about all 3 axes ±0.05° pointing accuracy using Earth sensors Fully autonomous fault detection, isolation, and recovery On-orbit steering and pointing offset capability Automatic execution of maneuver sequences Low-thrust rockets provide accurate control during stationkeeping
Power Subsystem	**Telemetry, Command & Ranging Subsystem**
Highly regulated, direct energy transfer power supply Single-axis multi-panel solar array using Gallium Arsenide solar cells Energy storage via nickel-hydrogen batteries Fully autonomous battery charge management	Secure command link, configurable to INTELSAT, ESA, or U.S. domestic telecommand standards Configurable to any one of four telemetry rates Reprogrammable telemetry frame contents Highly modular payload interface units provide maximum flexibility
Thermal Subsystem	**Structure/Mechanisms**
Fully passive design augmented by heaters Embedded heat pipes in payload panels Ground commandable adjustment of heater set points Battery mounting minimizes thermal gradients Conductive coatings maximize ESD protection	Highly modular structure design 3 to 1 torque margins for all deployment mechanisms All mechanisms qualified to 1.5 times design life

The preliminary spacecraft mass and power budgets are given in Tables 4.6.1-2 and 4.6.1-3.

Table 4.6.1-2 - Spacecraft Mass Budget

Item	**Mass (kg)**
Spacecraft Platform	1479
Communications Payload	967
Dry Mass Total	2446
Pressurant, Fuel & Oxidizer	2202
Liftoff Weight	4648
Liftoff Capability (Proton M)	4800
Margin	152

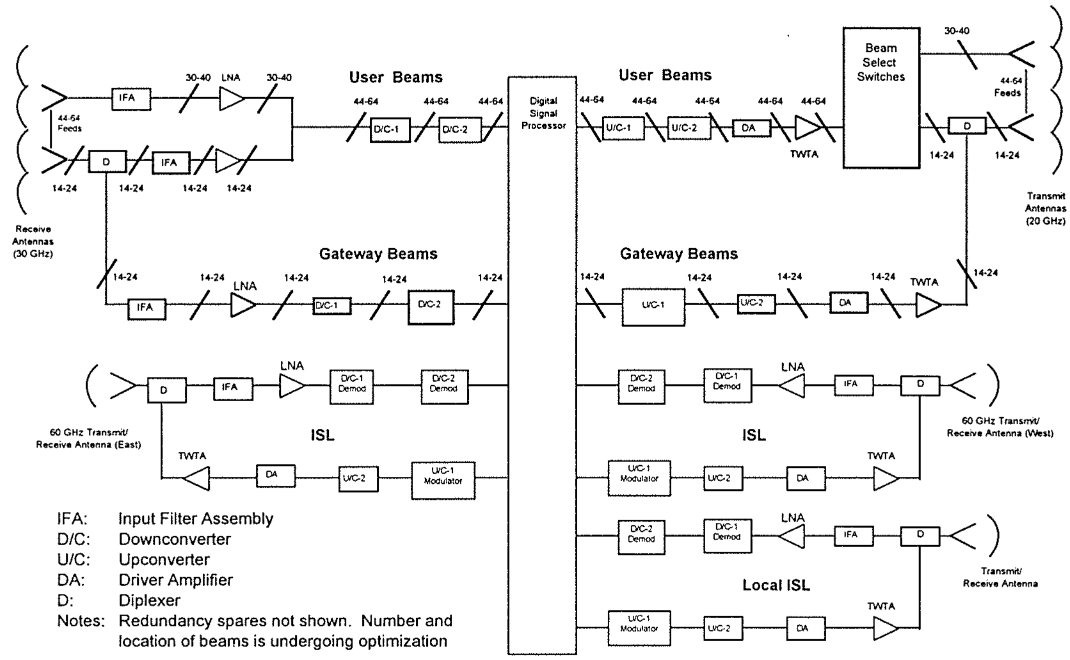
Table 4.6.1-3 - Spacecraft Power Budget

Item	**Power (Watts)**	
	Equinox Eclipse	**Summer Solstice**
Communications Payload	4767	7538
Spacecraft Platform	900	801
Battery Recharge	0	702
Spacecraft EOL Power	5667	9041
Solar Array EOL Power	N/A	9786
Margin	N/A	8.9%
Battery Depth of Discharge (Nominal)	80%	N/A

4.6.2. COMMUNICATIONS PAYLOAD

The Astrolink-Phase II™ System communications payload is a state-of-the-art design, utilizing the latest developments in sophisticated Ka-band antenna technology, powerful on-board processing, efficient Ka-band traveling wave tube amplifiers ("TWTAs"), and ISLs. A functional block diagram of the communications payload is shown in Figure 4.6.2-1. The signal flow and functions of the various equipment blocks in the communications payload are described below.

Figure 4.6.2-1 - Communications Payload Functional Block Diagram



4.6.2.1.Communications Subsystem Description

The Astrolink-Phase II™ Ka-band payload will include four pairs of parabolic antennas. Each pair consists of a receive antenna and a transmit antenna each having multiple feed horns to generate congruent receive and transmit beams. Received signals are bandpass filtered and amplified by low noise amplifiers ("LNAs"), downconverted in a two-step process to a low intermediate frequency and fed to the digital signal processor ("DSP"), where the composite received signal is digitally demultiplexed, demodulated, decoded and error corrected to recover the baseband ATM cells used for transport of all data.

Signals from the ISLs are amplified by LNAs, downconverted and demodulated externally to the DSP due to their higher data-rate. Once demodulated and decoded, the

ISL data stream consists of sequences of ATM cells that are routed by the switch fabric of the DSP in an identical manner to user terminal cells.

ATM cells from user terminals, gateways and ISLs have identical formats and are processed in an identical manner through the DSP. Entry Order Wire ("EOW") signals from user terminals requesting to access the Astrolink-Phase II™ System are recovered by a separate EOW processing channel in the DSP but, after recovery, the ATM cells in the data stream are handled in an identical manner.

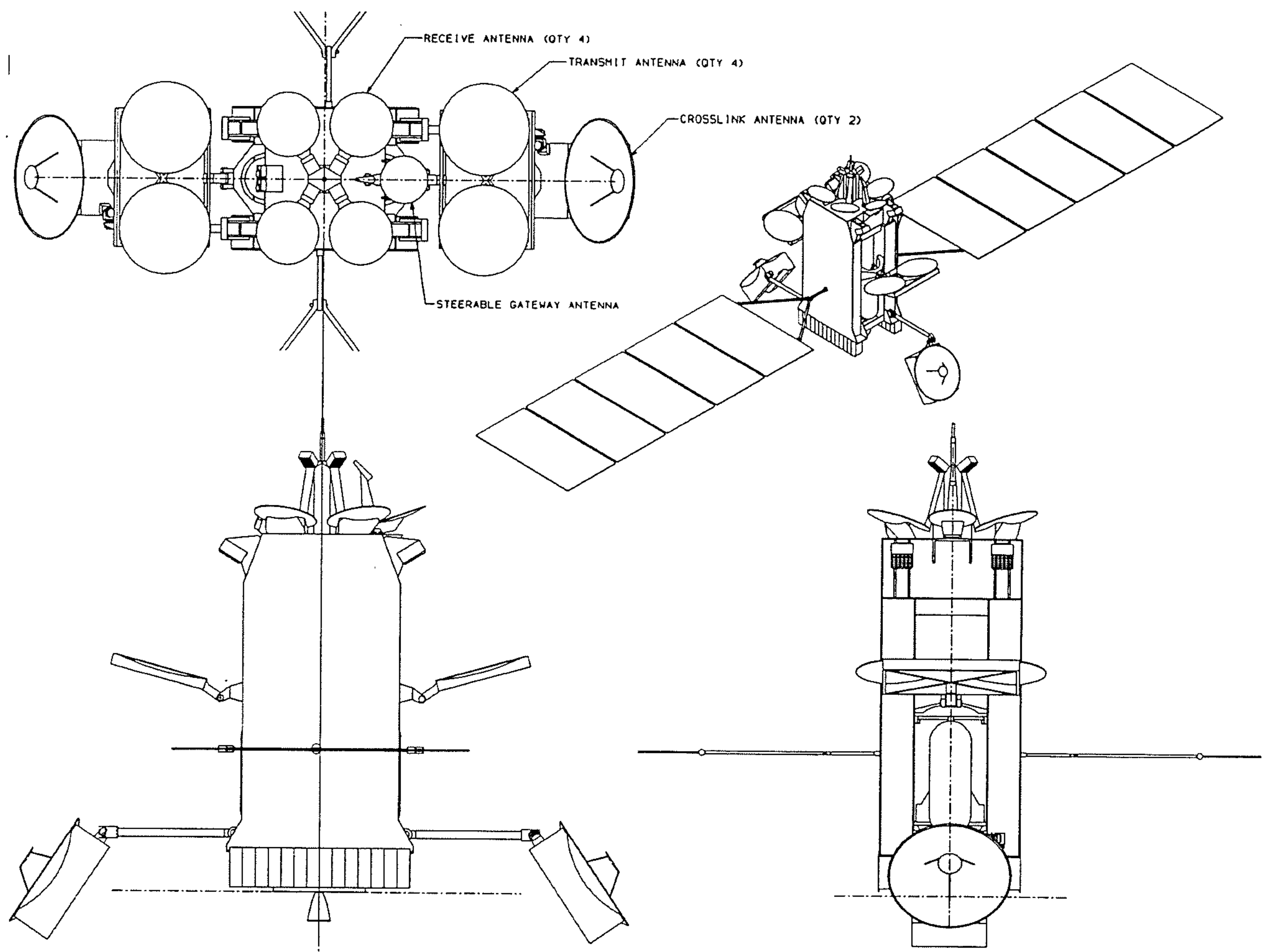
All recovered ATM data cells are routed through the switch fabric of the DSP, queued, re-encoded for error correction, and re-assembled into output streams corresponding to each DSP output port (either user downlink, gateway downlink, or ISL). The output streams from each DSP port are modulated onto carriers, upconverted to the transmit frequency, amplified by TWTAs, and fed to the appropriate feed horn of the transmit antenna to generate a downlink or ISL beam.

Normal equipment redundancy techniques are used in the payload for all active equipment. Spare LNAs, downconverters, upconverters and TWTAs are included in the payload. The DSP is internally redundant and is capable of being reconfigured to bypass internally failed components.

4.6.2.2. Satellite Antennas

There are four transmit antennas and four receive antennas deployed off the east and west sides of the spacecraft. The receive antennas, being smaller in size, are mounted on top of the spacecraft near the Earth-facing panel. Each antenna employs an offset reflector fed by an array of up to 22 feed elements. Each feed element generates one spot beam in the coverage area. The reflector geometry is optimized to satisfy the electrical performance while meeting all the spacecraft and launch vehicle constraints. The mechanical configuration of the antennas on the Astrolink-Phase II™ spacecraft is shown in Figure 4.6.2.2-1.

Figure 4.6.2.2-1 - Astrolink-Phase II™ Satellite



Electrically, each feed horn generates both orthogonal circular polarizations. The feed horn is connected by an orthomode transducer to two LNAs in the case of a receive horn, or two TWTAs in the case of a transmit horn. Supplemental gateway and user channel signals, which are on a different frequency than the principal user or gateway channels, are connected to the appropriate antenna feed horn by means of a frequency diplexer.

4.6.2.3. Digital Signal Processor

A key component of the Astrolink-Phase II™ satellite communications payload is the high-speed digital signal processor ("DSP"). The DSP performs three main functions: input processing, ATM cell routing, and output processing.

For the user beams, each input signal from an antenna beam is composed of a large number of carriers from different user terminals. This composite signal is downconverted to a low intermediate frequency and directed to an input port of the DSP. The DSP digitally demultiplexes the composite signal to separate the individual carriers, then demodulates and error corrects each of the carrier signals to recover the baseband ATM cells. Gateway uplink signals, which are also composed of multiple carriers, are processed in the same manner.

ISL beams, because of their much higher data-rate, are received and demodulated externally to the DSP and are then fed to one of the DSP ISL ports which decode and error correct the incoming stream to recover the original ATM cells.

The DSP routes the recovered ATM cells to the appropriate output port. ATM cells identified as DSP control cells are routed to the control processor in the DSP to perform payload functions such as updating routing tables, changing coding levels of individual user terminals, and other operations. Received ATM cells identified as Operations and Maintenance ("OAM") cells are routed via a gateway earth station to the

Network Control Center ("NCC") to perform such functions as user authentication, call setup, call teardown, dynamic assignment of bandwidth, etc.

After routing, the DSP re-codes the ATM cells with an error correcting code, queues and assembles the cells in the appropriate time sequence into each of the output TDM signal streams. Each output signal stream intended for user or gateway downlinks modulates a carrier at the appropriate intermediate frequency and is upconverted to the final Ka-band frequency for transmission to Earth. Because of the significantly higher rate, signal streams intended for transmission via ISLs are modulated onto an intermediate frequency carrier externally to the DSP.

4.6.2.4. Payload Operating Characteristics

4.6.2.4.1. Transponder Gain Control and Saturation Flux Density

Because the use of an on-board signal processor makes the uplink and downlink signal levels at the satellite independent of each other, the information normally provided concerning transponder gain, gain control, and saturation flux density in conventional "bent pipe" satellite systems is not relevant the Astrolink-Phase II™ System.

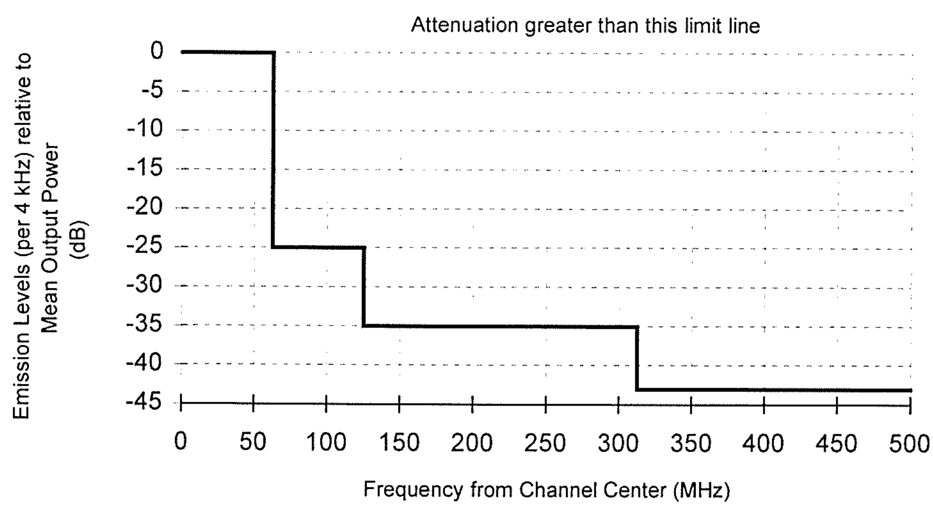
The Astrolink-Phase II™ System will utilize a closed-loop, uplink power control system for service links in which each terminal adjusts its transmitter operating power based on the received signal level from the satellite. The terminal transmitter operating power level will be a function of the path attenuation, which is dependent on the range from the ground station to the satellite and atmospheric attenuation due to water vapor and weather effects.

4.6.2.4.2. Transmission Channel Frequency Response and Unwanted Emissions

The Astrolink-Phase II™ System's satellite receive and transmit channel filter responses are not yet fully defined. The final in-band frequency responses will be determined taking into account the requirement for negligible bit error rate degradation under all practical conditions. The final out-of-band frequency responses will be determined taking into account the requirements for protecting the receiver front-end amplifiers from overload due to out-of-band signals, and adequate suppression of unwanted out-of-band emissions from the satellite.

The combined effects of the modulator spectrum shaping, spectrum spreading in the TWTA and output filtering will produce out-of-band emissions that will not exceed the mask given in Figure 4.6.2.6-1. The break-points in the mask are at 62.5 megahertz, 125 megahertz and 312.5 megahertz, corresponding to 50%, 100%, and 250% of the channel bandwidth, respectively.

Figure 4.6.2.4.2-1 - Out-of-Band Emission Mask for Downlink Channels



4.6.2.4.3. Frequency Stability

The on-board frequency reference used to synthesize the Astrolink-Phase II™ satellite transmit carrier frequencies is designed with a frequency tolerance of better than one part in 10^{10} over the short-term, and better than one part in 10^{8} over the long term.

4.6.2.4.4. Cessation of Emissions

Each Lockheed Martin satellite downlink, telemetry transmitter, or ISL will be capable of being individually turned off by ground telecommand in order to cease satellite emissions, if required.

4.6.2.4.5. Receive Performance

The satellite receive performance for user and gateway terminal uplink beams is summarized in Table 4.6.2.4.5-1. Note that the rightmost column represents worst case performance for coverage beams near to the edge of the Earth, which suffer the maximum off-boresight scan loss.

Table 4.6.2.4.5-1 - Satellite Receive Performance for User Terminal and Gateway/User Uplinks

Parameter	Units	Beam Peak at Nadir	Beam Edge
Receive Antenna Directivity	dBi	+44.4	+39.9
Receive System Noise Temperature	dBK	+27.8	+27.8
Receive G/T (EOL)	dB/K	+16.6	+12.1

4.6.2.4.6. Transmit Performance

The Astrolink-Phase II™ System's satellite transmit performance for user terminal downlinks is summarized in Table 4.6.2.4.6-1, below. The satellite transmit performance for gateway terminal downlinks is summarized in Table 4.6.2.4.6-2. Note that the rightmost column of each table represents worst case performance for coverage beams near to the edge of the Earth, which suffer the maximum off-boresight scan loss and include allowance for satellite antenna pointing errors.

Table 4.6.2.4.6-1 - Satellite Transmit Performance for User Terminal Downlinks

Parameter	Units	Beam Peak at Nadir	Beam Edge
TWTA Output Power (55 Watts)	dBW	+17.4	+17.4
Post-TWTA Losses	dB	-1.9	-1.9
Antenna Directivity	dBi	+44.6	+40.1
EIRP (Beginning of Life)	dBW	+60.1	+55.6

Table 4.6.2.4.6-2 - Satellite Transmit Performance for Gateway/User Downlinks

Parameter	Units	Beam Peak at Nadir	Beam Edge
TWTA Output Power (22 Watts)	dBW	+13.4	+13.4
Post TWTA Losses	dB	-2.2	-2.2
Antenna Directivity	dBi	+44.6	+40.1
EIRP (Beginning of Life)	dBW	+55.8	+51.3

4.6.3. Tracking, Telemetry and Control ("TT&C") System

As previously discussed in Section 4.3.2.3, due to the high propagation impairments to signals in the Ka-band associated with atmospheric and weather effects, Lockheed Martin proposes to perform all TT&C functions in extended C-band frequencies.[10] Attached to Exhibit D-1 is a technical showing demonstrating that the

[10] A number of Ka-band licensees, including Lockheed Martin, have petitioned the Commission to designate ten megahertz of spectrum in each of the bands 3600-3700 MHz (space-to-Earth) and 6425-6525 MHz (Earth-to-space) for TT&C operations for GSO FSS satellites which operate in bands above Ku-band. Lockheed Martin reserves the right to request alternative TT&C frequencies should extended C-band spectrum be unavailable for TT&C operations.

proposed TT&C operations in extended C-band will not interfere with conforming operations in the band.

During all TT&C operations, command signals will be transmitted to the spacecraft within the 6425-6525 MHz band. The command uplink consists of a carrier frequency modulated by digital commands sent at a rate of 1024 bits per second. Telemetry transmitters will operate within the 3650-3700 MHz band. The telemetry carriers are each phase modulated with a 4096 bits per second telemetry data stream. Two-way ranging is accomplished by substituting range tones for commands on the uplink. The demodulated tones are then remodulated onto the telemetry carrier downlink. Range is estimated by measuring the phase shift between the transmitted and received tones at the TT&C ground station.

During the launch and early operations phase, and during any periods of emergencies resulting in loss of Earth lock, TT&C operations will be conducted through one or more low-gain omni-directional antennas on the spacecraft. Each omni antenna assembly is comprised of a bi-conical telemetry antenna and a slotted-array command antenna mounted together in a single assembly. Both antennas generate toroidal patterns, with orthogonal linear polarizations. The toroidal coverage region extends ± 30° from the plane containing the Earth during normal mission operations and 360° parallel to the plane containing the Earth. During transfer orbit operations, the satellite is oriented so that nearly continuous coverage is available.

During normal on-station operations, TT&C functions will be conducted through orthogonal linearly polarized pyramidal horn antennas mounted on the spacecraft Earth facing panel. Each horn provides a conical beam 60° wide which is centered on the Earth during normal operations.

A list of the key TT&C RF link parameters is given in Table 4.6.3-1.

Table 4.6.3-1 - Key TT&C RF Link Parameters

Parameter		**Unit**	**Normal Mission Operations**	**Launch, Early Orbit and Emergency Operations**
Command	Frequency	MHz	6425.5 and 6427.5	6425.5 and 6427.5
	Coverage	N/A	Pyramidal Horn Antenna	Omni Antenna
	Flux Density	dBW/m^2	-90	-80
	Modulation	N/A	PCM-RZ/FSK/FM	PCM-RZ/FSK/FM
	Data Rate	Bps	1024	1024
Telemetry	Frequency	MHz	3650.5 and 3699.5	3650.5 and 3699.5
	Coverage	N/A	Pyramidal Horn Antenna	Omni Antenna
	EIRP	dBW	+4	-5.4
	Modulation	N/A	PCM BiPhase/PSK/PM	PCM BiPhase/PSK/PM
	Data Rate	Bps	4096	4096
Tracking	Frequency U/L	MHz	6425.5 and 6427.5	6425.5 and 6427.5
	Frequency D/L	MHz	3650.5 and 3699.5	3650.5 and 3699.5
	Modulation U/L	N/A	FM/FM	FM/FM
	Modulation D/L	N/A	FM/PM	FM/PM
	Tone Frequencies	Hz	0, 35, 283, 3968 on 27.78 KHz Subcarrier or 27.778 KHz Fine Tone	0, 35, 283, 3968 on 27.78 KHz Subcarrier or 27.778 KHz Fine Tone

4.6.4. ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM ("AD&CS")

During normal operations, the Astrolink-Phase II™ satellite is three-axis stabilized using reaction wheels and a continuously active gyro inertial reference. The spacecraft is designed to maintain antenna pointing within ±0.05° of nominal pointing direction during normal operating mode. The AD&CS will maintain spacecraft orbit inclination and longitudinal drift within ±0.05° of nominal.

4.7. EMISSION DESIGNATIONS AND ALLOCATED BANDWIDTHS

Table 4.7-1 lists the emission designations for all the telecommunications signals employed by the Astrolink-Phase II™ System.

Table 4.7-1- Astrolink-Phase II™ System Emission Designations

Transmission	Designation	Description
Uplink (Earth-to-space)	18M0Q7W 3M60Q7W 750KQ7W 750KQ7D 18M0Q7W (*) 1M50FXD	10.4 Mbps User Terminal Data 2.08 Mbps User Terminal Data 416 kbps User Terminal Data User Terminal Entry Order Wire 145.6 Mbps Gateway Terminals TT&C Telecommand/Ranging
Downlink (space-to-Earth)	125MG7W 600KG7D	113.8 Mbps User Terminals and Gateways TT&C Telemetry/Ranging
Inter-Satellite	600MG7W	ISL

* Gateway transmits seven simultaneous 18M0Q7W carriers.

4.8. EARTH STATIONS

4.8.1. USER TERMINALS

The Astrolink Phase-II™ System will utilize four classes of user terminals to accommodate the range of user requirements for capacity-on-demand. Standard

Astrolink-Phase II™ user terminals will be equipped with antenna diameters ranging from 65 cm to 180 cm. Table 4.8.1-1 summarizes the key characteristics of typical Astrolink-Phase II™ user terminals.

Table 4.8.1-1 - Key Characteristics of Typical Astrolink-Phase II™ User Terminals

Terminal Class*	Antenna Diameter	Transmitter Power	Maximum Uplink Data Rate**	Aggregate Downlink Data Rate***
AA	65 cm	4 W	416 kbps	102.4 Mbps
A	90 cm	2 W	416 Kbps	102.4 Mbps
B	90 cm	9 W	2.08 Mbps	102.4 Mbps
C	1.8 m	11 W	10.4 Mbps	102.4 Mbps

* Other user terminals with antenna diameters between 65 cm and 1.8 m may also be used in the Astrolink-Phase II™ System.
** Net user data-rate after removal of ATM cell overhead.
*** Aggregate net data-rate for all users in beam.

These user terminals will be relatively inexpensive, which will promote their use directly on customer premises for both business and consumer applications. The terminals will be equipped with a variety of user equipment interfaces, including standard data network connections. Once installed, they will immediately provide capacity-on-demand to the Astrolink-Phase II™ System users.

In addition to standard Astrolink-Phase II™ user terminals, Lockheed Martin anticipates utilizing dual-frequency terminals also capable of communicating with other compatible systems, such as Lockheed Martin's proposed Q/V-band satellite system.

All Astrolink-Phase II™ downlinks are designed to operate effectively with the smallest terminal size (65 cm) for users located in the central part of the beam coverage area depending on the rain region, elevation angle, and required service quality. Users located elsewhere in the beam coverage area, or requiring improved service quality, will employ larger terminals. The primary need for a larger terminal is to reduce the transmitter RF power requirements when used with higher data-rate uplinks, which will reduce the terminal cost. Another reason for using a larger terminal is to provide a higher link availability for critical applications, and to improve system availability in high rainfall regions and high latitude areas which require low antenna look angles.

In clear sky conditions, the power amplifier output will be backed-off in accordance with the level of signal received from the spacecraft. This uplink power control scheme will minimize interference both within the Astrolink-Phase II™ System and to adjacent satellite networks operating in the same frequency bands.

Lockheed Martin anticipates that millions of Astrolink-Phase II™ user terminals may eventually be deployed. Lockheed Martin is not applying for licenses for user terminals at this time. The Commission may wish to license Astrolink-Phase II™ user terminals under a blanket licensing scheme.[11]

4.8.2. GATEWAY EARTH STATIONS

Astrolink-Phase II™ gateway earth stations will be equipped with antennas with diameters ranging between 3 and 5.5 meters. These gateway earth stations will be used to interconnect the Astrolink-Phase II™ network to terrestrial communications networks. One gateway earth station in the coverage area of each satellite will be used to interconnect the satellite to its associated Network Control Center ("NCC").

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[11] *See, e.g., Routine Licensing of Large Numbers of Small Antenna Earth Stations Operating in the Ka-Band*, Petition for Rulemaking (filed Dec. 23, 1996, on behalf of AT&T Corp., GE American Communications, Inc., Hughes Communications, Inc., Lockheed Martin Corp., and Loral Space & Communications, Ltd.).

Astrolink-Phase II™ gateway earth stations will be licensed and operated in accordance with the local regulations of the territory in which they are located. Lockheed Martin is not applying for licenses for gateway earth stations at this time.

4.8.3. EARTH STATION OPERATIONAL PROCEDURES TO AVOID INTERFERENCE

Every effort will be made to prevent the possibility of misalignment of Astrolink-Phase II™ user terminals and earth stations which might cause interference to adjacent satellites. To further prevent emissions in a direction other than to the desired satellite, terminals will be equipped with interlocks which will prevent terminal RF transmissions unless the terminal is receiving the correct signal strength level from the satellite and has acquired the correct satellite downlink signal. This interlock will prevent inadvertent activation of the terminal transmit function if it is accidentally pointed to another Astrolink-Phase II™ satellite or a satellite from another network.

In addition to these preventative measures, operational procedures will be established to avoid, detect, and correct any interference problems that may occur. Each Astrolink-Phase II™ satellite will be in constant communication with operating ground terminals within its service area. A Network Control Center ("NCC"), which is also in constant operational communication with the satellite, will have the ability to turn off transmissions from individual ground terminals if necessary. An NCC might stop the transmissions of a ground terminal if that ground terminal were causing unacceptable uplink interference. The identification of an interfering ground terminal can be made by the NCC, with the cooperation of the interfered-with satellite operator, based upon information concerning the frequency and time slot occurrence of the interference.

The refinement of such interference resolution procedures will continue as the detailed design of the proposed satellite system progresses and as coordination with adjacent satellite operators takes place. Every effort will be made to anticipate and solve interference concerns before they arise.

4.9. LINK BUDGETS

The range of ground terminals to be used in the Astrolink-Phase II™ System, together with the data-rates available, are described in Sections 4.8.1 and 4.8.2, above. Representative link budgets for these cases are given in Sections 4.9.1 and 4.9.2 for user terminal links, and Section 4.9.4 for gateway earth station links. Because of the on-board signal demodulation of all communications signals in the satellite system, the link budgets for uplink and downlink are independent of each other and are therefore presented separately below.

4.9.1. User Terminal Uplinks

The link budgets for user terminal uplinks are calculated for data-rates of 416 kbps, 2.08 Mbps and 10.4 Mbps, which are the maximum data-rates achievable by the four classes of standard user terminals in the Astrolink-Phase II™ System. The corresponding standard terminal sizes are 65 and 90 cm for the lowest data-rate, 90 cm for the medium data-rate, and 180 cm for the highest data-rate.

Uplink budgets are shown in Tables 4.9.1-1, 4.9.1-2, 4.9.1-3 and 4.9.1-4 for each of the four standard classes of user terminals. Budgets for the 65 cm terminal are presented for 30° look angle to the satellite and a user location within the central part of the beam coverage. Budgets for all other terminals are presented for 20° elevation look angle to the satellite. The tables indicate performance under clear sky and rain conditions. The budgets include 0.1 dB of polarization loss, plus 0.6 dB of atmospheric (gaseous absorption) loss at 30° elevation and 0.9 dB at 20° elevation. Rain attenuation budgets of 8.2 to 14.6 dB are achieved which provide 99.5% or better availability to more than 60% of the 3,752 highest population metropolitan areas in the world that are visible from at least one Astrolink-Phase II™ satellite. The link budgets include interference contributions from within the Astrolink-Phase II™ System (intra-system interference) and representative interference levels from GSO satellite network uplinks assumed to be 2° away (inter-system interference). The calculation of intra-system and inter-system interference is addressed in Section 4.11, below.

Table 4.9.1-1(a) - Uplink Budget for Class AA 65 cm User Terminal at Beam Peak (416 kbps Data Rate)

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	kbps	416	416
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	65	65
Ground Terminal RF Transmit Power	Watts	4	4
Ground Terminal Antenna gain	dBi	44.1	44.1
Ground Terminal EIRP	dBW	49.3	49.3
Elevation Angle	degrees	30	30
Range to Satellite	km	38,609	38,609
Path Loss	dB	-213.6	-213.6
Atmospheric & Other Losses	dB	-0.7	-0.7
Rain Attenuation	dB	0	14.6
Satellite Received G/T	dB/K	16.6	16.6
Satellite Received C/N	dB	22.8	8.2
Intra-System Interference C/I	dB	14.1	14.1
Inter-System Interference C/I	dB	22.7	22.7
Total Received C/(N+I)	dB	13.0	7.1
Total Eb/No	dB	10.5	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-1(b) - Uplink Budget for Class AA 65 cm User Terminal at –3.8 dB Gain Contour (416 Kbps Data Rate)

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		at –3.8 dB countour	–3.8 dB countour
Data Rate	kbps	416	416
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	65	65
Ground Terminal RF Transmit Power	Watts	4	4
Ground Terminal Antenna gain	dBi	44.1	44.1
Ground Terminal EIRP	dBW	49.3	49.3
Elevation Angle	degrees	30	30
Range to Satellite	km	38,609	38,609
Path Loss	dB	-213.6	-213.6
Atmospheric & Other Losses	dB	-0.7	-0.7
Rain Attenuation	dB	0	-10.8
Satellite Received G/T	dB/K	12.8	12.8
Satellite Received C/N	dB	18.9	8.1
Intra-System Interference C/I	dB	14.1	14.1
Inter-System Interference C/I	dB	22.7	22.7
Total Received C/(N+I)	dB	12.4	7.0
Total Eb/No	dB	9.9	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-2(a) - Uplink Budget for Class A 90 cm User Terminal at Beam Peak (416 kbps Data Rate)

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	kbps	416	416
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal RF Transmit Power	Watts	0.7	0.7
Ground Terminal Antenna gain	dBi	47.0	47.0
Ground Terminal EIRP	dBW	44.4	44.4
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-9.2
Satellite Received G/T	dB/K	16.6	16.6
Satellite Received C/N	dB	17.4	8.2
Intra-System Interference C/I	dB	14.1	13.5
Inter-System Interference C/I	dB	25.5	25.5
Total Received C/(N+I)	dB	12.2	7.0
Total Eb/No	dB	9.7	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-2(b) - Uplink Budget for Class a 90 cm User Terminal at Beam Edge (416 kbps Data Rate)

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	kbps	416	416
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal RF Transmit Power	Watts	2.0	2.0
Ground Terminal Antenna gain	dBi	47.0	47.0
Ground Terminal EIRP	dBW	48.9	48.9
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-9.2
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	17.4	8.2
Intra-System Interference C/I	dB	14.1	13.5
Inter-System Interference C/I	dB	25.5	25.5
Total Received C/(N+I)	dB	12.2	7.0
Total Eb/No	dB	9.7	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-3(a) - Uplink Budget for Class B 90 cm User Terminal at Beam Peak (2080 kbps Data Rate)

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	kbps	2080	2080
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal RF Transmit Power	Watts	3.2	3.2
Ground Terminal Antenna gain	dBi	47.0	47.0
Ground Terminal EIRP	dBW	51.0	51.0
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.8
Satellite Received G/T	dB/K	16.6	16.6
Satellite Received C/N	dB	17.0	8.2
Intra-System Interference C/I	dB	14.1	13.6
Inter-System Interference C/I	dB	25.5	25.5
Total Received C/(N+I)	dB	12.1	7.0
Total Eb/No	dB	9.5	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-3(b) - Uplink Budget for Class B 90 cm User Terminal at Beam Edge (2080 kbps Data Rate)

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	kbps	2080	2080
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal RF Transmit Power	Watts	9.0	9.0
Ground Terminal Antenna gain	dBi	47.0	47.0
Ground Terminal EIRP	dBW	55.5	55.5
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.8
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	17.0	8.2
Intra-System Interference C/I	dB	14.1	13.6
Inter-System Interference C/I	dB	25.5	25.5
Total Received C/(N+I)	dB	12.1	7.0
Total Eb/No	dB	9.5	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-4(a) - Uplink Budget For Class C 180 cm User Terminal at Beam Peak (10400 kbps Data Rate)

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	kbps	10,400	10,400
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	180	180
Ground Terminal RF Transmit Power	Watts	3.9	3.9
Ground Terminal Antenna gain	dBi	53.0	53.0
Ground Terminal EIRP	dBW	57.3	57.3
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.2
Satellite Received G/T	dB/K	16.6	16.6
Satellite Received C/N	dB	16.3	8.1
Intra-System Interference C/I	dB	14.1	13.6
Inter-System Interference C/I	dB	31.5	31.5
Total Received C/(N+I)	dB	12.0	7.0
Total Eb/No	dB	9.5	7.5
Required Eb/No	dB	9.5	7.5

Table 4.9.1-4 (b) - Uplink Budget For Class C 180 cm User Terminal at Beam Edge (10400 kbps Data Rate)

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	kbps	10,400	10,400
Frequency	GHz	29.5625	29.5625
Ground Terminal Antenna Diameter	cm	180	180
Ground Terminal RF Transmit Power	Watts	11.0	11.0
Ground Terminal Antenna gain	dBi	53.0	53.0
Ground Terminal EIRP	dBW	61.8	61.8
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.8	-213.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.2
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	16.3	8.1
Intra-System Interference C/I	dB	14.1	13.6
Inter-System Interference C/I	dB	31.5	31.5
Total Received C/(N+I)	dB	12.0	7.0
Total Eb/No	dB	9.5	7.5
Required Eb/No	dB	9.5	7.5

4.9.2. User Terminal Downlinks

All user terminals, irrespective of their antenna size, receive the full TDM downlink signal from which the terminals extract individual user data. As previously discussed in Section 4.5, under rain conditions, link margins can be adjusted for each individual terminal affected by rain by adjusting the signal coding to that terminal. This is accomplished by the adaptive TDM scheme which was previously discussed in Section 4.5.2, above.

Tables 4.9.2-1, 4.9.2-2 and 4.9.2-3 show the downlink budgets for the four standard terminal classes. Class AA, with a 65 cm antenna is presented at 30° look angle elevation and for users within the central part of the beam coverage. All other terminals are presented at 20° look angle elevation and for the full beam coverage (Classes A and B share the same 90 cm antenna size and have identical downlink budgets). The link budgets are calculated for a data-rate of 102.4 Mbps which is the net aggregate data-rate for all users in the beam after removal of the ATM header and other system overheads. The tables indicate performance under clear sky and rain conditions. The budgets include 0.1 dB of polarization loss, plus 0.6 dB of atmospheric (gaseous absorption) loss (for 30° look angle) or 0.9 dB (for 20° look angle). The downlink budgets also include an assessment of the intra-system and inter-system interference. The link budgets also include the effects of degradation of the terminal G/T during rain conditions.

Table 4.9.2-1(a) - Downlink Budget for 65 cm User Terminal at Beam Peak

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	61.3	61.3
Elevation Angle	degrees	30	30
Range to Satellite	km	38,609	38,609
Path Loss	dB	-210.2	-210.2
Atmospheric & Other Losses	dB	-0.7	-0.7
Rain Attenuation	dB	0	-5.0
Ground Terminal Antenna Diameter	cm	65	65
Ground Terminal Receive System G/T	dB/K	15.5	13.8
Ground Terminal Received C/N	dB	14.5	7.8
Intra-System Interference C/I	dB	13.3	13.3
Inter-System Interference C/I	dB	19.3	19.3
Total Received C/(N+I)	dB	10.3	6.5
Total Eb/No	dB	9.0	5.2
Required Eb/No	dB	7.5	5.2

TABLE 4.9.2-1(b) - Downlink Budget For 65 Cm User Terminal At –3.3db Gain Contour

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		at –3.3 dB contour	-3.3 dB contour
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	58.0	58.0
Elevation Angle	degrees	30	30
Range to Satellite	km	38,609	38,609
Path Loss	dB	-210.2	-210.2
Atmospheric & Other Losses	dB	-0.7	-0.7
Rain Attenuation	dB	0	-2.3
Ground Terminal Antenna Diameter	cm	65	65
Ground Terminal Receive System G/T	dB/K	15.5	14.4
Ground Terminal Received C/N	dB	11.2	7.8
Intra-System Interference C/I	dB	13.3	13.3
Inter-System Interference C/I	dB	19.3	19.3
Total Received C/(N+I)	dB	8.7	6.5
Total Eb/No	dB	7.5	5.2
Required Eb/No	dB	7.5	5.2

TABLE 4.9.2-2(a) - Downlink Budget For 90 Cm User Terminal At Beam Peak

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	60.1	60.1
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-210.4	-210.4
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-5.4
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal Receive System G/T	dB/K	18.1	16.5
Ground Terminal Received C/N	dB	15.5	8.5
Intra-System Interference C/I	dB	13.3	13.0
Inter-System Interference C/I	dB	22.1	22.1
Total Received C/(N+I)	dB	10.9	7.1
Total Eb/No	dB	9.6	8.8
Required Eb/No	dB	7.5	5.2

TABLE 4.9.2-2(b) - Downlink Budget For 90 Cm User Terminal At Beam Edge

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	55.6	55.6
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-210.4	-210.4
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-5.4
Ground Terminal Antenna Diameter	cm	90	90
Ground Terminal Receive System G/T	dB/K	18.1	16.5
Ground Terminal Received C/N	dB	11.0	4.0
Intra-System Interference C/I	dB	13.3	13.0
Inter-System Interference C/I	dB	22.1	22.1
Total Received C/(N+I)	dB	8.8	3.4
Total Eb/No	dB	7.5	5.2
Required Eb/No	dB	7.5	5.2

TABLE 4.9.2-3(a) - Downlink Budget For 180 Cm User Terminal At Beam Peak

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Peak	Beam Peak
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	60.1	60.1
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-210.4	-210.4
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-10.7
Ground Terminal Antenna Diameter	cm	180	180
Ground Terminal Receive System G/T	dB/K	23.9	21.9
Ground Terminal Received C/N	dB	21.4	8.7
Intra-System Interference C/I	dB	13.3	12.1
Inter-System Interference C/I	dB	28.1	28.1
Total Received C/(N+I)	dB	12.6	7.0
Total Eb/No	dB	11.3	8.7
Required Eb/No	dB	7.5	5.2

TABLE 4.9.2-3(b) - Downlink Budget For 180 Cm User Terminal At Beam Edge

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	102.4	102.4
Frequency	GHz	20.0125	20.0125
Satellite EIRP	dBW	55.6	55.6
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-210.4	-210.4
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-10.7
Ground Terminal Antenna Diameter	cm	180	180
Ground Terminal Receive System G/T	dB/K	23.9	21.9
Ground Terminal Received C/N	dB	16.9	4.2
Intra-System Interference C/I	dB	13.3	12.1
Inter-System Interference C/I	dB	28.1	28.1
Total Received C/(N+I)	dB	11.6	3.5
Total Eb/No	dB	10.3	5.2
Required Eb/No	dB	7.5	5.2

4.9.3. System Availability

Using the nominal link budget calculations as a basis, link availability calculations can be made for any specific location with the aid of the Crane Rain model.[12] System availability as a function of rain attenuation was analyzed for the 3,752 largest metropolitan areas visible from at least one satellite in the Astrolink-Phase II™ constellation. The results for 99.5% system availability by users are shown in Figure 4.9.3-1 for the downlink and in Figure 4.9.3-2 for the uplink. These figures show that the

[12] Crane, R.K., *Prediction of Attenuation by Rain*, IEEE Trans. Comm, Vol. COM-28, No. 9 (September 1980).

desired 99.5% availability can be provided to 60% of the metropolitan areas with rain margins of 3 dB on the downlink and 7 dB on the uplink, which justify the figures used in the link budgets shown in Sections 4.9.1 and 4.9.2, above.

Figure 4.9.3-1 - Percent of Cities Covered vs. Downlink Rain Attenuation for 99.5% Availability

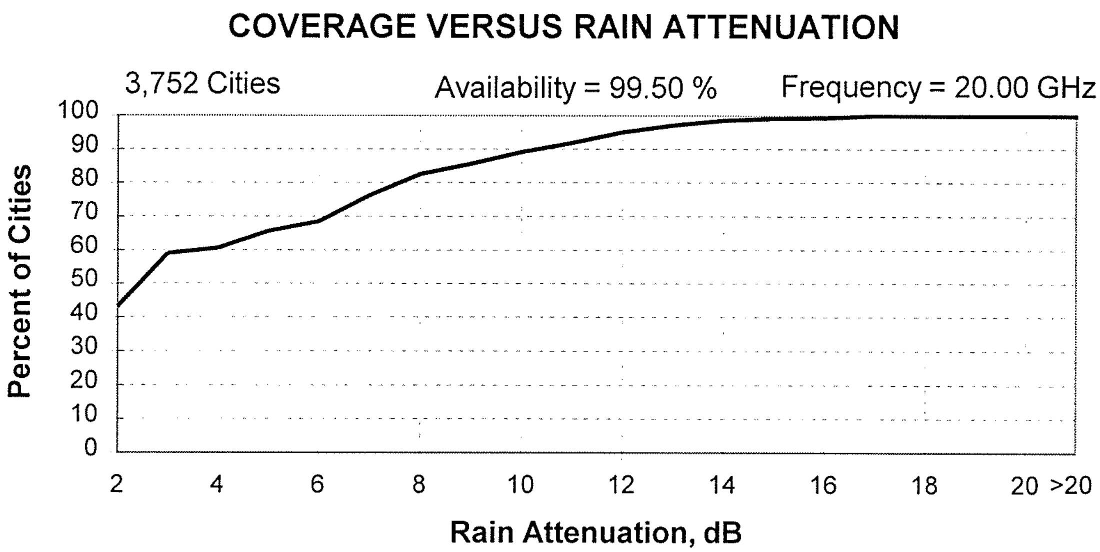
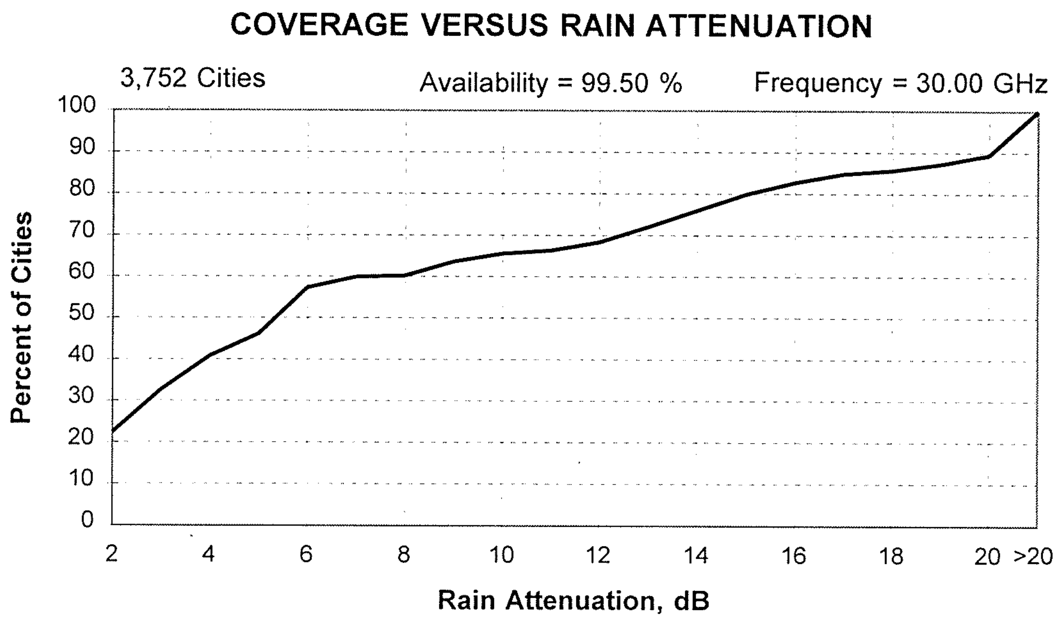


Figure 4.9.3-2 - Percent of Cities Covered vs. Uplink Rain Attenuation for 99.5% Availability



4.9.4. Gateway Earth Station Links

Gateway earth stations will be used to interconnect the Astrolink-Phase II™ System with terrestrial networks. Each Astrolink-Phase II™ satellite also will be connected to its associated NCC by a gateway earth station. Gateway earth stations will employ larger diameter (typically 3.0-5.5 meters) tracking antennas. Gateway earth stations located in high rain environments or for critical applications may use larger antennas and/or spatial diversity techniques to improve system availability.

All gateway earth stations will operate with an uplink data rate of 145.6 Mbps and a downlink data rate 113.8 Mbps (net data rate after removal of ATM headers).

Tables 4.9.4-1(a) and (b) shows the uplink and downlink budgets for a 3 meter gateway earth station in a clear sky and in rain conditions for 20° earth station antenna elevation. With a modest High Power Amplifier (HPA) of 170 Watts, rain margins of 6.2 dB uplink and 6.6 dB downlink are available, assuming a worst case beam edge location of the gateway terminal. This low cost gateway configuration would be well suited to certain Astrolink-Phase II™ business customer needs.

Tables 4.9.4-2(a) and (b) show the uplink and downlink margins for a somewhat larger 3.75 meter gateway earth station. With the same 170 Watt HPA, rain margins of 8 dB uplink and 8.4 dB downlink are available, again assuming a worst case location at the beam edge and 20° look angle elevation. This gateway configuration would be suitable for the majority of interconnections between the Astrolink-Phase II™ System and terrestrial networks.

Finally, Tables 4.9.4-3(a) and (b) show the uplink and downlink margins for a large 5.5 meter gateway terminal suitable for the most critical applications, such as the gateway connecting the satellite to its associated Network Control Center, or in high rain regions of the world. This configuration, with the same 170 Watt HPA, provides rain margins of 10.8 dB on the uplink and 11.4 dB on the downlink, again assuming a worst case location at the beam edge and 20° look angle elevation.

In practice, the gateway antenna size will be selected based on the actual look angle to the Astrolink-Phase II™ satellite and the climatic zone where the gateway is located to obtain the specified link availability.

Table 4.9.4-1(a) - Uplink Budget For 3 M Gateway Terminal

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	145.6	145.6
Frequency	GHz	28.4	28.4
Ground Terminal Antenna Diameter	cm	300	300
Ground Terminal RF Transmit Power	Watts	31.7	170.0
Ground Terminal Antenna gain	dBi	56.0	56.0
Ground Terminal EIRP	dBW	67.3	74.6
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.5	-213.5
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-6.2
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	13.7	14.7
Intra-System Interference C/I	dB	18.9	16.6
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	12.0	12.0
Total Eb/No	dB	7.0	7.0
Required Eb/No	dB	7.0	7.0

Table 4.9.4-1(b) - Downlink Budget For 3 M Gateway Terminal

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	113.8	113.8
Frequency	GHz	18.6	18.6
Satellite EIRP	dBW	51.3	51.3
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-209.8	-209.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-6.6
Ground Terminal Antenna Diameter	cm	300	300
Ground Terminal Receive System G/T	dB/K	28.5	26.9
Ground Terminal Received C/N	dB	17.7	9.5
Intra-System Interference C/I	dB	23.3	19.1
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	15.4	8.8
Total Eb/No	dB	11.6	5.0
Required Eb/No	dB	5.0	5.0

Table 4.9.4-2(a) - Uplink Budget For 3.75 M Gateway Terminal

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	145.6	145.6
Frequency	GHz	28.4	28.4
Ground Terminal Antenna Diameter	cm	375	375
Ground Terminal RF Transmit Power	Watts	31.7	170.0
Ground Terminal Antenna gain	dBi	57.9	57.9
Ground Terminal EIRP	dBW	67.3	76.5
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.5	-213.5
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.0
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	13.7	15.0
Intra-System Interference C/I	dB	18.9	16.3
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	12.0	12.0
Total Eb/No	dB	7.0	7.0
Required Eb/No	dB	7.0	7.0

Table 4.9.4-2(b) - Downlink Budget For 3.75 M Gateway Terminal

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	113.8	113.8
Frequency	GHz	18.6	18.6
Satellite EIRP	dBW	51.3	51.3
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-209.8	-209.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-8.4
Ground Terminal Antenna Diameter	cm	375	375
Ground Terminal Receive System G/T	dB/K	30.5	28.8
Ground Terminal Received C/N	dB	19.7	9.5
Intra-System Interference C/I	dB	23.3	18.6
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	16.5	8.8
Total Eb/No	dB	12.7	5.0
Required Eb/No	dB	5.0	5.0

Table 4.9.4-3(a) - Uplink Budget For 5.5 M Gateway Terminal

Link Parameters	Units	Clear Sky	Rain
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	145.6	145.6
Frequency	GHz	28.4	28.4
Ground Terminal Antenna Diameter	cm	550	550
Ground Terminal RF Transmit Power	Watts	31.7	170.0
Ground Terminal Antenna gain	dBi	61.3	61.3
Ground Terminal EIRP	dBW	67.3	79.8
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-213.5	-213.5
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-10.8
Satellite Received G/T	dB/K	12.1	12.1
Satellite Received C/N	dB	13.7	15.4
Intra-System Interference C/I	dB	18.9	15.7
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	12.0	12.0
Total Eb/No	dB	7.0	7.0
Required Eb/No	dB	7.0	7.0

Table 4.9.4-3(b) - Downlink Budget For 5.5 M Gateway Terminal

Link Parameters	**Units**	**Clear Sky**	**Rain**
Ground Terminal Location		Beam Edge	Beam Edge
Data Rate	Mbps	113.8	113.8
Frequency	GHz	18.6	18.6
Satellite EIRP	dBW	51.3	51.3
Elevation Angle	degrees	20	20
Range to Satellite	km	39,551	39,551
Path Loss	dB	-209.8	-209.8
Atmospheric & Other Losses	dB	-1.0	-1.0
Rain Attenuation	dB	0	-11.4
Ground Terminal Antenna Diameter	cm	550	550
Ground Terminal Receive System G/T	dB/K	33.8	32.0
Ground Terminal Received C/N	dB	23.0	9.7
Intra-System Interference C/I	dB	23.3	17.6
Inter-System Interference C/I	dB	21.5	21.5
Total Received C/(N+I)	dB	17.7	8.8
Total Eb/No	dB	13.9	5.0
Required Eb/No	dB	5.0	5.0

4.9.5. TT&C LINKS

Table 4.9.5-1 shows the spacecraft command and ranging uplinks for normal operating conditions and also for launch, early orbit, and emergency conditions. Table 4.9.5-2 shows the corresponding values for the telemetry and ranging downlinks.

Table 4.9.5-1 - TT&C Command And Ranging Uplinks

Parameter	Units	Normal Mission Operations	Launch, Early Orbit & Emergency Operations
Earth Station EIRP	dBW	77.0	87.0
Earth Station Pointing Loss	dB	-0.5	-0.5
Free Space Loss	dB	-200.8	-200.8
Atmospheric Loss	dB	-0.5	-0.5
Polarization Loss	dB	-0.1	-0.1
Spacecraft Antenna Gain	dBi	11.0	-4.5
Multipath and Scattering Loss	dB	-0.8	-3.5
Spacecraft Passive Loss	dB	-14.4	-7.3
Spacecraft Received Power	dBW	-129.1	-130.2
Required Command Power	dBW	-138.0	-138.0
Command Margin	dB	8.9	7.8
Required Ranging Power	dBW	-135.0	-135.0
Ranging Margin	dB	5.9	4.8

Table 4.9.5-2 - TT&C Telemetry and Ranging Downlinks

Parameter	Units	Normal Mission Operations	Launch, Early Orbit & Emergency Operations
Spacecraft Output Power	dBW	7.1	7.1
Spacecraft Passive Loss	dB	-13.6	-6.5
Spacecraft Antenna Gain	dBi	11.0	-3.0
Multipath and Scattering Loss	dB	-0.5	-3.0
Spacecraft EIRP	dBW	4.0	-5.4
Free Space Loss	dB	-195.7	-195.7
Atmospheric Loss	dB	-0.4	-0.4
Polarization Loss	dB	-0.1	-0.1
Earth Station Pointing Loss	dB	-0.5	-0.5
Earth Station G/T	dB/K	27.0	32.5
Received C/No	dBHz	62.9	59.0
Telemetry Required C/No	dBHz	59.2	53.4
Telemetry Margin	dB	3.7	5.6
Ranging Required C/No	dBHz	57.6	51.8
Ranging Margin	dB	5.3	7.2

4.10. POWER FLUX DENSITY ANALYSIS

The following sub-sections provide power flux density ("pfd") analyses in frequency bands to be used by the Astrolink-Phase II™ system.

4.10.1. DOWNLINK COMMUNICATION BANDS

The pfd limits in the ITU Radio Regulations (Table S21-4) which apply in the 17.8–19.3 GHz downlink bands that will be used by the Astrolink-Phase II™ System are as follows:

- -115 dB(W/m^2) in any one megahertz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + (δ-5)/2 dB(W/m^2) in any one megahertz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane;
- -105 dB(W/m^2) in any one megahertz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

These limits relate to the pfd which would be obtained under assumed free-space propagation conditions.

The power of the digital signals employed by the Astrolink-Phase II™ system are spread almost evenly across a 125 megahertz bandwidth. Pfd values at angles of arrival of 0°, 5°, 25° and 90° were calculated in a one megahertz bandwidth and are provided in Table 4.10.1-1:

Table 4.10.1-1 Calculated Power Flux Density Communication

Elevation Angle	PFD ($dBW/m^2/MHz$)	Margin (dB)
0°	-124.3	9.3
5°	-124.2	9.2
25°	-123.7	18.7
90°	-123.0	18.0

As seen in Table 4.10.1-1, the worst case downlink pfd on the Earth's surface is 9.2 dB less than the pfd limit, and so compliance is assured.

In the downlink frequency band 18.6–18.8 GHz the FCC Rules have an additional pfd requirement on the FSS operations to protect the Earth exploration-satellite service (*see* Footnote US255) as follows: –101 dBW/m^2 in a 200 megahertz band for all angles of arrival within this frequency band. The Astrolink-Phase II™ System uses only gateway beams and no two adjacent 125 megahertz channels will be operated in the same beam. Therefore, the pfd calculation involves the contribution from a single 125 megahertz gateway channel only. The pfd in a 200 megahertz bandwidth were calculated for elevation angles of 0°, 20°, 30° and 90°. The results, shown in Table 4.10.1-2, comply with the required limits.

Table 4.10.1-2 Calculated Power Flux Density Communication Downlinks in 200 MHz

Elevation Angle	PFD ($dBW/m^2/200MHz$)	Margin
0°	-103.2	2.2
20°	-102.8	1.8
30°	-102.6	1.6
90°	-101.9	0.9

4.10.2. TT&C PFD LIMITS

The pfd limits in the ITU Radio Regulations (Table S21-4) and Section 25.208 of the FCC's rules that apply in the 3650–3700 GHz downlink band are as follows:

- -152 $dB(W/m^2)$ in any four kilohertz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -152 + (δ-5)/2 $dB(W/m^2)$ in any four kilohertz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane;
- -142 $dB(W/m^2)$ in any four kilohertz band for angles of arrival between 25 and 90 degrees above the horizontal plane.
-

These limits relate to the power flux density that would be obtained under assumed free-space propagation conditions.

The maximum pfd value for the TT&C downlink, corresponding to the shortest range from the satellite at 90° elevation, is -158 dBw/m^2. This complies with the above-mentioned pfd limit regardless of the spreading bandwidth.

4.11. INTERFERENCE AND SHARING ANALYSIS

This section addresses both intra-system interference generated within the Astrolink-Phase II™ System and inter-system interference from adjacent satellite networks and other co-primary services. The appropriate interference contributions are used in the link budget analyses of Section 4.9.

4.11.1. INTRA-SYSTEM INTERFERENCE

Self-interference arising from within the Astrolink-Phase II™ network is a result of intermodulation products from the satellite amplifiers, possible sidelobe effects of adjacent spot beams, and polarization reuse interference.

The total intra-system interference is the sum of these three contributing factors. The worst case aggregate intra-system C/I has been calculated to be 14.1 dB for the uplink and 13.3 dB for the downlink. Due to the lower amount of frequency re-use, higher C/I values of between 17.5 to 20.1 dB are used for the gateway earth stations. These values have been included in the link budget calculations provided in Section 4.9.

4.11.2. INTER-SYSTEM INTERFERENCE

4.11.2.1. GSO FSS

The Astrolink-Phase II™ System has been designed to be compatible, from an interference point of view, with 2° orbit spacing from adjacent, co-frequency, co-coverage satellites. This is achieved by careful selection of the user terminal antenna size, depending on its location within the beam, and by using uplink power control combined with adaptive downlink TDM to combat rain fades.

In this analysis, we assume that the adjacent satellite networks (one on each side of each Astrolink-Phase II™ satellite) are identical to the Astrolink-Phase II™ System in terms of their ground terminal and satellite emissions. There are several reasons why this assumption is likely to be accurate or, if anything, conservative:

- Higher levels of interference occur with smaller ground terminals because of the wider beamwidths and correspondingly lower isolation from adjacent satellites. The assumption that the adjacent satellite network uses small terminals is therefore the most conservative approach.

- The use of smaller terminals in the adjacent satellite network would not be compatible with 2° orbit spacing.

- If larger ground terminals are used in the adjacent satellite network, they will have narrower beamwidths and so present less of an interference problem.

- All new satellite networks of the future, such as those to be implemented at Ka-band, are likely to use digital modulation schemes, which create the most benign interference environment.

- The use of higher order modulation schemes at Ka-band, which would require higher carrier-to-noise ratios and therefore more interference protection, is unlikely. Ka-band tends to be a power limited, rather than a bandwidth limited, environment due to power limitation of satellite and ground station amplifiers, and due to the relatively high levels of rain attenuation.

By making the assumption that the adjacent satellite networks are identical to the Astrolink-Phase II™ system, it is only necessary to perform the interference analysis in one direction, namely from the adjacent satellite network into the Astrolink-Phase II™ system. This involves double entry interference—one from the network on each side of the Astrolink-Phase II™ satellite.

Under the above assumptions, the adjacent satellite interference will be a function of the ground terminal antenna discrimination towards adjacent satellites and its location relative to the coverage contours of the interfering and interfered-with satellites. It is not dependent on the channel data-rate (on the uplink), because the same coding and modulation is used on all uplink channels.

Using the above assumption, the C/I ratios for adjacent satellites were calculated for the various user terminal antenna sizes for the uplink and downlink. The angular discrimination at the ground was calculated to be 2.07°, taking into account the topocentric angle (within the 30° elevation) between 2° spaced satellites less a ±0.05° allowance for east-west station keeping per satellite. For the earth station antenna off-axis gain the usual expression, 29-25 log (θ), was used.

The link budgets in Section 4.9 use adjacent satellite C/I values calculated in this way. These show that a 90 cm user terminal antenna can be used under any circumstances in a 2° spacing environment. Smaller user terminal antennas, down to 65 cm in diameter, may be limited to geographic locations away from the edge of the beam or they may be required to meet higher performance off-axis gain. In the situation where there is no U.S. licensed satellite within 2°, which is likely for many proposed Astrolink-Phase II™ orbit locations, the standard specified 65 cm antenna can be used. The larger gateway terminal antennas will have much greater adjacent satellite discrimination, as can be seen from the gateway link budgets of Section 4.9.

4.11.2.2. NGSO FSS

In the 17.7-18.8 GHz, 19.7-20.2 GHz, 28.35-28.6 GHz and 29.5-30.0 GHz frequency bands, GSO FSS systems such as the Astrolink-Phase II™ System have a primary domestic U.S. allocation, while NGSO FSS is designated on a secondary basis. In these bands, NGSO FSS systems must protect the Astrolink-Phase II™ System from unacceptable interference and the Astrolink-Phase II™ System will not be required to protect the secondary operation of NGSO FSS systems. The most promising technique to achieve this interference protection will be the use of satellite diversity in the NGSO FSS system.

The FCC requires any NGSO FSS system to make a technical showing to demonstrate in detail the level of interference protection it will provide to GSO FSS systems before it can be brought into operation on a secondary basis. The recent WRC-97 has implemented provisional "epfd" and "apfd" limits on NGSO FSS systems in these bands, and there will be further debate in the U.S. concerning the applicability of these limits to U.S. licensed systems.[13] Lockheed Martin is confident that the FCC will ensure that any eventual regulatory mechanisms adopted to protect primary GSO FSS systems from NGSO FSS will be acceptable to all GSO FSS licensees.

In the 18.8-19.3 GHz and 28.6-29.1 GHz frequency bands, the situation is reversed and the Astrolink-Phase II™ System will operate on a secondary basis to primary, U.S.-licensed NGSO FSS systems.[14] Thus, the Astrolink-Phase II™ System must protect these NGSO FSS systems. To achieve this result, Lockheed Martin will ensure that transmissions to and from particular Astrolink-Phase II™ satellites cease whenever interference alignment situations occur with respect to operational NGSO FSS

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[13] These "apfd" and "epfd" limits quantify the application of Radio Regulation S22.2.

[14] Internationally GSO FSS and NGSO FSS are co-primary in these bands and coordination between them is subject to Resolution 46 (S9.11A). Therefore, the

satellites. There are two different ways in which this will be implemented, depending on the type of service being provided by the Astrolink-Phase II™ System. The first method will simply require link outages in the Astrolink-Phase II™ System, and therefore will only be used for communications applications that can tolerate sporadic, short-term outages (*e.g.*, a single user requiring delay-insensitive Internet access). The second method involves satellite or earth station diversity, similar to that proposed by NGSO FSS systems in order to protect GSO FSS systems. In this case, Astrolink-Phase II™ communications traffic will be switched to an alternative Astrolink-Phase II™ satellite, or through an alternative and geographically separate Astrolink- Phase II™ earth station, whenever interference alignment situations occur, thereby ensuring continuity of service in the Astrolink-Phase II™ System.[15]

In order to implement these interference mitigation techniques, the geometry of each co-frequency NGSO FSS satellite serving the same geographic area as the Astrolink-Phase II™ satellites will be determined by the Astrolink™ Network Control Center ("NCC") using orbit data provided by the relevant NGSO system operators. This analysis will provide the essential data for accurate prediction of interference events, and

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Astrolink-Phase II™ Sytem will be coordinated with non-U.S. NGSO FSS systems under the ITU procedures.

[15] The satellite diversity technique will be usable for geographic areas of the world that are served by more than one Astrolink™ or Astrolink-Phase II™ satellite. It will require Astrolink™ terminals to be equipped with two fixed antennas, each pointed towards an Astrolink™ or Astrolink- Phase II™ satellite.

thereby determine the times at which cessation of emissions or diversity switching must occur.

The interference between the NGSO FSS systems and the Astrolink-Phase II™ System, without mitigation, would be sporadic in nature, with the duration of the interference events being a function of earth station locations, antenna beamwidths, general link parameters, and operational procedures of both systems. Therefore, the criteria that will trigger the cessation of emissions or diversity switching in the Astrolink-Phase II™ System will depend on the operational parameters of the two systems, and on the agreed upon levels of interference protection of the NGSO FSS system. Lockheed Martin will coordinate the secondary operations of the Astrolink-Phase II™ System with NGSO FSS licensees in view of the above-referenced factors. Of course, Lockheed Martin also will operate its Astrolink- Phase II™ System in primary NGSO FSS bands in accordance with the all applicable rules governing secondary GSO FSS operations.

4.11.2.3. Inter-Satellite Links ("ISLs")

ISLs have highly directional antennas that produce extremely narrow beamwidths with high side lobe isolation, which greatly facilitates sharing with other satellite systems that might also be using ISLs. Depending on the number and location of GSO networks that will be employing ISLs and the specific frequency bands utilized, coordination between operators may be necessary. Studies in ITU-R Working Party 4A have shown that sharing of ISLs is feasible between GSO satellites spaced as close as 2°.

Coordination of LISLs should be very straightforward because of the low power employed for these short-range links.

4.11.2.4. Fixed Service

The Astrolink-Phase II™ System will operate in the 28.75-29.1 GHz and 29.25-30.0 GHz bands in the Earth-to-space direction. The interference cases in the uplink direction are from fixed service transmitters into the Astrolink-Phase II™ satellite receivers and from the Astrolink-Phase II™ transmit earth stations into the fixed service receivers.

In the United States, the band 27.85-28.35 GHz has been designated for LMDS on a primary basis and to GSO FSS on a secondary basis. This specific case is discussed in Section 4.11.2.5. In the remaining uplink bands, there is no designation for fixed service use in the United States.

Internationally, there is no allocation to the fixed service in the 29.5-30.0 GHz band, but there is an international fixed service allocation in the 27.85-29.1 GHz and 29.25-29.5 GHz bands that may result in potential interference between that service and the Astrolink-Phase II™ System in some countries. However, it is not expected that the terrestrial fixed service will cause interference into the Astrolink-Phase II™ satellite receivers because of the low elevation angles at which the fixed service operates and the high propagation losses in this frequency band. The most likely case of interference is from Astrolink-Phase II™ earth stations into terrestrial fixed service receivers if they are located in close proximity. In order to avoid this interference, Astrolink- Phase II™ earth stations will operate in accordance with Sections 25.204 and 25.209 of the Commission's rules and S21.8 of the ITU Radio Regulations. If cases still exist where harmful interference is caused to fixed service receivers, Lockheed Martin will coordinate Astrolink-Phase II™ with the affected fixed service operator.

4.11.2.5. Local Multipoint Distribution Service ("LMDS")

The Astrolink-Phase II™ System proposes to operate in the 27.85-28.35 GHz band in the Earth-to-space direction. In the United States, this band is designated for use by LMDS on a primary basis and for GSO FSS use on a secondary basis. The possible interference cases will be from LMDS transmitters into the Astrolink-Phase II™ satellite receivers and from the Astrolink-Phase II™ transmit earth stations into LMDS receivers.

It is not likely that the Astrolink-Phase II™ satellite receivers will experience interference from LMDS transmitters due to the propagation and path losses in this band. Consistent with its obligations as a secondary user, Lockheed Martin will operate the Astrolink-Phase II™ System in a manner that will not cause unacceptable interference to the LMDS receivers. This will be ensured by geographic separation of the Astrolink-Phase II™ System transmitters and LMDS receivers and by use of larger earth stations that provide the required side lobe protection. In addition, other mitigation techniques, such as site specific shielding, can be employed.

It appears that the principal deployment of the LMDS systems will be in major metropolitan areas. Therefore, the Astrolink-Phase II™ System may be required to limit its use of this band in the U.S. to earth stations deployed outside of these metropolitan areas. Lockheed Martin believes that it will be possible to conduct site-specific coordination with LMDS operators in specific geographic areas to permit Astrolink-Phase II™ operations in this band. Site-specific coordination will provide affected parties the opportunity to take into account the particular system parameters of the LMDS system and the level of acceptable interference between the operators.

4.11.2.6. Mobile-Satellite Service Feeder Links

The Astrolink-Phase II™ System operates co-primary with the NGSO MSS feeder links in the 29.25-29.5 GHz band. Existing FCC rules permit only certain types of NGSO MSS feeder link designs to operate in this band, and Lockheed Martin is committed to coordinate with U.S.-licensed operators of such systems.

4.11.2.7. Earth Exploration-Satellite and Space Research

The Earth exploration-satellite ("EES") and space research ("SR") passive services are allocated on a co-primary basis in the 18.6-8.8 GHz band. As demonstrated in Section 4.10.1, the Astrolink-Phase II™ System will meet the required pfd limit to protect these passive services.

4.11.2.8. Mobile-Satellite and Mobile Services

It is expected that co-frequency, co-coverage operations of the Astrolink-Phase II™ System and the generic mobile-satellite service or mobile service will not be possible given the technical and operational parameters of the mobile systems, such as the use of omni-directional antennas.

4.12. LAUNCHER DESCRIPTION

The Astrolink-Phase II™ spacecraft is compatible with the mass and volume constraints of the Ariane and Proton M launch vehicles assuming a 12-year mission life.[16] The spacecraft will also be compatible with Lockheed Martin's EELV launch vehicle currently in development. Figure 4.12-1 shows the stowed launch configuration within the Proton M launch vehicle fairing.

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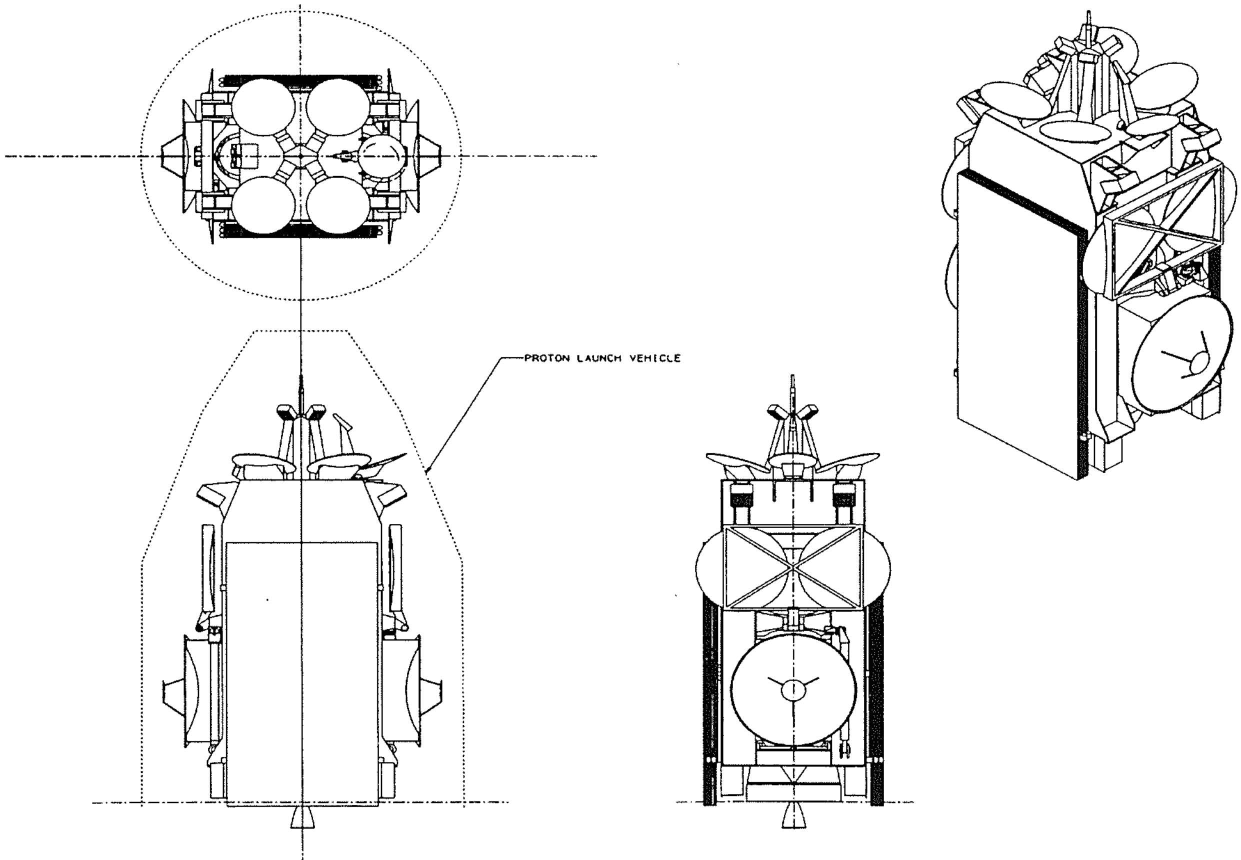
[16] The Proton M is currently in development and will be available at the time of launch.

Figure 4.12-1 - Astrolink-Phase II™ Spacecraft Launch Configuration Using Proton M



4.13. SATELLITE GROUND FACILITIES

4.13.1. Tracking, Telemetry and Control ("TT&C") Earth Stations

The proposed system will utilize one primary TT&C earth station dedicated to each satellite and a sufficient number of backup TT&C earth stations to ensure that each satellite will be visible from at least one primary and one backup TT&C station. Thus, a minimum of five primary TT&C earth stations and a smaller number of backup TT&C earth stations will be required for the Astrolink-Phase II™ satellites. The final locations of TT&C earth stations have not yet been determined, and TT&C earth stations serving separate satellites may be collocated. All TT&C earth stations will be licensed and operated under with the local regulations of the territory in which they are located. Lockheed Martin is not requesting a license for any TT&C earth stations at this time.

4.13.2. Spacecraft Operations Centers

Lockheed Martin plans one primary and one backup Spacecraft Operations Center ("SOC") to control satellite operations. The SOCs will communicate with the Astrolink-Phase II™ satellites through TT&C earth stations. Launch and early mission operations will be handled from the A2100™ Spacecraft Operations Center ("ASOC"), which operates at Sunnyvale, California, and will utilize the existing Lockheed Martin TT&C stations in Carpentersville, New Jersey and the island of Guam. Once operational, spacecraft monitoring, stationkeeping maneuver planning, and preparing and executing necessary satellite command sequences will be accomplished by the Astrolink™ System SOC. The final locations of the SOCs have not yet been determined, but they may be collocated with one or more TT&C earth stations.

4.13.3. Network Control Centers

There will be one Network Control Center ("NCC") associated with each Astrolink-Phase II™ satellite. The NCC which will communicate with its associated satellite via a gateway earth station. The NCC will authenticate users, perform call setup and teardown functions, manage the spacecraft resources to maximize system utilization, generate billing information, monitor the quality of service, and perform recovery operations in case of outages. A "master" Astrolink™ NCC will coordinate inter-satellite traffic, manage network resources, perform overall system monitoring, and plan and supervise recovery operations in case of network outages.

4.14. OPERATIONS

Launch and early mission operations will be handled from the A2100™ Spacecraft Operations Center ("ASOC"), which operates at Sunnyvale California, and will utilize existing Lockheed Martin TT&C earth stations in Carpentersville, New Jersey and the island of Guam. Once operational, spacecraft control will be handled entirely by the Astrolink™ System SOC and TT&C earth stations.

Satellite telemetry will be received at TT&C earth stations and relayed via terrestrial or satellite communications links to the Astrolink™ System SOC, where satellite health and status will be monitored. The signals from each satellite will be capable of being received by at least two geographically separated TT&C earth stations so that constant monitoring and control is possible in the event of a major outage at one facility. Stationkeeping maneuver planning and execution, as well as required satellite commands, will be generated at the SOC and relayed to the appropriate TT&C earth station for transmission to the satellite. A backup SOC facility will be provided which will be capable of controlling a satellite in case of an outage at the primary SOC facility. In special circumstances, such as the loss of terrestrial communication links, emergency commands may be sent to the spacecraft directly from any of the TT&C earth stations in view of the satellite.

The NCC will authenticate users and provide access to authorized users in accordance with available network resources. The NCCs will manage network resources, set up and tear down calls, provide directory services, and generate billing information. In addition, the NCCs will monitor the quality of service and perform service restoration in case of outages.

5. PUBLIC INTEREST CONSIDERATIONS

Deployment of the Astrolink-Phase II™ System will further a number of important public interest objectives. As a result of the WTO Agreement on Basic Telecommunications and other factors, the $600 billion global telecommunications market is expected to double or even triple within the next ten years. The Astrolink-Phase II™ System will serve this burgeoning communications market by expanding the advanced, broadband communications capacity of Lockheed Martin's Astrolink™ System and thereby meet the expected communications needs of consumers and businesses around the world.

In addition, the communications capabilities of the proposed system will enhance the Global Information Infrastructure ("GII"). Existing telecommunications facilities are being severely strained by the explosive growth in demand for domestic and international communications services. The Astrolink-Phase II™ System will provide "instant" infrastructure to meet this demand and, since the system will utilize small inexpensive Astrolink™ terminals, it will afford a broad range of users the ability to access an expanding GII and benefit from new and innovative services to be provided globally. By improving communications capabilities around the world, the Astrolink-Phase II™ System will permit greater access to communications services, facilitate cultural exchange, promote the free flow of information, and enhance opportunities for international trade.

Grant of Lockheed Martin's application will also promote competition in satellite communications services. The Astrolink-Phase II™ system will provide telecommunications carriers and other customers with an expanded choice of satellite facilities and services. Lockheed Martin is legally, technically, and financially qualified to implement the Astrolink-Phase II™ System on a global scale, and will proceed with construction and deployment upon the receipt of required regulatory authorizations. Accordingly, grant of this application will ensure a competitive market framework for new and innovative services, and customer choice in the satellite communications marketplace.

The construction and deployment of the satellite system also will further important U.S. economic goals. The Astrolink-Phase II™ System will lead to substantial additional investment in the U.S. aerospace industry and create and sustain a number of new, high-wage professional jobs in the areas of research and development, production, and administration. As noted in Section 8.1 of this application, the cost of construction, launch, and first-year operation of the Astrolink-Phase II™ System will be $2.16 billion, which will directly benefit the U.S. economy because the system will be manufactured in the United States by Lockheed Martin. Astrolink Phase II™ will create new jobs in the service sector, terminal equipment market, and other areas. Also, because of the global nature of the Astrolink-Phase II™ System, construction and deployment of this satellite network will also spur economic growth in other regions of the world.

Finally, grant of Lockheed Martin's application will promote continuing U.S. leadership in the satellite industry. The United States leads the world in developing and implementing advanced satellite technologies, resulting in significant economic, social, and other benefits for the U.S. public and the global community. Deployment of the

Astrolink-Phase II System will stimulate additional investment in the U.S. satellite industry, spur further advances in Ka-band technologies, promote new and innovative communications services, and help maintain U.S. leadership in advanced satellite communications systems and services.

6. MILESTONES

The Astrolink-Phase II™ spacecraft will be manufactured by Lockheed Martin, which will proceed with construction, launch and operation of the proposed system upon receipt of required regulatory approvals. Lockheed Martin proposes to manufacture, launch, and place into service the Astrolink-Phase II™ satellites pursuant to the following schedule:

Table 6-1 - Major Milestones

Milestone	Milestone Completion
Commence construction of first satellite	Authorization + 12
Commence construction of remaining satellites	Authorization + 16 to Authorization + 24
Complete construction of first satellite	Authorization + 48
Complete construction of remaining satellites	Authorization + 50 to Authorization + 54
Launch of first satellite	Authorization + 54
Launch of remaining satellites	Authorization + 56 to Authorization + 58
Place first satellite into service	Authorization + 56
Place remaining satellites into service	Authorization + 58 Authorization + 60

7. LEGAL QUALIFICATIONS

Lockheed Martin Corporation ("Lockheed Martin"), a Maryland corporation, has headquarters offices located at 6801 Rockledge Drive, Bethesda, MD 20817. Lockheed Martin is a diversified, advanced technology company with $27 billion in sales and core businesses in defense, space, energy, commercial, and government markets. Lockheed Martin is a publicly held corporation and its stock is traded on the New York Stock

Exchange under the symbol LMT. Lockheed Martin is the licensee of the Astrolink™ System, a Ka-band GSO FSS system recently authorized by the Commission to provide advanced broadband satellite communications services in the United States and around the world.

The legal qualifications of Lockheed Martin are demonstrated in FCC Form 312, which is submitted as part of this application.

8. FINANCIAL QUALIFICATIONS

8.1. SYSTEM COSTS

The estimated costs of development, construction and launch of the five Astrolink-Phase II™ satellites are approximately $1.9 billion. Earth station construction, including TT&C earth stations, gateways, and NCCs, will require an additional investment of $140 million. Pre-operating expenses of the Astrolink-Phase II™ System are estimated at approximately $20 million. Estimated operating expenses for one year after launch of the initial satellite are $100 million. These estimated costs are itemized in Table 8.1-1.

Table 8.1-1 - Estimated System Costs

Activity	**Cost (Millions)**
Satellite Development and Construction, Launch Services, and Insurance	$1,900
Earth Station Construction, including TT&C, Gateways, and Network Control	$ 140
Pre-Operating Expenses	$ 20
First-Year Operating Costs	$ 100
TOTAL	$2,160

Lockheed Martin will manufacture the Astrolink-Phase II™ spacecraft. The estimated satellite development and construction costs are based on Lockheed Martin's internal data and its substantial satellite manufacturing experience. Estimated launch costs, including insurance, are premised on prevailing industry trends. Earth station construction costs are based on known and anticipated costs for such facilities. First year operating expenses include the costs of system operations, maintenance, insurance, general and administrative costs, marketing, depreciation, and interest.

8.2. SOURCE OF FUNDS

Lockheed Martin is a publicly held corporation whose financial strength is a matter of public record. Lockheed Martin has sufficient financial resources to finance the construction, launch, and first-year operating costs of the Astrolink-Phase II™ System.

As of December 31, 1996, Lockheed Martin had total assets in excess of $29.25 billion and current assets in excess of $9.9 billion. Net sales for the fiscal year ended December 31, 1996, amounted to $26.875 billion. Lockheed Martin's net earnings for the fiscal year ended December 31, 1996, were $1.347 billion. Appendix 1 to this narrative statement includes the audited financial statements of Lockheed Martin Corporation's 1996 Annual Report.

In addition to relying on internal resources, Lockheed Martin intends to pursue additional equity and/or debt placements to finance the construction, launch, and operation of the Astrolink-Phase II™ System. Lockheed Martin remains committed to implementing the Astrolink-Phase II™ System and, absent a material change in circumstances, intends to expend funds and to implement an economically viable business plan which will be the basis for raising funds from lenders and/or equity investors, necessary to construct and launch the proposed satellite system and operate the system for one year after launch of the first satellite.[17]

9. TECHNICAL QUALIFICATIONS

Lockheed Martin has the technical qualifications, expertise, and resources to implement the Astrolink-Phase II™ System. As shown in other sections of this application, Lockheed Martin has participated in all aspects of U.S. government and commercial space programs for the past four decades, from system development and manufacture to launch processing and operations. Moreover, the Astrolink-Phase II™ System complies with all relevant U.S. and international technical specifications governing satellite operations in the subject bands. Accordingly, Lockheed Martin is technically qualified to develop and implement the global satellite system to meet the world's demand for advanced satellite communications technologies and services.

10. U.S. AND INTERNATIONAL COORDINATION

Lockheed Martin will comply with all U.S. and international requirements in coordinating the proposed system. Lockheed Martin will provide the Commission with all necessary coordination materials to be forwarded to the Radiocommunication Bureau of the International Telecommunications Union ("ITU"). To the extent that it has not

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[17] Lockheed Martin reserves the right to amend this application to conform to any financial requirements that the Commission may hereafter adopt for second-round Ka-band applicants.

already done so in the context of the first Ka-band processing round, Lockheed Martin respectfully requests that the Commission proceed with ITU coordination procedures as soon as possible in order to preserve U.S. interests in the requested orbital resources. In addition, Lockheed Martin will comply fully with the consultation requirements of Article XIV of the INTELSAT Agreement.

11. WAIVERS

For the reasons contained therein, the Commission should grant the waivers of Parts 2 and 25 of its rules requested by Lockheed Martin in Exhibit D to this application. Lockheed Martin believes that it has complied fully with all pertinent Commission rules and policies, and has supplied all relevant information required to license the Astrolink-Phase II™ System. To the extent the Commission views any portion of this application as not fully in accordance with current regulatory requirements, Lockheed Martin hereby requests that the Commission grant any additional waivers that may be necessary or appropriate in the context of this application.

12. FURTHER INFORMATION

Lockheed Martin has attempted to comply fully with all of the space station application requirements set out in Part 25 of the Commission's rules. To the extent the Commission requires additional information in connection with this application, Lockheed Martin will respond promptly to any Commission request for such information.

13. NAME AND ADDRESS OF COUNSEL

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Carlos M. Nalda, Esquire
Dow, Lohnes & Albertson
1200 New Hampshire Avenue, N.W.
Washington, D.C. 20036-6802
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14. CONCLUSION

The Astrolink-Phase II™ System will significantly enhance the capabilities of Lockheed Martin's Astrolink™ System, an advanced satellite communications network that will provide new and innovative satellite communications technologies and services, will contribute to an expanding Global Information Infrastructure, will foster competition in the satellite communications marketplace, and will further other important U.S. public interest objectives. For reasons set forth herein, Lockheed Martin requests that the Commission promptly grant this application so that the significant benefits afforded by the proposed system may be realized at the earliest possible time.

Respectfully submitted,

Lockheed Martin Corporation

By: Mel R. Brashears

Mel R. Brashears
President and Chief OperatingOfficer
Space and Strategic Missiles Sector
Lockheed Martin Corporation

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December 19, 1997

ENGINEERING CERTIFICATE

I hereby certify that I am the technically qualified person responsible for the preparation of the engineering information contained in the technical portions of the foregoing application, that I am familiar with Part 25 of the Commission's rules, and that the technical information is complete and accurate to the best of my knowledge and belief.

Eduardo L. Elizondo
Systems Engineer Consultant
Lockheed Martin Telecommunications

December 19, 1997

Exhibit D-1

Waiver Request

Lockheed Martin's Astrolink-Phase II™ application requests authority to perform TT&C operations in extended C-band frequencies. Under the U.S. Table of Frequency Allocations, TT&C functions are normally conducted in bands allocated to the space operation service or in the band in which the underlying service is being conducted.[1/] If the Commission finds that Section 2.1, Section 25.202(g) or any other provision of its rules would preclude TT&C operations in extended C-band absent a waiver, then Lockheed Martin respectfully requests that the Commission waive these rules (or provide other appropriate authorization) to permit grant of this portion of the Astrolink-Phase II™ application.

Section 1.3 of the Commission's rules permits a waiver of any rule, in whole or in part, for good cause.[2/] For reasons set forth in this application, compelling technical and public interest considerations support permitting Lockheed Martin to perform TT&C functions for the Astrolink-Phase II™ System in extended C-band frequencies.

1/ *See* 47 C.F.R. § 2.1 (1997); *see also* 47 C.F.R. § 25.202(g) (1997).

2/ 47 C.F.R. § 1.3 (1997).

Lockheed Martin is submitting herewith a technical showing that the proposed Astrolink-Phase II™ TT&C operations would not cause interference to other conforming operations in the extended C-band.[3/]

Permitting Lockheed Martin to perform TT&C operations in extended C-band spectrum would facilitate implementation of the Astrolink-Phase II™ System by improving system reliability, by lowering system satellite construction and operational costs, and by facilitating early deployment of this global satellite network. Permitting Lockheed Martin to perform Astrolink-Phase II™ TT&C operations in extended C-band would also serve the public interest by improving the operational characteristics of the Astrolink-Phase II™ System, reducing the cost of Astrolink-Phase II™ services, and hastening the introduction of new and innovative broadband communications services in the U.S. and foreign markets.

Commission precedent supports the grant of a waiver or other authorization in this situation. Indeed, the Commission has previously approved TT&C operations on a non-conforming basis in circumstances nearly identical to this case. Thus, for example, the Commission recently granted Directsat Corporation's modification application to consolidate on-station, transfer orbit, and emergency-mode TT&C functions in C-band spectrum, which was

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3/ See *Astrolink™ Authorization*, ____ FCC Rcd ____, 1997 FCC LEXIS 2388, ¶23 (Int'l Bur., rel. May 9, 1997), wherein the Commission stated that should Lockheed Martin wish to pursue TT&C operations in non-conforming bands, it should submit an exhibit demonstrating that such TT&C operations will not interfere with other conforming operations in the band.

neither the underlying service band nor a band allocated to the space operations service.[4/] Similarly, the Commission authorized Space Imaging L.P., an Earth Exploration Satellite Service licensee, to perform TT&C functions in spectrum outside of its service bands and space operation bands.[5/]

Lockheed Martin proposes to perform Astrolink-Phase II™ System TT&C operations in extended C-band frequencies under the same conditions imposed by the Commission in granting similar requests, *viz.*, Lockheed Martin would operate in the requested bands on an unprotected, non-interference basis only, thereby protecting conforming users in the band.[6/]

A number of other considerations support this request. For example, advanced Ka-band communications systems and services are at a relatively early stage of development and issues regarding spectrum utilization and system deployment are still being defined. Thus, a measure of flexibility as to TT&C operations is appropriate to facilitate the introduction of these advanced broadband communications systems and services. In addition, any party believing it may be adversely affected by TT&C operations in the extended C-band will have a full

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4/ *See Directsat Corporation Application for Modification of Construction Permit for a Direct Broadcast Satellite System*, Order, 11 FCC Rcd 22375 (Office of Eng'g Tech. and Int'l Bur., rel. Sept. 9, 1996).

5/ *See Space Imaging L.P. Application to Construct, Launch and Operate a Commercial Remote-Sensing Satellite System in Low-Earth Orbit*, 10 FCC Rcd 10911 (Int'l Bur., rel. Aug. 23, 1995).

6/ *See Directsat Corporation,* 11 FCC Rcd at 22377-78*; see also Space Imaging*, 10 FCC Rcd at 10913.

opportunity to address any potential interference concerns. In this regard, Lockheed Martin and eight other GSO FSS Ka-band licensees have submitted a *Petition for Rulemaking* to designate extended C-band spectrum for TT&C functions of GSO FSS satellites operating in bands above Ku-band.[7/]

For these reasons, Lockheed Martin requests that the Commission waive Section 2.1, Section 25.202(g) and any other applicable rule, or provide other appropriate authorization necessary to permit Lockheed Martin to perform TT&C operations using extended C-band frequencies.

7/ *See Amendment of Parts 2 and 25 of the Commission's Rules to Designate Extended C-Band Spectrum for TT&C Functions of GSO FSS Systems Operating in Bands Above Ku-Band,* Petition for Rulemaking (filed Aug. 7, 1997, on behalf of Comm, Inc., EchoStar Satellite Corp., GE American Communications, Inc., Hughes Communications Galaxy, Inc., KaStar Satellite Communications Corp., Lockheed Martin Corp., Orion Network Systems, Inc., PanAmSat Licensee Corp., and VisionStar, Inc.) ("*Petition for Rulemaking*").

Exhibit D-1

Technical Showing

The use of extended C-band frequencies in the bands 3650-3700 MHz and 6425-6525 MHz for the tracking, telemetry and control ("TT&C") operations of the Astrolink-Phase II™ System will greatly facilitate the deployment of its geostationary orbit ("GSO") constellation. It will permit the use of highly reliable and cost-effective space and ground equipment for orbital insertion, station keeping and on-orbit maneuvers and other spacecraft housekeeping functions. As this usage will be on a non-conforming basis, the Astrolink-Phase II™ System will operate its extended C-band TT&C operations on a non-protected, non-interfering basis with respect to conforming services licensed in this band. Should the Commission act on the pending rulemaking requesting the use of extended C-band for TT&C operations, the Astrolink-Phase II™ System will be operated in conformance with the rules adopted in that proceeding.[1/] The Astrolink-Phase II™ System will maintain a 24-hour point of contact that can arrange to remedy any interference problems that may arise.

The Astrolink-Phase II™ System will require no more than two TT&C sites in the U.S. Use of other TT&C sites around the world will be subject to coordination with affected satellite networks and with terrestrial networks, as required by the country where the TT&C sites are located.

1/ *See Amendment of Parts 2 and 25 of the Commission's Rules to Designate Extended C-Band Spectrum for TT&C Functions of GSO FSS Systems Operating in the Bands Above Ku-Band*, Petition for Rulemaking (filed Aug. 7, 1997, on behalf of Comm, Inc.; EchoStar Satellite Corp.; GE American Communications Corp.; Lockheed Martin Corp.; Orion Network Systems, Inc.; PanAmSat Licensee Corp.; and VisionStar, Inc.) ("*Petition for Rulemaking*").

The required TT&C spectrum for the Astrolink-Phase II™ System consists of only one telecommand carrier of 1.5 MHz bandwidth and two 600 kHz bandwidth telemetry carriers. The preferred frequencies are at the edges of the bands to facilitate coordination with other users.[2/] The technical characteristics of the Astrolink-Phase II™ proposed C-band TT&C operations are provided in Table 1 below.

Table 1 - Technical Characteristics of the Proposed Extended C-band TT&C Operations

Parameter		Unit	Normal Mission Operations	Launch, Early Orbit and Emergency Operations
Command	Frequency	MHz	6425.5 and 6427.5	6425.5 and 6427.5
	Coverage	N/A	Pyramidal Horn Antenna	Omni Antenna
	Flux Density	dBW/m2	-90	-80
	Modulation	N/A	PCM-RZ/FSK/FM	PCM-RZ/FSK/FM
	Data Rate	Bps	1024	1024
Telemetry	Frequency	MHz	3650.5 and 3699.5	3650.5 and 3699.5
	Coverage	N/A	Pyramidal Horn Antenna	Omni Antenna
	EIRP	dBW	+4	-5.4
	Modulation	N/A	PCM BiPhase/PSK/PM	PCM BiPhase/PSK/PM
	Data Rate	Bps	4096	4096
Tracking	Frequency U/L	MHz	6425.5 and 6427.5	6425.5 and 6427.5
	Frequency D/L	MHz	3650.5 and 3699.5	3650.5 and 3699.5
	Modulation U/L	N/A	FM/FM	FM/FM
	Modulation D/L	N/A	FM/PM	FM/PM
	Tone Frequencies	Hz	0, 35, 283, 3968 on 27.78 kHz Subcarrier or 27.778 kHz Fine Tone	0, 35, 283, 3968 on 27.78 kHz Subcarrier or 27.778 kHz Fine Tone

2/ The requested TT&C frequencies are 6425.5 MHz and 6427.5 MHz for uplink and 3650.5 MHz and 3699.5 MHz for downlink. Lockheed Martin understands that these frequencies may be subject to change as a result of coordination with other users.

Operation with Other U.S.-Licensed GSO Networks

Only a limited number of U.S.-licensed and/or operational GSO FSS networks operate in the extended C-band. Coordination on a case-by-case basis with such networks for the operation of the Astrolink-Phase II™ TT&C sites in extended C-band is therefore feasible. U.S. satellite filings that overlap the desired extended C-band TT&C frequencies exist for the following orbit locations: 174.3°W, 165°W, 119°W, 47°W, 12°W, 68°E, 72°E, 126°E, 139°E, 144°E and 172°E.[3/] As noted above, the proposed Astrolink-Phase II™ TT&C frequencies will be at the edge of the frequency bands. GSO operators typically reserve the edges of the frequency band for TT&C operations and this facilitates coordination of these signals with other GSO systems.[4/]

During normal on-station operations it should only be necessary to coordinate with other GSO satellites in the proximity of the Astrolink-Phase II™ orbit locations. Because of the characteristics of TT&C operations (*i.e.*, relatively small amounts of spectrum and large earth stations), the coordination of TT&C operations with other GSO networks is feasible with orbital separations as close as 2° or less.

3/ This list of filings were obtained from a review of the December 1997 version of Section 9 of the ITU's SNL (Space Network List) and the September 1997 version of the ITU's SRS (Space Radiocommunications Stations).

4/ Section 25.202(g) of the Commission's rules requires TT&C signals to remain at the edge of the band. 47 C.F.R. § 25.202(g) (1997).

The proposed Astrolink-Phase II™ orbit locations are 127°W, 79°W, 52°E, 99°E and 151.5°E.[5/] The closest U.S. satellite to a potential Astrolink-Phase II™ satellite is therefore 7.5° away. This 7.5° separation would occur between the ORION-AP-2 filing (filed by the U.S. on behalf of the Republic of the Marshall Islands) at 144°E and the proposed Astrolink-Phase II™ network at 151.5°E. Lockheed Martin remains confident that coordination can be achieved with all of the U.S.-filed networks, including ORION-AP-2, without burdensome constraints.

In the event that other U.S. Ka-band satellites utilize extended C-band spectrum for their TT&C operations, there will never be orbit spacings of less than 2°, and coordination can therefore be readily achieved.[6/] In cases where the spacing is only 2°, it may be advisable to coordinate exact TT&C carrier frequencies to avoid co-frequency operation. As all of these Ka-band satellites are still in the construction phase, coordination of the carrier frequencies should not pose any problem.

The use of extended C-band for transfer-orbit TT&C could potentially cause short-term interference to GSO FSS networks operating in these bands that are at orbit locations far removed from the Astrolink-Phase II™ orbital locations. However, transfer-orbit operations occur for only a limited period of time. Interference effects will therefore be only of short duration given the movement of the satellites relative to each other during this period. At such

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5/ The 2°E orbit location will be substituted for the 127°W location if the 2°E location is not assigned to Lockheed Martin as part of the first Ka-band processing round.

6/ The Commission's Ka-band orbital assignment plan is designed to ensure at least 2° orbital spacing between adjacent U.S. Ka-band satellites.

times, interference may occur from the Astrolink-Phase II™ telecommand signal to GSO FSS networks when the tracking Astrolink-Phase II™ earth station is in line with an operational GSO satellite. Another potential interference path will be from the Astrolink-Phase II™ satellite telemetry signal into a GSO receiving earth station when the Astrolink-Phase II™ satellite is in-line with the GSO earth station. To avoid these potential interference occurrences, Lockheed Martin will determine, prior to launch, which GSO orbital locations may be affected based on the transfer orbit path (which is a function of the launch vehicle and launch site). The Astrolink-Phase II™ System operations will then be coordinated with the potentially affected GSO networks and, if necessary, the TT&C operations will be ceased for the short duration of any in-line events.

Operations with U.S.-Licensed Terrestrial Networks

The downlink frequency bands (in the range 3650-3700 MHz) requested for the TT&C operations of the Astrolink-Phase II™ System are also allocated for government use to Aeronautical Radionavigation (ground based) and Radiolocation on a primary basis.[7/] The Astrolink-Phase II™ System will be coordinated with all U.S. government systems operating in these frequency bands. As the most likely source of interference is related to the interaction between Astrolink-Phase II™ earth stations and government terrestrial systems, and

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7/ Lockheed Martin notes that the NTIA has identified the 3650-3700 MHz band for reallocation to shared government/non-government use in January 1999. *See* Gerald F. Hundt, et al., *Spectrum Reallocation Final Report*, NTIA, Dept. of Commerce, Special Pub. No. 95-32 (Feb. 1995).

is therefore highly location dependent, this coordination will be more appropriate once Lockheed Martin submits its TT&C earth station applications to the Commission.[8/] Lockheed Martin notes that, in similar situations where operations are proposed within government allocated spectrum on a non-interference basis, NTIA has not objected.[9/]

The uplink frequency bands (in the range 6425-6525 MHz) requested for the TT&C operations of the Astrolink-Phase II™ System are also allocated for non-government use to the fixed and mobile services on a primary basis. Furthermore, the TT&C earth stations will be located in geographic areas away from metropolitan areas where the majority of these systems will operate. Geographic separation will therefore be a primary method of coordinating with these terrestrial services. In addition, other mitigation techniques such as site specific shielding can be employed. As with coordination with government systems, coordination with the non-government terrestrial services in the 6425-6525 MHz band will be more appropriate when Lockheed Martin submits its TT&C earth station applications to the Commission.

8/ Protection of terrestrial services from satellite downlinks in the adjacent 3700-4200 MHz band is ensured by the power flux density ("pfd") limits in Section 25.208 of the Commission's rules. The same limits are applied to the 3650-3700 MHz band in S21.16 of the ITU Radio Regulations. The proposed Astrolink-Phase II™ System complies fully with these pfd limits.

9/ *See Directsat Corporation Application for Modification of Construction Permit for a Direct Broadcast Satellite System*, Order, 11 FCC Rcd 22375, 22376 (Office of Eng'g & Tech. & Int'l Bur., rel. Sept. 9, 1996).

Exhibit D-2

Waiver Request

Lockheed Martin's Astrolink-Phase II™ System is designed to satisfy the rapidly increasing demand for broadband telecommunications services in the United States and around the world. The five orbit locations requested for the Astrolink-Phase II™ System are essential for Lockheed Martin to provide Ka-band coverage of multiple geographic regions, to meet the burgeoning demand for broadband communications services globally, and to compete effectively with other domestic and international satellite networks.

Section 25.140(f) of the Commission's rules limits the number of orbital locations an applicant may be assigned beyond its current authorizations in any given frequency band. As discussed below, however, this rule was adopted at an earlier stage in the development of satellite technology, for a very limited purpose, and the restriction in the rule should therefore not apply in the context of global Ka-band satellite networks. Indeed, the Commission has been willing to waive Section 25.140(f) in appropriate circumstances, including most recently in the first Ka-band processing round.[1/] If the Commission concludes that Section 25.140(f) or any related provision of the rules is applicable to Lockheed Martin's request for the Astrolink-Phase II™ orbit locations and would preclude grant of the application absent a waiver, then Lockheed

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1/ *See Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services*, Third Report and Order, CC Docket No. 92-297, ¶ 24 (rel. Oct. 15, 1997) ("*Third Report and Order*"). *See also Assignment of Orbital Locations to Space Stations in the Domestic Fixed Satellite Service*, 11 FCC Rcd 13788, 13792 (1996).

Martin respectfully requests that the Commission waive such rule to permit grant of this application.[2/]

As the Commission stated in the *Third Report and Order*, the limitations on orbital assignments set out in the rules pertained historically to the provision of domestic FSS in the United States.[3/] The purpose of this limitation was to avoid prematurely assigning an excessive number of domestic orbital locations to a single applicant and to promote entry opportunities in the bands.[4/] These policy considerations do not apply to global satellite networks such as the Astrolink-Phase II™ System. Indeed, the Commission waived the orbital assignment limitation in the first Ka-band processing round, reciting a number of important public interest factors for permitting global Ka-band systems to proceed with deployment of satellites in multiple orbital locations.

First, the Commission noted that many of the proposed Ka-band systems were not limited to U.S. domestic satellite service, but would serve geographic areas around the world. Second, the Ka-band applicants had agreed to an orbital assignment plan which accommodated all proposed first round applicants. Third, the Commission noted that it had licensed 13 different GSO FSS system operators to utilize Ka-band frequencies, and there would therefore be a mix of competitors for services in this band.

2/ Section 1.3 of the Commission's rules, 47 C.F.R. § 1.3 (1997), permits waiver of the rules, in whole or in part, for good cause.

3/ *See Third Report and Order* ¶ 24.

4/ *See id.*; *see also Licensing Space Stations in the Domestic Fixed-Satellite Service*, Report and Order, 58 R.R. 2d 1267 (1985).

These factors likewise justify a waiver of Section 25.140(f) in the second Ka-band processing round to permit the deployment of Lockheed Martin's Astrolink-Phase II™ System. The Astrolink-Phase II™ System is a global communications network that will serve geographic areas throughout the world. Unlike the case of purely domestic FSS satellite systems, applying the Section 25.140(f) orbital limitations to international satellite networks would serve no public interest purpose, and would actually frustrate the development by U.S. licensees of global systems and services. Moreover, given the 13 initial GSO FSS systems licensed in the Ka-band (in addition to an authorized NGSO operator), and considering the second round Ka-band proposals, the Commission can be assured of vigorous competition in the provision of Ka-band services. Far from restricting competition, a grant of Lockheed Martin's Astrolink-Phase II™ System application will help to ensure new and robust competition in the commercial satellite services sector.[5/]

Finally, the Commission should refrain from applying to global satellite systems regulatory restrictions created to achieve specific objectives in the U.S. domestic satellite market, particularly where such restrictions serve no public interest purpose and would inhibit the development and growth of global satellite networks.

5/ It is not possible, of course, to know whether an orbital assignment plan can be achieved among all second round Ka-band applicants, and it is therefore premature to address the relevance and weight this factor should be given in the context of a second Ka-band processing round. Presumably the applicants will endeavor to achieve an orbital assignment plan that can accommodate all of the second round Ka-band satellites.

For these reasons, Lockheed Martin respectfully requests that the Commission waive Section 25.140(f) of the rules, to the extent required, to permit Lockheed Martin to implement the Astrolink-Phase II™ System.

EXHIBIT K

Statement of Facts

The Filer, Lockheed Martin Corporation ("Lockheed Martin"), a Maryland corporation, was formed in connection with the merger of Lockheed Corporation and Martin Marietta Corporation, a business combination which was consummated on March 15, 1995. Lockheed Martin has never been convicted of a felony by any state or federal court. The following matters relating to predecessor companies are being reported out of an abundance of caution.

On January 27, 1995, Lockheed Corporation pleaded guilty in federal district court in Atlanta, Georgia, to a single count of conspiracy to violate the Foreign Corrupt Practices Act and conspiracy to falsify its books, records, and accounts. The plea was related to a 1989 contract between Lockheed Corporation and Egypt for the sale of C-130 aircraft. As part of the resolution of this litigation, Lockheed Corporation paid certain fines to the United States Government.

In March 1987, pursuant to an agreement entered into with the United States Attorney for Maryland, Martin Marietta Corporation pleaded guilty in federal district court in Maryland to two counts of mail fraud (18 U.S.C. §1341) and one count of false statements (18 U.S.C. §1001) in connection with activities of a subsidiary of Martin Marietta Corporation which provided travel-related services. As part of this agreement, Martin Marietta paid certain fines and reimbursed investigative costs to the United States Government.

Additionally, in April 1996, Loral Corporation became a wholly-owned subsidiary of Lockheed Martin by merging with a subsidiary of Lockheed Martin. The business units acquired by Lockheed Martin in this transaction were subsequently integrated into Lockheed Martin Corporation and Loral Corporation ceased to exist. On December 8, 1989, Loral Corporation pleaded guilty in federal district court in Virginia to charges of conspiracy, conversion of government property, and false statement. The pleas were related to the activities of Loral Defense Systems in obtaining competitor proprietary and government source selection information to assist it in securing certain defense contracts. As part of the resolution of this litigation, Loral Corporation paid certain fines, civil damages, penalties, and investigative costs to the United States Government.

Exhibit L

Stockholders Owning and/or Voting 10% or More of Filer's Voting Stock

Lockheed Martin Corporation ("Lockheed Martin"), a diversified advanced-technology company, is a Maryland corporation with its principal place of business at 6801 Rockledge Drive, Bethesda, MD 20817. Lockheed Martin is a publicly held corporation whose stock is traded on the New York Stock Exchange under the symbol LMT.

The following stockholders hold 10% or more of the voting stock of Lockheed Martin as trustees of certain employee benefit plans:

US Trust Company of California, N.A. ("US Trust")
555 South Flower Street
Los Angeles, CA 90071

State Street Bank and Trust Company ("State Street")
225 Franklin Street
Boston, MA 021100

All of the shares held by US Trust and State Street are registered in the name of the following company:

CEDE & Co.
The Depository Trust Company
P.O. Box 20
Bowling Green Station
New York, NY 10274

Exhibit M

Officers and Directors of the Filer

The names and addresses of the officers and directors of the Filer, Lockheed Martin Corporation, are listed below:

Officers:

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APPENDIX 1

FINANCIAL QUALIFICATIONS

Declaration of Marcus C. Bennett

I, Marcus C. Bennett, hereby declare under penalty of perjury that:

1. I am the Executive Vice President and Chief Financial Officer of Lockheed Martin Corporation.

2. Attached is a true and correct copy of the Audited Consolidated Financial Statements for Lockheed Martin Corporation as of December 31, 1996, as provided in Lockheed Martin Corporation's 1996 Annual Report.

3. As set forth in Section 8 of this Application, Lockheed Martin is committed to implementing the proposed satellite communications system and, absent a material change in circumstances, intends to expend funds and to implement an economically viable business plan which will be the basis for raising funds from lenders and/or equity investors, necessary to construct and launch the proposed satellite system and operate the system for one year after launch of the first satellite.

Marcus C. Bennett
Executive Vice President and
Chief Financial Officer
Lockheed Martin Corporation

Date: December 19, 1997

The Corporation's Responsibility for Financial Reporting

The management of Lockheed Martin Corporation prepared and is responsible for the consolidated financial statements and all related financial information contained in this report. The consolidated financial statements, which include amounts based on estimates and judgments, have been prepared in accordance with generally accepted accounting principles applied on a consistent basis.

The Corporation maintains a system of internal accounting controls designed and intended to provide reasonable assurance that assets are safeguarded, transactions are properly executed and recorded in accordance with management's authorization, and accountability for assets is maintained. An environment that establishes an appropriate level of control consciousness is maintained and monitored and includes examinations by an internal audit staff and by the independent auditors in connection with their annual audit.

The Corporation's management recognizes its responsibility to foster a strong ethical climate. Management has issued written policy statements which document the Corporation's business code of ethics. The importance of ethical behavior is regularly communicated to all employees through the distribution of written codes of ethics and standards of business conduct and through ongoing education and review programs designed to create a strong compliance environment.

The Audit and Ethics Committee of the Board of Directors is composed of eight outside directors. This Committee meets periodically with the independent auditors, internal auditors and management to review their activities.

The consolidated financial statements have been audited by Ernst & Young LLP, independent auditors, whose report follows.

Marcus C. Bennett
Executive Vice President and Chief Financial Officer

Robert E. Rulon
Vice President and Controller

Report of Ernst & Young LLP, Independent Auditors

Board of Directors and Stockholders
Lockheed Martin Corporation

We have audited the accompanying consolidated balance sheet of Lockheed Martin Corporation as of December 31, 1996 and 1995, and the related consolidated statements of earnings, stockholders' equity, and cash flows for each of the three years in the period ended December 31, 1996. These financial statements are the responsibility of the Corporation's management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, the consolidated financial statements referred to above present fairly, in all material respects, the consolidated financial position of Lockheed Martin Corporation at December 31, 1996 and 1995, and the consolidated results of its operations and its cash flows for each of the three years in the period ended December 31, 1996, in conformity with generally accepted accounting principles.

The Corporation changed its method of accounting for Employee Stock Ownership Plans effective January 1, 1994 as discussed in Note 1 to the consolidated financial statements.

Ernst + Young LLP

Washington, D.C.
January 20, 1997, except for Note 3,
as to which the date is February 3, 1997

Consolidated Statement of Earnings

(In millions, except per share data)	Year Ended December 31, 1996	1995	1994
Net sales	**$26,875**	$22,853	$22,906
Costs and expenses:			
Cost of sales	**24,594**	20,881	21,127
Merger related and consolidation expenses	**—**	690	—
Earnings from operations	**2,281**	1,282	1,779
Other income and expenses, net	**452**	95	200
	2,733	1,377	1,979
Interest expense	**700**	288	304
Earnings before income taxes and cumulative effect of change in accounting	**2,033**	1,089	1,675
Income tax expense	**686**	407	620
Earnings before cumulative effect of change in accounting	**1,347**	682	1,055
Cumulative effect of change in accounting	**—**	—	(37)
Net earnings	**$ 1,347**	$ 682	$ 1,018
Earnings per common share:			
Assuming no dilution:			
Before cumulative effect of change in accounting	**$ 6.80**	$ 3.28	$ 5.32
Cumulative effect of change in accounting	**—**	—	(.20)
	$ 6.80	$ 3.28	$ 5.12
Assuming full dilution:			
Before cumulative effect of change in accounting	**$ 6.04**	$ 3.05	$ 4.83
Cumulative effect of change in accounting	**—**	—	(.17)
	$ 6.04	$ 3.05	$ 4.66

See accompanying Notes to Consolidated Financial Statements.

Consolidated Statement of Cash Flows

(In millions)	Year Ended December 31, 1996	1995	1994
Operating Activities			
Earnings before cumulative effect of change in accounting	**$ 1,347**	$ 682	$1,055
Adjustments to reconcile earnings to net cash provided by operating activities:			
Merger related and consolidation—expenses	**—**	690	—
—payments	**(244)**	(208)	—
Depreciation and amortization	**732**	605	638
Amortization of intangible assets	**465**	296	279
Deferred federal income taxes	**(251)**	(116)	73
Materials transactions	**(365)**	—	(118)
Changes in operating assets and liabilities:			
Receivables	**(328)**	(394)	(169)
Inventories	**(125)**	430	(221)
Customer advances and amounts in excess of costs incurred	**544**	(294)	20
Other	**(139)**	(399)	(64)
Net cash provided by operating activities	**1,636**	1,292	1,493
Investing Activities			
Additions to properties, net of purchased operations	**(737)**	(500)	(509)
Loral transaction	**(7,344)**	—	—
Other acquisition, investment and divestiture activities	**(35)**	(294)	(125)
Net proceeds—Materials public offering	**—**	—	189
Other	**87**	95	(57)
Net cash used for investing activities	**(8,029)**	(699)	(502)
Financing Activities			
Increases (decreases) in short-term borrowings, net	**1,110**	(14)	(7)
Increases in long-term debt	**7,000**	125	43
Repayments and extinguishments of long-term debt	**(2,105)**	(287)	(512)
Issuances of common stock	**97**	61	32
Purchases of common stock	**—**	(150)	—
Dividends on common stock	**(302)**	(254)	(214)
Dividends on preferred stock	**(60)**	(60)	(60)
Net cash provided by (used for) financing activities	**5,740**	(579)	(718)
Net (decrease) increase in cash and cash equivalents	**(653)**	14	273
Cash and cash equivalents at beginning of year	**653**	639	366
Cash and cash equivalents at end of year	**$ —**	$ 653	$ 639

See accompanying Notes to Consolidated Financial Statements.

Consolidated Balance Sheet

(In millions)	December 31, 1996	1995
Assets		
Current assets:		
Cash and cash equivalents	**$ —**	$ 653
Receivables	**4,999**	3,876
Inventories	**3,053**	2,835
Deferred income taxes	**1,088**	580
Other current assets	**800**	264
Total current assets	**9,940**	8,208
Property, plant and equipment	**3,721**	3,134
Intangible assets related to contracts and programs acquired	**1,767**	1,553
Cost in excess of net assets acquired	**10,394**	2,794
Other assets	**3,435**	1,869
	$29,257	$17,558
Liabilities and Stockholders' Equity		
Current liabilities:		
Accounts payable	**$ 1,294**	$ 787
Customer advances and amounts in excess of costs incurred	**2,600**	1,570
Salaries, benefits and payroll taxes	**991**	567
Income taxes	**925**	292
Short-term borrowings	**1,110**	—
Current maturities of long-term debt	**180**	722
Other current liabilities	**1,604**	1,246
Total current liabilities	**8,704**	5,184
Long-term debt	**10,188**	3,010
Post-retirement benefit liabilities	**2,077**	1,795
Other liabilities	**1,432**	1,136
Stockholders' equity:		
Series A preferred stock, $50 liquidation preference per share	**1,000**	1,000
Common stock, $1 par value per share	**193**	199
Additional paid-in capital	**92**	683
Retained earnings	**5,823**	4,838
Unearned ESOP shares	**(252)**	(287)
Total stockholders' equity	**6,856**	6,433
	$29,257	$17,558

See accompanying Notes to Consolidated Financial Statements.

Consolidated Statement of Stockholders' Equity

(In millions)	*Preferred Stock*	*Common Stock*	*Additional Paid-in Capital*	*Retained Earnings*	*Unearned ESOP Shares*	*Guarantee of ESOP Obligations*	*Total Stockholders' Equity*
Balance at December 31, 1993	$ 1,000	$ 198	$ 689	$ 3,721	$ —	$(407)	$ 5,201
Earnings before cumulative effect of change in accounting	—	—	—	1,055	—	—	1,055
Cumulative effect of change in accounting	—	—	—	(37)	(350)	407	20
Dividends declared on preferred stock ($3.00 per share)	—	—	—	(60)	—	—	(60)
Dividends declared on common stock ($1.14 per share)	—	—	—	(214)	—	—	(214)
Stock awards and options, and ESOP activity	—	1	45	5	33	—	84
Balance at December 31, 1994	1,000	199	734	4,470	(317)	—	6,086
Net earnings	—	—	—	682	—	—	682
Dividends declared on preferred stock ($3.00 per share)	—	—	—	(60)	—	—	(60)
Dividends declared on common stock ($1.34 per share)	—	—	—	(254)	—	—	(254)
Repurchases of common stock	—	(2)	(148)	—	—	—	(150)
Stock awards and options, and ESOP activity	—	2	97	—	30	—	129
Balance at December 31, 1995	1,000	199	683	4,838	(287)	—	6,433
Net earnings	**—**	**—**	**—**	**1,347**	**—**	**—**	**1,347**
Dividends declared on preferred stock ($3.00 per share)	**—**	**—**	**—**	**(60)**	**—**	**—**	**(60)**
Dividends declared on common stock ($1.60 per share)	**—**	**—**	**—**	**(302)**	**—**	**—**	**(302)**
Stock awards and options, and ESOP activity	**—**	**2**	**151**	**—**	**35**	**—**	**188**
Stock exchanged for Materials shares	**—**	**(8)**	**(742)**	**—**	**—**	**—**	**(750)**
Balance at December 31, 1996	**$1,000**	**$193**	**$ 92**	**$5,823**	**$(252)**	**$ —**	**$6,856**

See accompanying Notes to Consolidated Financial Statements.

Note 1 — Summary of Significant Accounting Policies

Organization — Lockheed Martin Corporation (Lockheed Martin or the Corporation) is engaged in the design, manufacture, integration and operation of a broad array of products and services ranging from aircraft, spacecraft and launch vehicles to energy management, missiles, electronics, and information systems. The Corporation serves customers in both domestic and international defense and civilian markets, with its principal customers being agencies of the U.S. Government.

Basis of consolidation and use of estimates — The consolidated financial statements include the accounts of wholly-owned and majority-owned subsidiaries. All material intercompany balances and transactions have been eliminated in consolidation. The preparation of consolidated financial statements in conformity with generally accepted accounting principles requires management to make estimates and assumptions, in particular estimates of anticipated contract costs and revenues utilized in the earnings recognition process, that affect the reported amounts in the financial statements and accompanying notes. Actual results could differ from those estimates.

Classifications — Receivables and inventories are primarily attributable to long-term contracts or programs in progress for which the related operating cycles are longer than one year. In accordance with industry practice, these items are included in current assets.

Certain amounts for the prior years have been reclassified to conform with the 1996 presentation.

Cash and cash equivalents — Cash and cash equivalents are net of outstanding checks that are funded daily as presented for payment. Cash equivalents are generally comprised of highly liquid instruments with maturities of three months or less when purchased. Due to the short maturity of these instruments, carrying value on the Corporation's consolidated balance sheet approximates fair value.

Inventories — Inventories are stated at the lower of cost or estimated net realizable value. Costs on long-term contracts and programs in progress represent recoverable costs incurred for production, allocable operating overhead, and, where appropriate, research and development and general and administrative expenses, less amounts attributed to cost of sales. Pursuant to contract provisions, agencies of the U.S. Government and other customers have title to, or a security interest in, certain inventories as a result of progress payments and advances. General and administrative expenses related to commercial products and services provided essentially under commercial terms and conditions are expensed as incurred. Costs of other product and supply inventories are principally determined by the first-in, first-out or average cost methods.

Property, plant and equipment — Property, plant and equipment are carried principally at cost. Depreciation is provided on plant and equipment generally using accelerated methods of depreciation during the first half of the estimated useful lives of the assets; thereafter, straight-line depreciation generally is used. Estimated useful lives generally range from 8 years to 40 years for buildings and 2 years to 20 years for machinery and equipment.

Intangible assets — Intangible assets related to contracts and programs acquired are amortized over the estimated periods of benefit (15 years or less) and are displayed on the consolidated balance sheet net of accumulated amortization of $505 million and $400 million at December 31, 1996 and 1995, respectively. Cost in excess of net assets acquired (goodwill) is amortized ratably over appropriate periods, primarily 40 years, and is displayed on the consolidated balance sheet net of accumulated amortization of $617 million and $438 million at December 31, 1996 and 1995, respectively. The carrying values of intangible assets are reviewed if the facts and circumstances indicate potential impairment of their carrying value, and any impairment determined is recorded in the current period.

Environmental matters — The Corporation records a liability for environmental matters when it is probable that a liability has been incurred and the amount can be reasonably estimated. A substantial portion of these costs are expected to be reflected in sales and cost of sales pursuant to U.S. Government agreement or regulation. At the time a liability is recorded for future environmental costs, an asset is recorded for estimated future recovery considered probable through the pricing of products and services to agencies of the U.S. Government. The portion of those costs expected to be allocated to commercial business is reflected in costs and expenses at the time the liability is established.

Sales and earnings — Sales and anticipated profits under long-term fixed-price production contracts are recorded on a percentage of completion basis, generally using units of delivery as the measurement basis for effort accomplished. Estimated contract profits are taken into earnings in proportion to recorded sales. Sales under certain long-term fixed-price contracts which, among other things, provide for the delivery of minimal quantities or require a significant amount of development effort in relation to total contract value, are recorded using the percentage of completion cost-to-cost method of accounting where sales and profits are recorded based on the ratio of costs incurred to estimated total costs at completion.

Sales under cost-reimbursement-type contracts are recorded as costs are incurred. Applicable estimated profits are included in earnings in the proportion that incurred costs bear to total estimated costs. Sales of products and services provided essentially under commercial terms and conditions are recorded upon shipment or completion of specified tasks.

Amounts representing contract change orders, claims or other items are included in sales only when they can be reliably estimated and realization is probable. Incentives or penalties and awards applicable to performance on contracts are considered in estimating sales and profit rates, and are recorded when there is sufficient information to assess anticipated contract performance. Incentive provisions which increase or decrease earnings based solely on a single significant event are generally not recognized until the event occurs.

When adjustments in contract value or estimated costs are determined, any changes from prior estimates are reflected in earnings in the current period. Anticipated losses on contracts or programs in progress are charged to earnings when identified.

Research and development and similar costs — Corporation-sponsored research and development costs primarily include research and development and bid and proposal effort related to government products and services. Except for certain arrangements described below, these costs are generally included as part of the general and administrative costs that are allocated among all contracts and programs in progress under U.S. Government contractual arrangements. Corporation-sponsored product development costs not otherwise allocable are charged to expense when incurred. Under certain arrangements in which a customer shares in product development costs, the Corporation's portion of such unreimbursed costs is expensed as incurred. Customer-sponsored research and development costs incurred pursuant to contracts are accounted for as contract costs.

Derivative financial instruments — The Corporation uses derivative financial instruments to manage its exposure to fluctuations in interest rates and foreign exchange rates. The Corporation designates its interest rate swap agreements as hedges of specific debt instruments and recognizes the interest differentials as adjustments to interest expense over the terms of the related debt obligations. Forward exchange contracts are also designated as qualifying hedges of firm commitments or specific anticipated transactions. Gains and losses on these contracts are recognized in income when the hedged transactions occur. At December 31, 1996, the amounts of forward exchange contracts outstanding, as well as the amounts of gains and losses recorded during the year, were not material. The Corporation does not hold or issue financial instruments for trading purposes.

Earnings per common share — Earnings per common share were based on the weighted average number of common shares outstanding during the year. Earnings per common share, assuming no dilution, were computed based on net earnings less the dividend requirement for preferred stock. The weighted average number of common shares outstanding, assuming no dilution, was approximately 189.1 million in 1996, 189.3 million in 1995 and 187.0 million in 1994.

Earnings per common share, assuming full dilution, were computed assuming that the average number of common shares was increased by the conversion of preferred stock. The weighted average number of common shares outstanding, assuming full dilution, was approximately 223.0 million in 1996, 223.2 million in 1995 and 218.3 million in 1994.

Accounting Changes — Effective January 1, 1996, the Corporation adopted Statement of Financial Accounting Standards (SFAS) No. 121, "Accounting for the Impairment of Long-Lived Assets and for Long-Lived Assets to Be Disposed Of." SFAS No. 121 requires that certain long-lived assets to be held and used be reviewed for impairment whenever events or changes in circumstances indicate that the carrying amount of an asset may not be recoverable. Additionally, SFAS No. 121 requires that certain long-lived assets to be disposed of be reported at the lower of carrying amount or fair value less costs to sell. The impact of the adoption of this standard was not material to the Corporation's consolidated earnings or financial position.

Also in 1996, the Corporation adopted SFAS No. 123, "Accounting for Stock-Based Compensation." SFAS No. 123 allows companies to continue to measure compensation cost for stock-based employee compensation plans using the intrinsic value method of accounting as prescribed in Accounting Principles Board (APB) Opinion No. 25, "Accounting for Stock Issued to Employees," and related interpretations. The Corporation has elected to continue its APB Opinion No. 25 accounting treatment for stock-based compensation, and has adopted the provisions of SFAS No. 123 requiring disclosure of the pro forma effect on net earnings and earnings per share as if compensation cost had been recognized based upon the estimated fair value at the date of grant for options awarded.

The Corporation elected to adopt, effective January 1, 1994, the American Institute of Certified Public Accountants Statement of Position (SOP) No. 93-6, "Employers' Accounting for Employee Stock Ownership Plans," to account for its Employee Stock Ownership Plans (ESOPs). SOP No. 93-6 requires that unallocated common shares held by an ESOP trust be considered outstanding for voting and other Corporate purposes, but excluded from weighted average outstanding shares in calculating earnings per share. Adoption of this accounting method resulted in a cumulative effect adjustment which reduced net earnings for 1994 by $37 million, or $.17 per common share assuming full dilution. For 1996, 1995 and 1994, the weighted average unallocated ESOP shares excluded in calculating earnings per share totalled approximately 9.1 million, 10.3 million and 11.5 million common shares, respectively.

Note 2 — Business Combination with Loral Corporation

On January 7, 1996, the Corporation and its wholly-owned subsidiary, LAC Acquisition Corporation (LAC), entered into an Agreement and Plan of Merger (the Loral Merger Agreement) with Loral Corporation (Loral) pursuant to which LAC agreed to purchase all of the issued and outstanding shares of common stock of Loral (together with the associated preferred stock purchase rights) for an aggregate consideration of $38 per share in cash (the Tender Offer). The Tender Offer was made as part of a series of transactions that resulted in (i) the distribution to stockholders of Loral immediately prior to the consummation of the Tender Offer of shares of capital stock in Loral Space & Communications, Ltd. (Loral SpaceCom), a newly-formed company, which now owns and manages substantially all of Loral's former space and satellite telecommunications interests, and (ii) the acquisition by the Corporation of Loral's defense electronics and systems integration businesses (collectively, the Loral Transaction).

In accordance with the terms of the Tender Offer and the Loral Merger Agreement, on April 23, 1996, LAC purchased approximately 94.5 percent of the outstanding shares of common stock of Loral. Subsequent to the consummation of the Tender Offer, on April 29, 1996, LAC merged with and into Loral and each remaining share of common stock of Loral not owned by LAC was converted into the right to receive $38. Each outstanding share of common stock of LAC was converted into shares of common stock of Loral, and Loral changed its name to Lockheed Martin Tactical Systems, Inc. (Tactical Systems). As a result of these transactions, Tactical Systems became a wholly-owned subsidiary of the Corporation. The operations of Tactical Systems have been included in the results of operations of the Corporation from April 1, 1996.

In connection with the above transactions, the Corporation acquired shares of preferred stock of Loral SpaceCom that were convertible into 20 percent of Loral SpaceCom's common stock on a fully diluted basis at the acquisition date. The Corporation's ownership of the preferred stock of Loral SpaceCom is subject to certain limitations and restrictions set forth in the terms and conditions of the preferred stock and in agreements between the Corporation and Loral SpaceCom.

The total purchase price paid with respect to the above transactions, including acquisition costs, was approximately $7.6 billion. The Loral Transaction has been accounted for using the purchase method of accounting. Purchase accounting adjustments have been recorded to allocate the purchase price to assets acquired and liabilities assumed based on fair values at the date of acquisition. A summary of assets acquired and liabilities assumed follows:

(In millions)	
Working capital, excluding cash acquired	**$ (805)**
Property, plant and equipment	**1,073**
Intangible assets related to contracts and programs acquired	**440**
Cost in excess of net assets acquired	**8,045**
Other assets	**1,110**
Long-term debt	**(1,857)**
Post-retirement benefit liabilities	**(464)**
Other liabilities	**(198)**
Net investment	**7,344**
Cash acquired	**277**
Total cost of acquisition	**$ 7,621**

The following unaudited pro forma combined earnings data presents the results of operations of the Corporation and Tactical Systems for the years ended December 31, 1996 and 1995, as if the Loral Transaction had been consummated as of the beginning of the periods presented. This pro forma combined earnings data does not purport to be indicative of results of operations that would have resulted if the Loral Transaction had occurred on the applicable dates indicated above. Moreover, this data is not intended to be indicative of future results of operations.

(In millions, except per share data)	**1996**	*1995*
Pro forma net sales	**$28,235**	$28,859
Pro forma net earnings	**1,356**	572
Pro forma earnings per common share:		
Assuming no dilution	**6.85**	2.71
Assuming full dilution	**6.08**	2.56

The funds for the consummation of the Loral Transaction were provided through the issuance of commercial paper by the Corporation and through borrowings under revolving credit facilities with a syndicate of commercial banks. These credit facilities consisted of a 364-day unsecured revolving credit facility in the amount of $5 billion (the Short-Term Credit Facility) and a 5-year unsecured revolving credit facility in the amount of $5 billion (the 5-Year Credit Facility). In connection with the establishment of these credit facilities, the Corporation and Loral each terminated their previously existing revolving credit facilities. Approximately $6.6 billion of commercial paper was issued and approximately $1 billion was borrowed under the 5-Year Credit Facility to finance the Loral Transaction on the closing date. During the second quarter of 1996, the Corporation issued $5 billion of debt securities. The net proceeds from the sale of the debt securities were used to repay the $1 billion borrowed under the 5-Year Credit Facility and to reduce the amount of commercial paper outstanding. On July 26, 1996, the Corporation terminated the Short-Term Credit Facility. The Corporation amended its 5-Year Credit Facility on December 20, 1996. (See Note 8.)

Note 3 — Repositioning of Non-Core Businesses and New Organizational Structure

On January 31, 1997, the Corporation entered into a memorandum of understanding under which certain of its non-core business units will be repositioned as a new independent company. These business units, which are primarily composed of high-technology, product-oriented companies, contributed approximately 2% of the Corporation's 1996 consolidated net sales. The Corporation will retain a 34.9% interest in the new company.

The proposed transaction is subject to the parties entering into a mutually acceptable definitive purchase agreement, regulatory approvals, and other customary conditions, and is expected to close during the first half of 1997.

On February 3, 1997, concurrent with the announcement of this transaction, the Corporation announced a new organizational structure which reassigned management responsibility for certain business units. As a result, the Corporation's operations are now divided into five business segments. The operations of Tactical Systems have been reflected, for 1996 segment reporting purposes, in the Electronics, Information & Services, and Energy, Materials and Other segments. The segment data displayed in Note 15 has been presented in accordance with the new structure, and prior year data has been reclassified to conform to the new presentation.

Note 4 — Restructuring and Other Charges

During the fourth quarter of 1996, the Corporation recorded nonrecurring pretax charges, net of state income tax benefits, of $307 million, which decreased net earnings by $209 million, or $.94 per common share assuming full dilution. Approximately one-half of the charges reflected the financial impacts of a conservative strategy on the part of the Corporation toward its environmental remediation business with regard to current business conditions, existing contractual issues on a Department of Energy (DOE) program, and the pursuit of other environmental opportunities. The remaining charges resulted from a number of other corporate actions to improve efficiencies, increase competitiveness and focus on core businesses.

During the first quarter of 1995, the Corporation recorded a pretax charge of $165 million for merger related expenses in connection with the formation of Lockheed Martin. During the second quarter of 1995, the Corporation recorded a pretax charge of $525 million in conjunction with a corporate-wide consolidation plan under which the Corporation would close certain facilities and laboratories and eliminate duplicative field offices in the U.S. and abroad, eliminating up to approximately 12,000 positions. The charge represented the portion of the accrued costs and net realizable value adjustments that were not probable of recovery. The after-tax effect of these charges was $436 million, or $1.96 per common share assuming full dilution. As of December 31, 1996, cumulative merger related and consolidation payments were approximately $452 million, which primarily relate to the formation of the Corporation, the elimination of positions and the closure of foreign and domestic offices and facilities.

During 1996, the Corporation incurred costs anticipated in the 1995 consolidation plan which had not met the requirements for accrual earlier. These costs include relocation of personnel and programs, retraining, process re-engineering and certain capital expenditures, among others. Management estimates that, consistent with the original 1995 consolidation plan, $750 million of such costs will be incurred in the future, and currently anticipates that the remaining consolidation actions will be substantially completed by the end of 1998.

Under existing U.S. Government regulations, certain costs incurred for consolidation actions that can be demonstrated to result in savings in excess of the cost to implement can be deferred and amortized for government contracting purposes and included as allowable costs in future pricing of the Corporation's products and services. Included in other assets at December 31, 1996 is approximately $250 million of deferred costs that will be reflected in future sales and cost of sales.

Note 5 — Receivables

Receivables consisted of the following components:

(In millions)	**1996**	*1995*
U.S. Government:		
Amounts billed	**$1,012**	$ 925
Unbilled costs and accrued profits	**2,317**	1,622
Commercial and foreign governments:		
Amounts billed	**875**	654
Unbilled costs and accrued profits, primarily related to commercial contracts	**795**	675
	$4,999	$3,876

Unbilled costs and accrued profits consisted primarily of revenues on long-term contracts that had been recognized for accounting purposes but not yet billed to customers. Approximately $360 million of the December 31, 1996 unbilled costs and accrued profits are not expected to be billed within one year.

Note 6 — Inventories

Inventories consisted of the following components:

(In millions)	**1996**	*1995*
Work in process, primarily related to long-term contracts and programs in progress	**$4,456**	$3,752
Less customer advances and progress payments	**(2,446)**	(1,772)
	2,010	1,980
Other inventories	**1,043**	855
	$3,053	$2,835

Inventories at December 31, 1996 included unamortized deferred costs of approximately $360 million which are anticipated to be recovered through future contracts. Customer advances and progress payments applied above were those where the customer has title to, or a security interest in, inventories identified with the related contracts. Other customer advances were classified as current liabilities. Also included in 1996 inventories above were approximately $370 million of costs which are not expected to be recovered within one year.

An analysis of general and administrative costs, including research and development costs, included in work in process inventories follows:

(In millions)	**1996**	*1995*	*1994*
Beginning of year	**$ 431**	$ 480	$ 499
Incurred during the year	**2,154**	1,704	1,761
Charged to costs and expenses during the year:			
Research and development	**(784)**	(548)	(659)
Other general and administrative	**(1,341)**	(1,205)	(1,121)
End of year	**$ 460**	$ 431	$ 480

In addition, included in costs and expenses in 1996, 1995 and 1994 were general and administrative costs, including research and development costs, of approximately $574 million, $320 million and $223 million, respectively, incurred by commercial business units or programs.

Note 7 — Property, Plant and Equipment

Property, plant and equipment consisted of the following components:

(In millions)	**1996**	*1995*
Land	**$ 248**	$ 362
Buildings	**2,876**	2,463
Machinery and equipment	**5,328**	5,329
	8,452	8,154
Less accumulated depreciation and amortization	**(4,731)**	(5,020)
	$3,721	$3,134

Note 8 — Debt

Long-term debt consisted of the following components:

Type (Maturity Dates) *(In millions)*	Range of Interest Rates	**1996**	*1995*
Notes Payable (1997-2022)	5.7-9.4%	**$ 5,547**	$2,172
Debentures (2003-2036)	7.0-9.1%	**3,156**	828
Commercial Paper	5.6-7.3%	**1,250**	—
ESOP obligations (1997-2004)	8.3-8.4%	**324**	355
Payment obligations assumed from General Electric	5.0%	**—**	303
Other obligations	6.0-11.4%	**91**	74
		10,368	3,732
Less current maturities		**(180)**	(722)
		$10,188	$3,010

During the second quarter of 1996, the Corporation issued $5 billion of long-term fixed rate debt securities, the entire amount registered under the Corporation's shelf registration statement which became effective on May 10, 1996. These Notes and Debentures range in maturity from two years to 40 years, with interest rates ranging from between 6.55% and 7.75%. The registered holders of $300 million of 40 year Debentures may elect, between March 1 and April 1, 2008, to have each of their Debentures repaid by the Corporation on May 1, 2008. The debt securities are guaranteed by Tactical Systems (see Note 17).

In February 1996, the Corporation entered into interest rate hedging agreements to offset a portion of its exposure to rising interest rates related to the anticipated long-term financings. These agreements were closed in the second quarter of 1996 in connection with the Corporation's issuance of its long-term debt securities. The Corporation realized a gain of approximately $150 million on the closing of these agreements, which has been deferred and is being amortized and recognized as an adjustment to interest expense over the terms of the related debt obligations.

At the effective date of the Loral Transaction, the Corporation assumed approximately $1.9 billion of debt obligations of the former Loral Corporation.

Included in Debentures are $103 million of 7% obligations ($175 million at face value) which were originally sold at approximately 54% of their principal amount. These debentures, which are redeemable in whole or in part at the Corporation's option at 100% of their face value, have an effective yield of 13.25%.

A leveraged ESOP incorporated into the savings plan for heritage Lockheed Corporation (Lockheed) employees borrowed $500 million through a private placement of notes in 1989 (see Note 12). These notes are being repaid in quarterly installments over terms ending in 2004. The ESOP note agreement stipulates that, in the event that the ratings assigned to the Corporation's long-term senior unsecured debt are below investment grade, holders of the notes may require the Corporation to purchase the notes and pay accrued interest. These notes are obligations of the ESOP but are guaranteed by the Corporation and included as debt on the Corporation's consolidated balance sheet.

On December 20, 1996, the Corporation amended its 5-Year Credit Facility to reduce its amount from $5 billion to $3.5 billion (the Amended 5-Year Credit Facility). The Corporation also entered into a one year credit facility in the amount of $1.5 billion (collectively, the Credit Facilities). Borrowings under the Credit Facilities would be unsecured and bear interest, at the Corporation's option, at rates based on the Eurodollar rate or a bank Base Rate (as defined). Each bank's obligation to make loans under the Credit Facilities is subject to, among other things, compliance by the Corporation with various representations, warranties, covenants and agreements, including, but not limited to, covenants limiting the ability of the Corporation and certain of its subsidiaries to encumber their assets and a covenant not to exceed a maximum leverage ratio.

No borrowings were outstanding under the Credit Facilities at December 31, 1996. However, the Amended 5-Year Credit Facility supports commercial paper borrowings of approximately $2.4 billion outstanding at December 31, 1996, of which approximately $1.25 billion has been classified as long-term debt in the Corporation's consolidated balance sheet based on management's ability and intention to maintain this debt outstanding for at least one year. During the third quarter of 1996, the Corporation entered into interest rate swap agreements to fix the interest rates on $875 million of its commercial paper borrowings. These agreements will mature during 1997. The effects of these interest rate swap agreements are recorded periodically as an adjustment to interest expense related to commercial paper borrowings. The Corporation is exposed to the risk of nonperformance by the intermediaries to these agreements, though such nonperformance is not anticipated.

Excluding commercial paper classified as long term, the Corporation's long-term debt maturities for the five years following December 31, 1996, are: $180 million in 1997; $875 million in 1998; $850 million in 1999; $44 million in 2000; $799 million in 2001; and $6,370 million thereafter.

Certain of the Corporation's other financing agreements contain restrictive covenants relating to debt, limitations on encumbrances, and sale and lease-back transactions, and provisions which relate to certain changes in control.

SFAS No. 107, "Disclosures about Fair Value of Financial Instruments," and SFAS No. 119, "Disclosure about Derivative Financial Instruments and Fair Value of Financial Instruments," require the disclosure of the fair value of financial instruments, including assets and liabilities recognized and not recognized on the consolidated balance sheet, for which it is practicable to estimate fair value. Unless otherwise indicated elsewhere in the notes to the consolidated financial statements, the carrying value of the Corporation's financial instruments approximates fair value. The estimated fair values of the Corporation's long-term debt instruments at December 31, 1996, aggregated approximately $10.7 billion, compared with a carrying amount of approximately $10.4 billion on the consolidated balance sheet. The fair values were estimated based on quoted market prices for those instruments publicly traded. For privately placed debt, the fair values were estimated based on the quoted market prices for similar issues, or on current rates offered to the Corporation for debt of the same remaining maturities.

Interest payments were $655 million in 1996, $275 million in 1995 and $276 million in 1994.

Note 9 — Income Taxes

The provision for federal and foreign income taxes consisted of the following components:

(In millions)	**1996**	*1995*	*1994*
Federal income taxes:			
Current	**$914**	$510	$538
Deferred	**(251)**	(116)	73
Total federal income taxes	**663**	394	611
Foreign income taxes	**23**	13	9
Total income taxes provided	**$686**	$407	$620

Net provisions for state income taxes are included in general and administrative expenses, which are primarily allocable to government contracts. Such state income taxes were $45 million for 1996, $86 million for 1995 and $50 million for 1994.

The Corporation's effective income tax rate varied from the statutory federal income tax rate because of the following tax differences:

	1996	*1995*	*1994*
Statutory federal tax rate	**35.0%**	35.0%	35.0%
Increase (reduction) in tax rate from:			
Nondeductible amortization	**4.2**	3.2	2.1
Revisions to prior years' estimated liabilities	**(1.6)**	(3.4)	(.9)
Divestitures	**(5.6)**	—	—
Other, net	**1.8**	2.6	.8
	33.8%	37.4%	37.0%

The primary components of the Corporation's federal deferred income tax assets and liabilities at December 31 were as follows:

(In millions)	**1996**	*1995*
Deferred tax assets related to:		
Accumulated post-retirement benefit obligations	**$ 700**	$ 554
Accrued compensation and benefits	**333**	223
Merger related and consolidation reserves	**217**	168
Contract accounting methods	**619**	165
Other	**180**	137
	2,049	1,247
Deferred tax liabilities related to:		
Intangible assets	**486**	365
Prepaid pension asset	**297**	89
Property, plant and equipment	**178**	213
	961	667
Net deferred tax assets	**$1,088**	$ 580

Federal and foreign income tax payments, net of refunds received, were $1.1 billion in 1996, $223 million in 1995 and $502 million in 1994.

Note 10 — Other Income and Expenses

Other income and expenses, net, consisted of the following components:

(In millions)	**1996**	*1995*	*1994*
Royalty income	**$ 47**	$64	$ 59
Interest income	**60**	33	34
Materials transactions	**365**	—	118
Acquisition termination fee	**—**	—	50
Other	**(20)**	(2)	(61)
	$452	$95	$200

During the third quarter of 1996, the Corporation announced its intention to distribute via an exchange offer its remaining 81 percent interest in Martin Marietta Materials, Inc. (Materials) to its stockholders (the Exchange Offer). Under the terms of the Exchange Offer, the Corporation's stockholders were given the opportunity to exchange each Lockheed Martin common share held for 4.72 common shares of Materials on a tax-free basis. The Exchange Offer expired by its terms on October 18, 1996 and was oversubscribed. On October 23, 1996, approximately 7.9 million shares of the Corporation's common stock were exchanged for the 37.35 million shares of Materials common stock held by the Corporation. Upon the closing of this transaction, the Corporation had no remaining ownership interest in Materials and had reduced its common shares outstanding by approximately 4 percent. This fourth quarter, 1996 exchange was accounted for at fair value, resulting in the reduction of the Corporation's stockholders' equity by $750 million and the recognition of a pretax gain of $365 million.

In November, 1996, the Corporation announced the proposed divestiture of two of its business units, Defense Systems and Armament Systems. This transaction, which concluded with the Corporation's receipt of $450 million in cash on January 2, 1997, had no pretax effect on the results of operations for 1996. At December 31, 1996, $450 million, representing the net assets of the two business units, is included in other current assets.

On a combined basis, the Materials exchange and divestiture noted above increased net earnings by $351 million, or $1.58 per common share assuming full dilution.

In February 1994, Materials sold through an initial public offering (IPO) approximately 8.8 million shares, or 19% of its common stock. A portion of the proceeds from the offering was used to defease in substance certain long-term debt. The Corporation recognized a pretax gain, net of a loss on debt defeasance, of $118 million from the Materials IPO. The net after-tax gain from these transactions was $70 million, or $.32 per common share assuming full dilution.

During March 1994, the Corporation entered into an Agreement and Plan of Merger with Grumman Corporation (Grumman) which was subsequently terminated by Grumman. In April 1994, the Corporation received $50 million plus reimbursement of expenses pursuant to the termination provisions of the Agreement and Plan of Merger. The Corporation recorded an after-tax gain of $30 million, or $.14 per common share assuming full dilution.

Note 11 — Stockholders' Equity and Related Items

Capital structure — The authorized capital of the Corporation is composed of 750 million shares of common stock (192.7 million shares issued), 50 million shares of series preferred stock (no shares issued), and 20 million shares of Series A preferred stock (20 million shares issued). Approximately 70 million common shares have been reserved for issuance under benefit and incentive plans.

The Series A preferred stock has a par value of $1 per share (liquidation preference of $50 per share). The Corporation issued all of the authorized and outstanding shares of Series A preferred stock to General Electric Company (GE) in 1993 in connection with the acquisition of the GE Aerospace businesses. Dividends are cumulative and paid at an annual rate of $3.00 per share, or 6%. The shares held by GE are currently convertible into approximately 13% of the shares of the Corporation's common stock after giving effect to such conversion, have an aggregate liquidation preference of $1 billion, and are nonvoting except in special circumstances.

Accordingly, 29 million common shares have been reserved for this potential conversion. In April 1998 and thereafter, the Corporation will be entitled to redeem, at its option, any or all shares of the Series A preferred stock for either cash or common stock. The Series A preferred stock is held under a Standstill Agreement which, among other things, imposes certain limitations on either the increase or disposal of GE's interest in voting securities of the Corporation, on GE's solicitation of proxies and stockholder proposals, on GE's voting of its shares and on GE's ability to place or remove members of the Corporation's Board of Directors. In addition, the Standstill Agreement requires the Corporation to recommend to its stockholders the election of two persons designated by GE to serve as directors of the Corporation.

During the second quarter of 1996, the Corporation's Board of Directors terminated the systematic common stock repurchase plan which had been established in 1995 to counter the future dilutive effect of common stock issued by the Corporation under its 1995 Omnibus Performance Award Plan. A separate program authorized in 1995 for the repurchase of up to nine million common shares to counter the dilutive effect of common stock issued under the Corporation's other benefit and compensation programs and for other purposes related to such plans remains in effect. Approximately 2.3 million common shares were repurchased by the Corporation in 1995 under these programs; no shares were repurchased in 1996.

Stock option and award plans — On March 15, 1995, the stockholders approved the Lockheed Martin 1995 Omnibus Performance Award Plan (Omnibus Plan). Under the Omnibus Plan, employees of the Corporation may be granted stock-based incentive awards, including options to purchase common stock, stock appreciation rights, restricted stock or other stock-based incentive awards. Employees may also be granted cash-based incentive awards, such as performance units. These awards may be granted either individually or in combination with other awards. The Omnibus Plan requires that options to purchase common stock have an exercise price of not less than 100% of the market value of the underlying stock on the date of grant. The number of shares of Lockheed Martin common stock currently authorized to be issued in respect of awards under the Omnibus Plan is 12 million shares. The Omnibus Plan does not impose any minimum vesting periods on options or other awards. The maximum term of an option or any other award is ten years. The Omnibus Plan allows the Corporation to provide for financing of purchases, subject to certain conditions, by interest-bearing notes payable to the Corporation.

Prior to the merger of Lockheed and Martin Marietta Corporation (Martin Marietta) in 1995 (the Business Combination), Lockheed and Martin Marietta had also utilized share-based and cash-based incentive award plans. The Agreement and Plan of Reorganization relating to the Business Combination provided for each outstanding stock option, stock appreciation right and other stock-based incentive award to be converted into a similar instrument of Lockheed Martin upon consummation of the Business Combination. Effective with the adoption of the Omnibus Plan, no further grants of share-based or cash-based incentive awards have been or will be made under any of Lockheed's or Martin Marietta's prior plans. Accordingly, shares available for grant under these prior plans were removed from registration in 1995.

The following table summarizes the stock option activity of the Corporation's plans during 1994, 1995 and 1996:

	Number of Shares (In thousands)		
	Available for Grant	*Options Outstanding*	*Weighted Average Exercise Price*
December 31, 1993	3,784	8,469	$29.57
Additions	2,119	—	—
Granted	(2,403)	2,397	$42.65
Exercised	—	(1,463)	$27.10
Terminated	152	(159)	$38.04
December 31, 1994	3,652	9,244	$33.21
Additions	12,000	—	—
Granted	(2,228)	2,228	$59.38
Removed from registration	(3,674)	—	—
Exercised	—	(1,943)	$30.47
Terminated	81	(109)	$51.63
December 31, 1995	9,831	9,420	$39.74
Granted	**(2,649)**	**2,649**	**$75.04**
Exercised	**—**	**(2,241)**	**$32.65**
Terminated	**141**	**(170)**	**$63.32**
December 31, 1996	**7,323**	**9,658**	**$50.65**

Approximately 5.2 million, 6.5 million and 5.7 million outstanding options were exercisable at December 31, 1994, 1995 and 1996, respectively.

Information regarding options outstanding at December 31, 1996 follows (number of options in thousands):

	Options Outstanding			*Options Exercisable*	
Range of Exercise Prices	*Number of Options*	*Weighted Average Exercise Price*	*Weighted Average Remaining Contractual Life*	*Number of Options*	*Weighted Average Exercise Price*
Less than $39.99	3,408	$30.79	5 years	3,408	$30.79
$40.00 - $59.99	3,676	$51.98	8 years	2,241	$50.09
Greater than $60.00	2,574	$75.06	9 years	5	$75.79
Total	9,658	$50.65	7 years	5,654	$38.48

All stock-based incentive awards granted in 1996 and 1995 under the Omnibus Plan were stock options which have 10 year terms and vest over a two year service period. Exercise prices of options awarded in both years were equal to the market price of the stock on the date of grant. Pro forma information regarding net earnings and earnings per share as required by SFAS No. 123 has been determined as if the Corporation had accounted for its employee stock options under the fair value method. The fair value for these options was estimated at the date of grant using a Black-Scholes option pricing model with the following weighted-avcrage assumptions for 1996 and 1995, respectively: risk-free interest rates of 5.58% and 6.64%; dividend yield of 1.70%; volatility factors related to the expected market price of the Corporation's common stock of .186 and .216; and weighted-average expected option life of five years. The weighted average fair values of options granted during 1996 and 1995 were $17.24 and $16.09, respectively.

For purposes of pro forma disclosures, the options' estimated fair values are amortized to expense over the options' vesting periods. Therefore, the pro forma results for 1995 presented below include only 50% of the total pro forma expense for options awarded in that year. The Corporation's pro forma information follows:

(In millions, except per share data)	**1996**	*1995*
Pro forma net earnings	**$1,322**	$ 671
Pro forma earnings per common share:		
Assuming no dilution	**6.67**	3.23
Assuming full dilution	**5.93**	3.01

Note 12 — Post-Retirement Benefit Plans

The Corporation maintains separate plans for post-retirement benefits for its employees based on their association with the former heritage companies of Lockheed and Martin Marietta, and with Tactical Systems.

Defined Contribution Plans

The Corporation maintains a number of defined contribution plans which cover substantially all employees, the most significant of which are the 401(k) plans for salaried employees (the Salaried Plans) and hourly employees (the Hourly Plans). Under the provisions of these 401(k) plans, employees' eligible contributions are matched by the Corporation at established rates. The Corporation's matching obligations were $202 million in 1996, $180 million in 1995, and $192 million in 1994. Matching obligations for 1996 include contributions related to employees of Tactical Systems since the date of acquisition.

The Salaried Plan for heritage Lockheed employees includes an ESOP which purchased 17.4 million shares of the Corporation's common stock with the proceeds from a $500 million note issue which is guaranteed by the Corporation (see Note 8). A portion of the Corporation's match consisted of the Corporation's common stock (50% through June 30, 1995, and 100% thereafter), which was partially fulfilled with stock released from the ESOP at approximately 1.2 million shares per year based upon the debt repayment schedule through the year 2004, with the remainder being fulfilled through purchases of common stock from terminating participants or in the open market. Interest incurred on the ESOP debt totaled $29 million, $31 million and $33 million in 1996, 1995 and 1994, respectively. Dividends received by the ESOP with respect to unallocated shares held are used for debt service. The ESOP held approximately 21 million issued shares of the Corporation's common stock at December 31, 1996, of which approximately 12 million were allocated and 9 million were unallocated. The fair value of the unallocated ESOP shares at December 31, 1996 was approximately $800 million. Effective January 1, 1997, heritage Martin Marietta salaried employees became eligible to participate in this plan.

The Hourly Plans for heritage Lockheed employees include non-leveraged ESOPs. The Corporation's match to these plans were made through cash contributions to the ESOP trusts which were used, in part, to purchase common stock from terminating participants and in the open market for allocation to participant accounts. These ESOP trusts held approximately 2 million issued and outstanding shares of common stock at December 31, 1996.

Dividends paid to the salaried and hourly ESOP trusts on the allocated shares are paid annually by the ESOP trusts to the participants based upon the number of shares allocated to each participant.

Defined Benefit Plans

Most employees are covered by contributory or noncontributory defined benefit pension plans. Benefits for salaried plans are generally based on average compensation and years of service, while those for hourly plans are generally based on negotiated benefits and years of service. Substantially all benefits are paid from funds previously contributed to trustees. The Corporation's funding policy is to make contributions that are consistent with U.S. Government cost allowability and Internal Revenue Service deductibility requirements, subject to the full-funding limits of the Employee Retirement Income Security Act of 1974 (ERISA). When any funded plan exceeds the full-funding limits of ERISA, no contribution is made to that plan.

The net pension cost related to the Corporation's defined benefit plans included the following components:

(In millions)	**1996**	*1995*	*1994*
Service cost—benefits earned during the year	**$ 463**	$ 342	$ 429
Interest cost	**1,050**	881	828
Net amortization and other components	**889**	1,534	(1,067)
Actual return on assets	**(2,243)**	(2,571)	65
Net pension cost	**$ 159**	$ 186	$ 255

The following table sets forth the defined benefit plans' funded status and amounts recognized in the Corporation's consolidated balance sheet:

(In millions)	1996	1995
Plan assets at fair value	**$18,402**	$13,813
Actuarial present value of benefit obligations:		
Vested	**$13,486**	$10,684
Non-vested	**236**	115
Accumulated benefit obligation	**13,722**	10,799
Effect of projected future salary increases	**1,694**	1,589
Projected benefit obligation (PBO)	**15,416**	12,388
Plan assets greater than PBO	**2,986**	1,425
Reconciling items:		
Unrecognized net asset existing at the date of initial application of SFAS No. 87	**(196)**	(287)
Unrecognized prior-service cost	**461**	499
Unrecognized gain	**(2,484)**	(1,381)
Prepaid pension asset	**$ 767**	$ 256

The increases in the fair value of plan assets, the PBO and the prepaid pension asset are primarily related to the inclusion of the defined benefit plans of Tactical Systems in 1996. The fair value of plan assets also increased due to favorable investment returns in 1996.

At December 31, 1996, approximately 56 percent of the plan assets were equity securities with the remainder primarily being fixed income securities and cash equivalents. Actuarial determinations were based on various assumptions displayed in the following table. Net pension costs in 1996, 1995 and 1994 were based on assumptions in effect at the end of the respective preceding year. Benefit obligations as of each year-end were based on assumptions in effect as of those dates.

	1996	1995	1994
Assumptions:			
Discount rates	**7.8%**	7.5%	8.2-8.5%
Rates of increase in future compensation levels	**6.0**	6.0	5.5-6.0
Expected long-term rate of return on assets	**9.0**	8.8	8.0-8.8

Retiree Medical And Life Insurance Plans

Certain health care and life insurance benefits are provided to eligible retirees by the Corporation. These benefits are paid by the Corporation or funded through several trusts.

The net periodic post-retirement benefit cost included the following components:

(In millions)	1996	1995	1994
Service cost—benefits earned during the year	**$ 40**	$ 34	$ 54
Interest cost	**181**	177	164
Net amortization and other components	**13**	44	(29)
Actual return on assets	**(73)**	(82)	(3)
Curtailment gain	**(15)**	—	(21)
Net post-retirement cost	**$146**	$173	$165

The Corporation has made contributions to trusts (including Voluntary Employees' Beneficiary Association (VEBA) trusts and 401(h) accounts) established to pay future medical benefits to eligible retirees and dependents.

The following table sets forth the post-retirement benefit plans' obligations and funded status as of December 31:

(In millions)	1996	1995
Plan assets at fair value	**$ 736**	$ 590
Actuarial present value of benefit obligations:		
Active employees, eligible to retire	**$ 334**	$ 344
Active employees, not eligible to retire	**454**	428
Former employees	**1,819**	1,504
Accumulated post-retirement benefit obligation (APBO)	**2,607**	2,276
Assets less than APBO	**1,871**	1,686
Unrecognized prior service cost	**—**	16
Unrecognized gain	**206**	93
Post-retirement benefit unfunded liability	**$2,077**	$1,795

Actuarial determinations were based on various assumptions displayed in the following table. Net retiree medical costs for 1996, 1995 and 1994 were based on assumptions in effect at the end of the respective preceding years. Benefit obligations as of the end of each year reflect assumptions in effect as of those dates.

	1996	1995	1994
Assumptions:			
Discount rates	**7.8%**	7.5%	8.2-8.5%
Expected long-term rate of return on assets	**9.0**	8.8	8.0-8.8

The medical trend rates used in measuring the APBO were 7.5% in 1996 and 8% in 1995, and were assumed to gradually decrease to 4.5% by the year 2004. An increase of one percentage point in the assumed medical trend rates would result in an increase in the APBO of approximately 7.6% at December 31, 1996, and a 1996 post-retirement benefit cost increase of approximately 8.1%. The Corporation believes that the cost containment features it has previously adopted and the funding approaches underway will allow it to effectively manage its retiree medical expenses, but it will continue to monitor the costs of retiree medical benefits and may further modify the plans if circumstances warrant.

Note 13 — Leases

Total rental expense under operating leases, net of immaterial amounts of sublease rentals and contingent rentals, were $320 million, $236 million and $265 million for 1996, 1995 and 1994, respectively.

Future minimum lease commitments at December 31, 1996, for all operating leases that have a remaining term of more than one year were approximately $1.1 billion ($254 million in 1997, $207 million in 1998, $174 million in 1999, $124 million in 2000, $99 million in 2001, and $264 million in later years). Certain major plant facilities and equipment are furnished by the U.S. Government under short-term or cancelable arrangements.

Note 14 — Commitments and Contingencies

The Corporation or its subsidiaries are parties to or have property subject to litigation and other proceedings, including matters arising under provisions relating to the protection of the environment. In the opinion of management and counsel, the probability is remote that the outcome of these matters will have a material adverse effect on the results of the Corporation's operations or its financial position. These matters include the following items:

Environmental matters — In 1991, the Corporation entered into a consent decree with the U.S. Environmental Protection Agency (EPA) relating to certain property in Burbank, California, which obligated the Corporation to design and construct facilities to monitor, extract, and treat groundwater, and to operate and maintain such facilities for approximately eight years. A second consent decree is being finalized which will obligate the Corporation to fund the continued operation and maintenance of these facilities through the year 2018. The Corporation estimates that expenditures required to comply with the consent decrees over their remaining terms will be approximately $110 million.

The Corporation has also been operating under a cleanup and abatement order from the California Regional Water Quality Control Board affecting its facilities in Burbank, California. This order requires site assessment and action to abate groundwater contamination by a combination of groundwater and soil cleanup and treatment. Based on experience derived from initial remediation activities, the Corporation estimates the anticipated costs of these actions in excess of the requirements under the EPA consent decree to approximate $90 million over the remaining term of the project.

In addition, the Corporation is involved in other proceedings and potential proceedings relating to environmental matters, including disposal of hazardous wastes and soil and water contamination. The extent of the Corporation's financial exposure cannot in all cases be reasonably estimated at this time. A liability of approximately $340 million for those cases in which an estimate of financial exposure can be determined has been recorded.

Under an agreement with the U.S. Government, the Burbank groundwater treatment and soil remediation expenditures referenced above are being allocated to the Corporation's operations as general and administrative costs and, under existing government regulations, these and other environmental expenditures related to U.S. Government business, after deducting any recoveries from insurance or other responsible parties, are allowable in establishing the prices of the Corporation's products and services. As a result, a substantial portion of the expenditures will be reflected in the Corporation's sales and cost of sales pursuant to U.S. Government agreement or regulation. The Corporation has recorded an asset for the portion of these costs that are probable of future recovery in pricing of the Corporation's products and services for U.S. Government business. The portion that is expected to be allocated to commercial business has been reflected in cost of sales. The recorded amounts do not reflect the possible future recovery of portions of the environmental costs through insurance policy coverage or from other potentially responsible parties, which the Corporation is pursuing as required by agreement and U.S. Government regulation. Any such recoveries, when received, would reduce the Corporation's liability as well as the allocated amounts to be included in the Corporation's U.S. Government sales and cost of sales.

Waste remediation contract — In 1994, the Corporation was awarded a $180 million fixed price contract by the DOE for the Phase II design, construction and limited test of remediation facilities, and the Phase III full remediation of waste found in Pit 9, located on the Idaho National Engineering and Environmental Laboratory reservation. The Corporation has incurred and continues to incur significant unanticipated costs and schedule impacts due to complex technical and contractual matters which threaten the viability of the overall Pit 9 program. The Corporation is currently working to identify and quantify the overall effects, including the financial impact, of these matters, and discussions with the DOE are continuing; however, to date no resolution of these technical and contractual matters has been achieved. Upon completion of the Corporation's investigation into the circumstances which gave rise to these schedule, technical and cost issues, the Corporation will provide the DOE an appropriate request for equitable adjustment. The total amount of such request for equitable adjustment has not yet been determined.

Letters of credit and other matters — The Corporation has entered into standby letter of credit agreements and other arrangements with financial institutions primarily relating to the guarantee of future performance on certain contracts. In connection with the Loral Transaction, the Corporation assumed the obligations of Loral as guarantor under the Revolving Credit Agreement of Globalstar, L.P., an affiliate of Loral SpaceCom, up to a maximum principal amount of $250 million, subject to the assumption by certain of the Globalstar partners of a portion of the Corporation's obligations as guarantor. At December 31, 1996, the Corporation had contingent liabilities on outstanding letters of credit, guarantees, and other arrangements aggregating approximately $1.5 billion.

Note 15 — Information on Industry Segments and Major Customers

The Corporation operates in four principal business segments: Space & Strategic Missiles, Electronics, Information & Services, and Aeronautics. All other activities of the Corporation fall within the Energy, Materials and Other segment.

Space & Strategic Missiles — Engaged in the design, development, engineering and production of civil, commercial and military space systems, including spacecraft, space launch vehicles, manned space systems and their supporting ground systems and services; telecommunications systems and services; strategic fleet ballistic missiles; and defensive missiles.

Electronics — Engaged in the design, development, engineering and production of high performance electronic systems for undersea, shipboard, land-based, airborne and space-based applications. Major defense product lines include surface ship and submarine combat systems; anti-armor missiles; indirect fire support weapons systems; air defense systems; aircraft system integration; and electronic warfare. Major commercial product lines include satellite electronics; mail handling automation systems; and transportation systems.

Information & Services — Engaged in the development, integration and operation of large, complex information systems; engineering, technical, and management services for federal customers; transaction processing systems and services for state and local government agencies; commercial information technology outsourcing; manufacture and distribution of computer peripherals, graphics engines and intranet software; and the provision of internal information technology support to the Corporation.

Aeronautics—Engaged in the design, development, engineering and production of fighter, bomber, special mission, airlift, antisubmarine warfare, reconnaissance, surveillance and high performance aircraft; systems for military operations; aircraft controls and subsystems; thrust reversers; and aircraft modification and maintenance and logistics support for military and civilian customers.

Energy, Materials and Other — The Corporation manages certain facilities for the DOE. The contractual arrangements provide for the Corporation to be reimbursed for the cost of operations and receive a fee for performing management services. The Corporation reflects only the management fee in its sales and earnings for these government-owned facilities. In addition, while the employees at such facilities are employees of the Corporation, applicable employee benefit plans are separate from the Corporation's plans. The Corporation also provides environmental remediation services to commercial and U.S. Government customers, and has investments in other businesses. Through October, 1996, the Corporation provided construction aggregates and specialty chemical products to commercial and civil customers through its Materials subsidiary (see Note 10).

Selected Financial Data By Business Segment

(In millions)	**1996**	*1995*	*1994*
Net sales			
Space & Strategic Missiles	**$ 7,904**	$ 7,813	$ 7,000
Electronics	**6,705**	3,357	4,059
Information & Services	**5,863**	4,173	3,986
Aeronautics	**5,596**	6,617	7,091
Energy, Materials and Other	**807**	893	770
	$26,875	$22,853	$22,906
Operating profit			
Space & Strategic Missiles	**$ 973**	$ 463	$ 495
Electronics	**673**	224	451
Information & Services	**241**	267	214
Aeronautics	**441**	394	511
Energy, Materials and Other	**405**	29	308
	$2,733	$1,377	$1,979
Depreciation and amortization			
Space & Strategic Missiles	**$188**	$206	$218
Electronics	**239**	122	136
Information & Services	**121**	69	79
Aeronautics	**126**	142	126
Energy, Materials and Other	**58**	66	79
	$732	$605	$638
Amortization of intangible assets			
Space & Strategic Missiles	**$ 52**	$ 56	$ 61
Electronics	**209**	85	69
Information & Services	**124**	57	45
Aeronautics	**79**	89	89
Energy, Materials and Other	**1**	9	15
	$465	$296	$279

(In millions)	**1996**	*1995*	*1994*
Expenditures for property, plant and equipment			
Space & Strategic Missiles	**$264**	$165	$175
Electronics	**213**	100	102
Information & Services	**104**	63	66
Aeronautics	**75**	58	96
Energy, Materials and Other	**81**	114	70
	$737	$500	$509
Identifiable assets			
Space & Strategic Missiles	**$ 3,758**	$ 3,750	$ 4,222
Electronics	**11,363**	3,869	3,386
Information & Services	**6,111**	2,679	2,375
Aeronautics	**4,201**	3,827	4,316
Energy, Materials and Other	**3,824**	3,433	3,680
	$29,257	$17,558	$17,979

Net Sales By Customer Category

(In millions)	**1996**	*1995*	*1994*
U.S. Government[a]			
Space & Strategic Missiles	**$ 6,401**	$ 6,315	$ 5,815
Electronics	**4,469**	2,282	2,793
Information & Services	**3,860**	2,731	2,834
Aeronautics	**3,830**	4,274	4,970
Energy, Materials and Other	**154**	168	152
	$18,714	$15,770	$16,564
Foreign governments			
Space & Strategic Missiles	**$ 38**	$ 112	$ 290
Electronics	**1,668**	832	1,035
Information & Services	**140**	77	157
Aeronautics	**1,466**	1,966	1,958
Energy, Materials and Other	**—**	—	—
	$3,312	$2,987	$3,440
Commercial			
Space & Strategic Missiles	**$1,465**	$1,386	$ 837
Electronics	**568**	259	212
Information & Services	**1,863**	1,349	1,072
Aeronautics	**300**	377	163
Energy, Materials and Other	**653**	725	618
	$4,849	$4,096	$2,902

[a] *Sales made to foreign governments through the U.S. Government are included in sales to foreign governments.*

Export sales were $4.7 billion, $3.7 billion and $3.6 billion in 1996, 1995 and 1994, respectively.

Note 16 — Summary of Quarterly Information (Unaudited)

(In millions, except per share data)	**1996 Quarters**			
	First	*Second*[a]	*Third*[a]	*Fourth*[a][b]
Net sales	**$5,109**	**$7,076**	**$7,028**	**$7,662**
Earnings from operations	**472**	**693**	**675**	**441**
Net earnings	**272**	**299**	**311**	**465**
Earnings per common share, assuming full dilution	**1.22**	**1.33**	**1.38**	**2.11**

(In millions, except per share data)	**1995 Quarters**			
	First[c]	*Second*[c]	*Third*	*Fourth*
Net sales	$5,644	$5,606	$5,551	$6,052
Earnings (loss) from operations	290	(55)	510	537
Net earnings (loss)	137	(53)	287	311
Earnings (loss) per common share, assuming full dilution	.62	[d]	1.29	1.38

[a] *Net sales and earnings for the second, third and fourth quarters of 1996 include the operations of Tactical Systems (see Note 2).*

[b] *Earnings for the fourth quarter of 1996 include the effects of certain nonrecurring items (see Notes 4 and 10).*

[c] *Earnings for the first and second quarters of 1995 include the effects of merger related and consolidation expenses (see Note 4).*

[d] *Loss per common share, assuming full dilution, of $.24 has not been presented above as such amount was anti-dilutive when compared to the loss per common share, assuming no dilution, of $.36.*

Note 17 — Summarized Consolidating Financial Information

The $5 billion of debt obligations issued by the Corporation in the second quarter of 1996 are fully and unconditionally guaranteed by Tactical Systems. Pursuant to SEC disclosure requirements, summarized consolidating financial information follows:

(In millions)	*Lockheed Martin*[a]	*Tactical Systems*[b]	*Non-Guarantor Entities*	*Eliminations*	*Consolidated*
Earnings Data					
For the year ended December 31, 1996					
Net sales	$19,066	$ 303	$9,152	$(1,646)	$26,875
Earnings from operations	1,728	52	597	(96)	2,281
Net earnings	1,347	308	575	(883)	1,347
For the year ended December 31, 1995					
Net sales	$19,516	$ —	$4,216	$ (879)	$22,853
Earnings from operations	1,060	—	292	(70)	1,282
Net earnings	682	—	286	(286)	682
For the year ended December 31, 1994					
Net sales	$19,857	$ —	$3,580	$ (531)	$22,906
Earnings from operations	1,569	—	241	(31)	1,779
Net earnings	1,018	—	189	(189)	1,018
Cash Flows Data					
For the year ended December 31, 1996					
Net cash provided by (used for):					
Operating activities	$ 931	$ 353	$ 352	$ —	$ 1,636
Investing activities	(7,737)	(90)	(202)	—	(8,029)
Financing activities	6,101	(257)	(104)	—	5,740
Net (decrease) increase in cash and cash equivalents	(705)	6	46	—	(653)
Cash and cash equivalents:					
Beginning of year	640	—	13	—	653
End of year	$ (65)	$ 6	$ 59	$ —	$ —
For the year ended December 31, 1995					
Net cash provided by (used for):					
Operating activities	$ 1,067	$ —	$ 225	$ —	$ 1,292
Investing activities	(370)	—	(329)	—	(699)
Financing activities	(678)	—	99	—	(579)
Net increase (decrease) in cash and cash equivalents	19	—	(5)	—	14
Cash and cash equivalents:					
Beginning of year	621	—	18	—	639
End of year	$ 640	$ —	$ 13	$ —	$ 653
For the year ended December 31, 1994					
Net cash provided by (used for):					
Operating activities	$ 1,409	$ —	$ 84	$ —	$ 1,493
Investing activities	(349)	—	(153)	—	(502)
Financing activities	(762)	—	44	—	(718)
Net increase (decrease) in cash and cash equivalents	298	—	(25)	—	273
Cash and cash equivalents:					
Beginning of year	323	—	43	—	366
End of year	$ 621	$ —	$ 18	$ —	$ 639

Continued

(In millions)		Lockheed Martin[a]	Tactical Systems[b]	Non-Guarantor Entities	Eliminations	Consolidated
Balance Sheet Data						
As of December 31, 1996						
Current assets	—Public	$6,754	$ 603	$ 2,583	$ —	$ 9,940
	—Affiliated[c]	79	28	270	(377)	—
Noncurrent assets	—Public	10,198	1,347	7,772	—	19,317
	—Affiliated[c]	7,873	8,806	4,599	(21,278)	—
Current liabilities	—Public	5,962	135	2,607	—	8,704
	—Affiliated[c]	333	28	16	(377)	—
Long-term debt		8,972	1,204	12	—	10,188
Other noncurrent liabilities	—Public	2,781	857	(129)	—	3,509
Equity		6,856	8,560	12,718	(21,278)	6,856
As of December 31, 1995						
Current assets	—Public	$6,992	$ —	$ 1,216	$ —	$ 8,208
	—Affiliated[c]	262	—	448	(710)	—
Noncurrent assets	—Public	8,236	—	1,114	—	9,350
	—Affiliated[c]	1,541	—	4,451	(5,992)	—
Current liabilities	—Public	4,453	—	731	—	5,184
	—Affiliated[c]	448	—	262	(710)	—
Long-term debt		2,880	—	130	—	3,010
Other noncurrent liabilities	—Public	2,817	—	114	—	2,931
Equity		6,433	—	5,992	(5,992)	6,433

[a] *Data is related to the parent company only.*
[b] *Data is related to Tactical Systems, Inc. only and pertains to operations from April 1, 1996.*
[c] *Amounts represent activity with Lockheed Martin affiliated companies.*

Consolidated Financial Data
Seven Year Summary

(In millions, except per share data)	**1996**	1995	1994	1993	1992	1991	1990
Operating Results							
Net sales	**$26,875**	$22,853	$22,906	$22,397	$16,030	$15,871	$16,089
Costs and expenses	**24,594**	21,571	21,127	20,857	14,891	14,767	15,178
Earnings from operations	**2,281**	1,282	1,779	1,540	1,139	1,104	911
Other income and expenses, net	**452**	95	200	44	42	(49)	34
	2,733	1,377	1,979	1,584	1,181	1,055	945
Interest expense	**700**	288	304	278	177	176	180
Earnings before income taxes and cumulative effect of changes in accounting	**2,033**	1,089	1,675	1,306	1,004	879	765
Income tax expense	**686**	407	620	477	355	261	161
Earnings before cumulative effect of changes in accounting	**1,347**	682	1,055	829	649	618	604
Cumulative effect of changes in accounting	**—**	—	(37)	—	(1,010)	—	—
Net earnings (loss)	**$ 1,347**	$ 682	$ 1,018	$ 829	$ (361)	$ 618	$ 604
Per Common Share							
Assuming no dilution:							
Before cumulative effect of changes in accounting	**$ 6.80**	$ 3.28	$ 5.32	$ 3.99	$ 3.31	$ 3.05	$ 2.97
Cumulative effect of changes in accounting	**—**	—	(.20)	—	(5.15)	—	—
	$ 6.80	$ 3.28	$ 5.12	$ 3.99	$ (1.84)	$ 3.05	$ 2.97
Assuming full dilution:							
Before cumulative effect of changes in accounting	**$ 6.04**	$ 3.05	$ 4.83	$ 3.75	$ 3.31	$ 3.05	$ 2.97
Cumulative effect of changes in accounting	**—**	—	(.17)	—	(5.15)	—	—
	$ 6.04	$ 3.05	$ 4.66	$ 3.75	$ (1.84)	$ 3.05	$ 2.97
Cash Dividends	**$ 1.60**	$ 1.34	$ 1.14	$ 1.09	$ 1.04	$ .98	$ .90
Condensed Balance Sheet Data							
Current assets	**$ 9,940**	$ 8,208	$ 8,143	$ 6,961	$ 5,157	$ 5,553	$ 5,442
Property, plant and equipment	**3,721**	3,134	3,455	3,643	3,139	3,155	3,200
Intangible assets related to contracts and programs acquired	**1,767**	1,553	1,696	1,832	42	52	59
Cost in excess of net assets acquired	**10,394**	2,794	2,831	2,697	841	864	882
Other assets	**3,435**	1,869	1,854	1,949	1,648	895	883
Total	**$29,257**	$17,558	$17,979	$17,082	$10,827	$10,519	$10,466
Current liabilities—other	**$ 7,414**	$ 4,462	$ 5,177	$ 4,690	$ 3,176	$ 3,833	$ 4,235
Short-term borrowings	**1,110**	—	—	—	—	—	—
Current maturities of long-term debt	**180**	722	285	346	327	298	30
Long-term debt	**10,188**	3,010	3,594	4,026	1,803	1,997	2,392
Post-retirement benefit liabilities	**2,077**	1,795	1,859	1,848	1,579	54	—
Other liabilities	**1,432**	1,136	978	971	460	112	38
Stockholders' equity	**6,856**	6,433	6,086	5,201	3,482	4,225	3,771
Total	**$29,257**	$17,558	$17,979	$17,082	$10,827	$10,519	$10,466
Common Shares Outstanding at Year End	**192.7**	198.6	199.1	197.9	194.1	201.4	200.7