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

9-SAT-LA-95
10-SAT-AMEND-95

In The Matter Of The Application Of	)	
	)	
CONSTELLATION COMMUNICATIONS, INC.	)	File Nos. 17-DSS-P-91(48)
	)	and CSS-91-013
For Authority To Construct, Launch And Operate A Low Earth Orbit Satellite System In The 1610-1626.5 MHz And 2483.5-2500 MHz Bands.	)))	

AMENDMENT AND APPLICATION FOR LAUNCH AUTHORIZATION AND LICENSE

Of Counsel:

Robert A. Mazer
Rosenman & Colin
1300 19th Street, N.W.
Washington, DC 20036
(202) 463-7177

Constellation Communications, Inc.
10530 Rosehaven Street, Suite 410
Fairfax, Virginia 22030
(703) 352-1733

November 16, 1994

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EXECUTIVE SUMMARY

This Amendment to the June 3, 1991 satellite system Application of Constellation is focused on four general areas. First, Constellation is proposing these amendments to conform its system to the frequency assignment plan adopted by the Commission's Report and Order in CC Docket No. 92-166. Second, the orbital configuration has been modified to provide a more effective introduction of service, while providing better coverage with a slightly smaller number of operational satellites than originally proposed. It also includes in-orbit spare satellites to improve system availability. Third, Constellation is proposing a more technologically-advanced satellite design with multiple spot beams in the 1610-1626.5 MHz and 2483.5-2500 MHz bands to increase capacity, and to improve spectrum efficiency and inter-system and inter-service sharing. Fourth, Constellation is amending this application to provide the information needed to demonstrate its technical and financial qualifications in the manner specified by the Commission in its Report and Order and is submitting an application with the appropriate fees for launch authorization and license.

More specifically, this amendment reviews changes to Constellation's strategic team and technical program. Constellation has expanded its United States partners to include Bell Atlantic Corporation (through its wholly-owned subsidiary, Bell Atlantic Enterprises International) ("Bell Atlantic") and E-Systems, Inc. ("E-Systems") as equity investors in Constellation. Bell Atlantic's service orientation has focused Constellation's business objectives and planning, and its experience as a telephone network operator has assisted Constellation in its system development, particularly interconnection with the public switched telephone network ("PSTN"). Bell Atlantic's presence is an important step in the formation of the global team of partners to finance the Constellation LEO satellite system. E-Systems has systems integration and engineering expertise in all aspects of ground and space communications systems, including radio transceivers and modems, power amplifiers and filters, antenna systems, spread spectrum and other relevant technologies. As the systems integrator for Constellation, E-Systems' experience in large scale systems engineering and integration and sophisticated communications subsystems will ensure the reliability and service quality of the Constellation system. Each of these companies will play a critical role in the further development, implementation and financing of the Constellation system. Additionally, Constellation is pleased to report that it has established a strategic relationship with Telecomunicações Brasileiras S.A. - ("Telebrás"). Telebrás brings an unparalleled level of experience in technology and provision of services to this endeavor. Telebrás intends to be a "major shareholder" in the LEO system. Also, Constellation has established strategic relationships with Martin Marietta Astro Space and Texas Instruments, who are supporting the Constellation system's technical development.

Together, this team has the necessary experience to design, construct, launch and implement a first-rate mobile satellite communications system. Equally important, the team has vast knowledge in providing high quality and affordable telecommunications services.

With regard to its technical program, Constellation's amended orbital configuration reduces the number of operational satellites from 48 satellites to 46 satellites but improves coverage by increasing the number of orbital planes from four to eight and by increasing the orbital altitude from 1,020 km to 2,000 km. In particular, this reconfigured system is capable of providing initial commercial service after only a portion of the total satellites are launched. One of these planes will have an inclination of 0° and will contain 11 operational satellites. This equatorial belt of satellites can be established with only two launches and is capable of providing continuous service to the area between 23° North Latitude and 23° South Latitude. There are about a hundred countries included in this service area.

The other 35 operational satellites in the Constellation system will consist of 7 planes of satellites in circular orbits inclined at 62° at 2,000 km altitude configured in a Walker constellation. Taken together, the 46 satellites of Constellation's LEO MSS system provide United States and global coverage which complies with the technical requirements specified in the Report and Order.

In its 1991 Application, Constellation also recognized that the capacity of its system would have to grow as demand increased. Since that time, Constellation's ongoing market research and analysis has indicated that demand for its service is likely to be much higher than originally contemplated. As a result, Constellation is proposing a satellite design using 32 spot beams at the L and S-bands and a minimum capacity of over 1,000 voice circuits per satellite using code division multiple access ("CDMA"). These satellites are more spectrum efficient and cost effective than those originally proposed.

In sum, Constellation believes that the expansion of its team of investors and strategic partners and the changes in orbit configuration and satellite design represent a dynamic approach to the implementation of a technically and economically viable LEO satellite system. Of particular importance to the Commission's regulatory objectives are the improved spectrum efficiency and sharing capabilities resulting from these modifications. With a grant of a system license from the Commission, Constellation is confident that it will be a strong and successful competitor in the LEO MSS market.

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For Authority To Construct, Launch And Operate	)	
A Low Earth Orbit Satellite System In The	)	
1610-1626.5 MHz And 2483.5-2500 MHz Bands.	)	

AMENDMENT
AND
APPLICATION FOR LAUNCH AUTHORIZATION AND LICENSE

Constellation Communications, Inc. ("Constellation") submits this amendment to its pending application for authority to construct a system of low-Earth orbit ("LEO") satellites operating in the 1610-1626.5 MHz and 2483.5-2500 MHz frequency bands, and requests authority to launch and operate this system. This submission is being filed pursuant to the Commission's Report and Order in CC Docket No. 92-166, FCC 94-261, released October 14, 1994 ("Report and Order"), establishing rules for the 1.6/2.4 GHz Mobile Satellite Service ("MSS").

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I. Introduction

On June 3, 1991, Constellation filed an application for authority to construct a LEO satellite system[1] to be operated in the 1610-1626.5 MHz and 2483.5-2500 MHz frequency bands then allocated only to the radiodetermination satellite service ("RDSS"). At the same time, Constellation also filed a petition for rulemaking to allow multiple LEO systems to be licensed under the same rules as applied to RDSS.[2] In its application, Constellation requested assignment of a 2 MHz segment of the 1610-1626.5 MHz band (i.e., 1624.5-1626.5 MHz) for narrowband transmissions using frequency division multiple access ("FDMA") transmissions on an exclusive basis, and the 2483.5-2500 MHz band using time division multiplexed ("TDM") transmissions on a shared, non-exclusive basis, with other systems using spread spectrum techniques.[3] Constellation also proposed to utilize the current RDSS feeder link bands at 5150-5216 MHz and 6525-6541.5 MHz for its system.[4]

During the next three years, Constellation actively participated in the various proceedings leading up to the recent Report and Order adopting the rules to govern the licensing of LEO MSS satellite systems in the 1.6/2.4 GHz bands. As the Commission

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[1] The application was assigned the file numbers captioned above, and public notice of its acceptance was given on October 24, 1991. See, FCC Public Notice, DA 91-1308, 6 FCC Rcd 6002 (1991).

[2] The Petition for Rulemaking was assigned File No. RM-7771 and placed on public notice on August 13, 1991. See FCC Public Notice 14747, September 13, 1991. The Petition for Rulemaking was subsequently incorporated into the proceedings in CC Docket No. 92-166.

[3] See Application of Constellation Communications, Inc., June 3, 1991 at 1.

[4] Id. at 1-2. See also 47 CFR §25.202(a)(2).

is well aware, this proceeding has resulted in voluminous comments and replies in examining the initial applications, as well as waiver requests, petitions for rulemaking, allocation proposals, pioneer's preference requests, etc. Constellation has actively and extensively participated at each step of this proceeding. Constellation was an active member of the Negotiated Rulemaking Committee in CC Docket No. 92-166 during the first quarter of 1993,[5] as well as the Negotiated Rulemaking Committee in CC Docket No. 92-297 during the third quarter of 1994.[6] Additionally, Constellation representatives served on the United States delegation to the 1992 World Administrative Radio Conference ("WARC") and in related preparatory meetings.[7] Constellation also joined with other LEO applicants in filing joint proposals to resolve the complex issues in this proceeding.[8]

Throughout this proceeding, Constellation has advocated a multiple entry policy in the RDSS/MSS bands to offset the single designated entity licensed by the Commission in the conventional MSS bands at 1545-1599 MHz and 1646.5-1660.5

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[5] See FCC Public Notices DA 92-1085, August 7, 1992 and DA 92-1691, December 15, 1992; Report of the MSS Above 1 GHz Negotiated Rulemaking Committee April 6, 1993.

[6] See FCC Public Notices No. 43845, July 12, 1994 and 41726, February 11, 1994.

[7] See Report and Order in ET Docket No. 92-28, 9 FCC Rcd 536 (1994) (Allocation Order).

[8] See Proposal of Constellation, Ellipsat and TRW to the Negotiated Rulemaking Committee established for the MSS Above 1 GHz (January 5, 1993); Final Report of the Majority of Active Participants of Informal Working Group 1 to the Above 1 GHz Negotiated Rulemaking Committee (April 6, 1993); Joint Proposal of Constellation, Ellipsat and TRW (October 8, 1993), and Joint Proposal and Supplemental Comments of Constellation, Mobile Communications Holdings, Inc., Motorola and TRW (September 9, 1994).

MHz.[9] Although the rules adopted in the Report and Order did not completely achieve this goal, Constellation is amending its application to conform to the rules adopted in the Report and Order.

Constellation also realized from the outset that a LEO satellite system is necessarily an international undertaking. Such an undertaking would require a team of partners, each contributing their own expertise to the project. Constellation's initial team consisted of Defense Systems, Inc., MicroSat Launch Systems, Inc., and Pacific Communications Sciences, Inc.[10] This team provided the initial technical and business development for the Constellation system. Based on these efforts, Constellation has expanded its United States partners to include Bell Atlantic Corporation (through its wholly-owned subsidiary, Bell Atlantic Enterprises International) ("Bell Atlantic") and E-Systems, Inc. ("E-Systems") as equity investors in Constellation.[11] Each of these companies will play a critical role in the further development and implementation of the Constellation system.

Bell Atlantic is one of the seven Regional Bell Operating Companies ("RBOCs") with assets of approximately $30 billion and operating revenues for 1993 of approximately $13 billion. It provides telephone network services throughout the mid-Atlantic states, with more than 18 million access lines, and has cellular telephone

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[9] See, e.g., Second Report and Order in Gen. Docket No. 84-1234, 2 FCC Rcd 485 (1987).

[10] See Application of Constellation, June 3, 1994 at 4-6 and Exhibit E, Attachment 3.

[11] Bell Atlantic presently owns approximately 8% of Constellation voting stock and E-Systems owns approximately 31% of Constellation voting stock.

operations throughout the United States, with more than a million customers. Bell Atlantic also has telecommunications, computer and information system operations in a growing number of countries worldwide. Bell Atlantic's service orientation has focused Constellation's business objectives and planning, and its experience as a telephone network operator has helped Constellation in its system development, particularly interconnection with the public switched telephone network ("PSTN"). Bell Atlantic's presence is an important step in the formation of the global team of partners to finance the Constellation LEO satellite system. A copy of Bell Atlantic's 1993 Annual Report is attached as Exhibit 6.

E-Systems is a leading worldwide developer of high technology electronic systems and products. Its 1993 sales were in excess of $2 billion, and it has been on the Fortune 500 list since 1982. E-Systems has 16,700 employees, half of whom are degreed engineers, scientists or other technical professionals. The company has systems integration and engineering expertise in all aspects of ground and space communications systems, including radio transceivers and modems, power amplifiers and filters, antenna systems, spread spectrum and other relevant technologies. As the systems integrator for Constellation, E-Systems' experience in large scale systems engineering and integration and sophisticated communications subsystems will ensure the reliability and service quality of the Constellation system. A copy of E-Systems' 1993 Annual Report is attached as Exhibit 7.

Constellation has also established a strategic relationship with Telecomunicações Brasileiras S.A. - ("Telebrás"). Telebrás is the third largest company in Brazil based on total assets of more than US$21 billion. Telebrás, through its 28 operating companies, is the primary supplier of public telecommunications services in Brazil. It owns more than 90% of all public exchanges and the nationwide network of local telephone lines. Through one of its subsidiaries, Telebrás owns and operates 100% of the public interstate and international telephone transmission facilities in Brazil. Telebrás also provides telephone related services such as telex and telegraph transmission, cellular mobile telephone service and video and data communications. Constellation has signed a Memorandum of Understanding with Telebrás and Bell Atlantic with the intent of jointly developing a LEO system. Telebrás, in a letter appearing in Exhibit 4, indicates that it intends to be "major shareholder" of the "LEO system."

In addition, Martin Marietta Astro Space ("Martin Marietta") and Texas Instruments are strategic technical partners and are supporting Constellation's system development. Martin Marietta is one of the world's leading designers and manufacturers of space satellites for commercial, civil government and defense customers. The company has produced more than 180 satellites that have accumulated over 625 years of operation in space. The current Martin Marietta backlog is 60 satellites on firm order. Martin Marietta provides critical expertise in the design, manufacture and launch of the Constellation satellites. Texas Instruments is a high technology company with a high degree of expertise in space systems, including antenna design. Its products and services also include semiconductors, defense electronics systems, software productivity tools, printers, notebook computers and consumer electronic products, custom engineering and manufacturing sources, electrical controls, and metallurgical materials. Texas Instruments has sales and manufacturing operations in more than 30 countries. Texas Instruments provides critical expertise to the design and manufacture of the phased array antennas on board the satellites and other elements of the Constellation system.

As is demonstrated above, Constellation has, during the last three and one-half years, successfully assembled a highly experienced team that can design, construct, launch and implement a first-rate mobile satellite communications system. Equally important, the team has the unparalleled knowledge of how to provide high quality and affordable telecommunications services. Together, this team is well poised to develop a dynamic, commercially viable LEO system.

Constellation has sought from the outset to develop a system that would provide essential communications services in areas that could not be economically served by terrestrial radio facilities or geostationary satellites, and to do so with a system whose capabilities and costs evolve over time as the demand for such services evolves. In particular, Constellation's implementation plans include staged expansion of system capacity, low initial investment to produce early profits based on penetration of only a portion of the total global market, and obtaining revenues from resellers rather than direct retail sales to subscribers.[12] Constellation's amended proposal fully achieves these objectives.

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[12] See Application of Constellation at 11-12.

Constellation's amended orbital configuration reduces the number of operational satellites from 48 satellites to 46 satellites but improves coverage by increasing the number of orbital planes from four to eight and by increasing the orbital altitude from 1,020 km to 2,000 km.[13] In particular, this reconfigured system is capable of providing initial commercial service after only a portion of the total satellites are launched. One of these planes will have an inclination of 0° and will contain 11 operational satellites. This equatorial belt of satellites can be established with only two launches and is capable of providing continuous service to the area between 23° North Latitude and 23° South Latitude.[14] There are about a hundred countries included in this service area.

The other 35 operational satellites in the Constellation system will consist of 7 planes of satellites in circular orbits inclined at 62° at 2,000 km altitude configured in a Walker constellation. Taken together, the 46 satellites of Constellation's LEO MSS system provides United States and global coverage which complies with the technical requirements specified in the Report and Order.

In its 1991 Application, Constellation also recognized that the capacity of its system would have to grow as demand increased. Since that time Constellation's ongoing market research and analysis has indicated that demand for its service is likely to be much higher than originally contemplated. As a result, Constellation is

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[13] As discussed in Section III, the orbital altitude of any specific satellite is either slightly above or below 2,000 km in order to avoid satellite collisions. Constellation is also proposing to launch an in-orbit spare satellite for each of the eight planes.

[14] Service can be provided outside this area but at elevation angles below 15°.

proposing a satellite design using 32 spot beams at L and S-band[15] and a minimum capacity of over 1,000 voice circuits per satellite using code division multiple access ("CDMA").[16] These satellites are more spectrum efficient and cost effective than originally proposed.

Taken together, Constellation believes that the expansion of its team of investors and strategic partners and the changes in orbit configuration and satellite design represent a dynamic approach to the implementation of a technically and economically viable LEO satellite system. Of particular importance to the Commission's regulatory objectives are the improved spectrum efficiency and sharing capabilities resulting from these modifications. With a grant of a system license from the Commission, Constellation is confident that it will become a strong and successful competitor in the LEO MSS market.

II. Summary of Amendment

This amendment to the June 3, 1991 satellite system Application of Constellation is focused on four general areas. First, Constellation is proposing these amendments to conform its system to the frequency assignment plan adopted by the Commission's Report and Order in CC Docket No. 92-166. Second, the orbital configuration has been modified to provide a more effective introduction of service,

[15] In this filing, Constellation often refers to the 1610-1626.5 MHz band as "L-band," to the 2483.5-2500 MHz band as "S-band," and to frequencies between 3 and 8 GHz as "C-band".

[16] In addition, the average link margins indicated in the reference link budget analyses in Exhibit 2 are higher than those presented in Appendix C to the Application of Constellation.

while providing better coverage with a slightly smaller number of operational satellites than originally proposed. It also includes in-orbit spare satellites to improve system availability. Third, Constellation is proposing a more technologically-advanced satellite design with multiple spot beams in the 1610-1626.5 MHz and 2483.5-2500 MHz bands to increase capacity, and to improve spectrum efficiency and inter-system and inter-service sharing. Fourth, Constellation is amending this application to provide the information needed to demonstrate its technical and financial qualifications in the manner specified by the Commission in its Report and Order.

In its 1991 Application, Constellation proposed to use for its LEO system feeder links the same C-band frequencies already allocated for RDSS feeder links. Use of C-band frequencies for Constellation's feeder links remains essential to permit multiple gateway Earth stations to access the satellites via an Earth coverage antenna beam using CDMA techniques. Use of the higher frequencies at 20/30 GHz for feeder links is likely to require the use of narrow beam antennas to provide the gain needed to overcome the increased attenuation at those frequencies, which in turn increases satellite complexity and restricts flexibility in selection of gateway locations.

In the Report and Order, the Commission could not identify specific bands below 15 GHz for 1.6/2.4 GHz MSS feeder links, although it indicated that it would continue to pursue such allocations in the context of the 1995 World Radio Conference ("WRC").[17] Constellation has indicated on a number of occasions[18] its requirement

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[17] See Report and Order at ¶¶ 167-168.

[18] See, e.g., Joint Proposal and Supplemental Comments, September 9, 1994, at 11.

for 200 MHz of uplink C-band spectrum and 200 MHz of downlink C-band spectrum for its feeder links. Constellation believes that it would be feasible to share the same feeder link spectrum with other CDMA LEO systems provided that there is careful coordination and control of power levels used by the systems sharing the band. A number of bands in the C-band portion of the spectrum are currently being considered by the ITU Radiocommunications Study Group Task Groups 8/3 and 4/5 and the Commission's Industry Advisory Committee for the 1995 WRC. Of the alternatives being considered, Constellation is proposing in this amendment to use the 5050-5250 MHz band for its Earth-to-space feeder links and the 6825-7025 MHz band for its space-to-Earth feeder links. As recognized by the Commission,[19] Constellation will file any necessary amendment to modify its system to operate in the bands ultimately allocated for 1.6/2.4 GHz MSS feeder links.

Conformance with Assignment Plan: The Commission adopted an L-band frequency assignment plan that divides the 1610-1626.5 MHz band into two segments, one to be used by multiple CDMA systems and the other to be used by a single system using frequency division multiple access/time division multiple access ("FDMA/TDMA") transmissions. As initially filed in 1991, Constellation's system is neither a CDMA nor an FDMA/TDMA system under the Commission's frequency assignment plan.[20] The Commission's Report and Order does not allow Constellation

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[19] Report and Order at ¶ 169.

[20] The inbound transponder was to be operated in an SCPC/FDMA mode using narrowband QPSK transmissions, and the outbound transponder received a single TDM carrier which was demodulated and retransmitted as a direct sequence spread spectrum

to amend its application to propose FDMA/TDMA operations without being deferred to a future processing group.[21] Accordingly, it is now proposing to operate its system on a CDMA basis. As a result, the outbound transponders are no longer regenerative repeaters but simple frequency changing transponders, just as the inbound transponders. Exhibit 1 provides a revised description of the communications payload, and updated transmission parameters for CDMA operations are discussed in Exhibit 2.

The Constellation satellites are equipped with simple frequency changing transponders in both the inbound (mobile user-to-gateway) and outbound (gateway-to-mobile user) directions with a transponder bandwidth of 12 MHz. Transmissions to or from individual subscribers will have a bandwidth of 2.56 MHz[22], and such transmissions can be conducted at several different frequencies within the 12 MHz transponder bandwidth. At L-band, this bandwidth covers the 11.35 MHz band assigned to the CDMA systems at 1610-1621.35 MHz but provides filtering against the TDMA/FDMA signals in the top part of the band. At S-band, this 12 MHz of bandwidth is sufficient to provide maximum system capacity within the power limits of the satellites. In both cases, use of 12 MHz rather than 16.5 MHz reduces the amount of feeder link spectrum required. However, flexibility is retained to operate across the entire 1610-1626.5 MHz and 2483.5-2500 MHz bands since the

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signal occupying 16.5 MHz. See Application of Constellation, Appendix A at 13-17.

[21] Report and Order at ¶ 59.

[22] See Exhibit 2 for detailed transmission parameters.

center frequencies of the transponders can be switched in orbit to cover the entire 16.5 MHz of allocated frequency spectrum.

Orbit configuration: Constellation's application was premised on a phased system implementation for two reasons.[23] One was to keep initial investment low during the early periods when traffic was building up. Thus, an initial investment for first generation, low capacity satellites was intended to be followed by higher capacity satellites. Constellation's 1991 application contemplated that global coverage would be provided from the outset by the entire 48 satellite system.

The amended Constellation system of 46 satellites in 8 orbital planes provides full global coverage as required by the Commission's rules, while still providing a means for time phasing the introduction of continuous service. Moreover, by using non-polar orbits and increasing altitude, Constellation will provide significantly improved coverage to its customers.

Increased capacity and improved spectrum efficiency: In this amendment, Constellation is also proposing changes that will result in more efficient spectrum utilization. In addition to the use of CDMA, a significant improvement results from the use of L-band and S-band antenna arrays which generate 32 beams and increase satellite capacity to over 1,000 channels with improved link margins. At S-band, Constellation plans to operate each beam at a power level that just meets the power flux density limits specified in RR 2566 in order to avoid coordination with terrestrial

[23] See Application of Constellation at 2.

services under the procedures of Resolution 46. The increase in antenna gain at L-band compared to the initial filing also allows a reduction in uplink power from the 2 watts indicated in the 1991 Application to a fraction of a watt (e.g., 300 mw). The CDMA architecture allows adaptive power control available on each individual channel and multiple gateways to access each beam, and permits sharing of the spectrum with other LEO systems and other radio services.

Qualifications: In the Report and Order, the Commission established the legal, technical and financial qualifications required for an applicant to receive an authorization in the 1.6/2.4 GHz MSS.[24] Section IV, below, demonstrates that Constellation has fully complied with all of these requirements.

III. Information Required By the Commission's Rules and Regulations

The following amended information is submitted in accordance with §25.114 (c) of the Commission's rules and regulations.[25]

(1) Applicant: The name, address and telephone number of the applicant is:

Constellation Communications, Inc.
10530 Rosehaven Street, Suite 410
Fairfax, Virginia 22030

Telephone: (703) 352-1733
Facsimile: (703) 352-9279

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[24] See 47 CFR §25.143(b).

[25] This section of Constellation's filing responds to the information required to be submitted in all space station applications as set out in subparagraphs (1) through (22) of §25.114(c). Subparagraphs (23) to (27) are applicable only to specific satellites services other than the 1.6/2.4 GHz MSS. Subparagraph (28) dealing specifically with the 1.6/2.4 GHz MSS is addressed in Section IV of this filing.

(2) Correspondence: Correspondence relating to this application should be sent to:

Mr. Ronald J. Lepkowski
Constellation Communications, Inc.
10530 Rosehaven Street, Suite 410
Fairfax, Virginia 22030

Telephone: (703) 352-1733
Facsimile: (703) 352-9279

with a copy to applicant's counsel:

Robert A. Mazer, Esquire
Rosenman & Colin
1300 19th Street, N.W., Suite 200
Washington, DC 20036

Telephone: (202) 463-7177
Facsimile: (202) 463-7199

(3) Authority Requested: Constellation amends its June 3, 1991 Application to request a "blanket" license as defined in §25.143(a) of the rules for a LEO system of 46 operational and 8 in-orbit spare satellites in the 1.6/2.4 GHz MSS.[26] This "Amendment and Application For Launch Authorization and License" is filed pursuant to the Commission's requirements specified in ¶¶ 2 and 58-59 of the Report and Order.

Specifically, Constellation is requesting authority to construct, launch and operate a LEO system of satellites comprised of 46 operational satellites and 8 in-orbit spare satellites to be operated in the 1610-1626.5 MHz (Earth-to-space) and in the 2483.5-2500 MHz (space-to-Earth) bands. The specific parameters of the space

[26] The appropriate filing fees required by §1.1105 have been submitted to the Commission with this amendment.

stations to be licensed are set forth in Exhibit 1. Pursuant to the Report and Order, Constellation proposes to operate its satellites in the CDMA portion of the Commission's L-Band frequency assignment plan.

Constellation recognizes the uncertainties that currently exist concerning the availability of feeder link frequencies below 16 GHz. For the purposes of this filing, Constellation is proposing to use the 5050-5250 MHz band for Earth-to-space feeder links and the 6825-7025 MHz band for space-to-Earth feeder links. With respect to the option afforded by ¶ 166 of the Report and Order, Constellation requests that these bands be conditionally included in the blanket system license to be issued to Constellation pending the completion of the relevant proceedings to identify MSS LEO feeder link bands.

(4) General Description: A general description of the Constellation system was provided in its June 3, 1991 Application.[27] Figure 1 provides an overview of the facilities that comprise the Constellation system.

Constellation now proposes to construct and operate a system of 46 operational satellites in 8 orbital planes. In addition, 8 in-orbit spare satellites (one for each orbital plane) will also be launched initially. The satellites will be launched into a nominal orbital altitude of 2,000 km. Eleven of the operational satellites will be in an

[27] See Appendices B and C of the Application of Constellation for additional general information describing the user terminals and system architecture of the Constellation system. While most of the general information remains applicable, certain changes are indicated in the following paragraphs that result from conversion of the Constellation system to CDMA operations in order to comply with the Report and Order.

equatorial orbit (circular orbit with 0° inclination) where they will provide continuous services to that portion of the Earth located between about 23° North Latitude and 23° South Latitude. The other 35 operational satellites will be operated in 7 planes of 5 satellites each to complete coverage of the United States and the rest of the world.

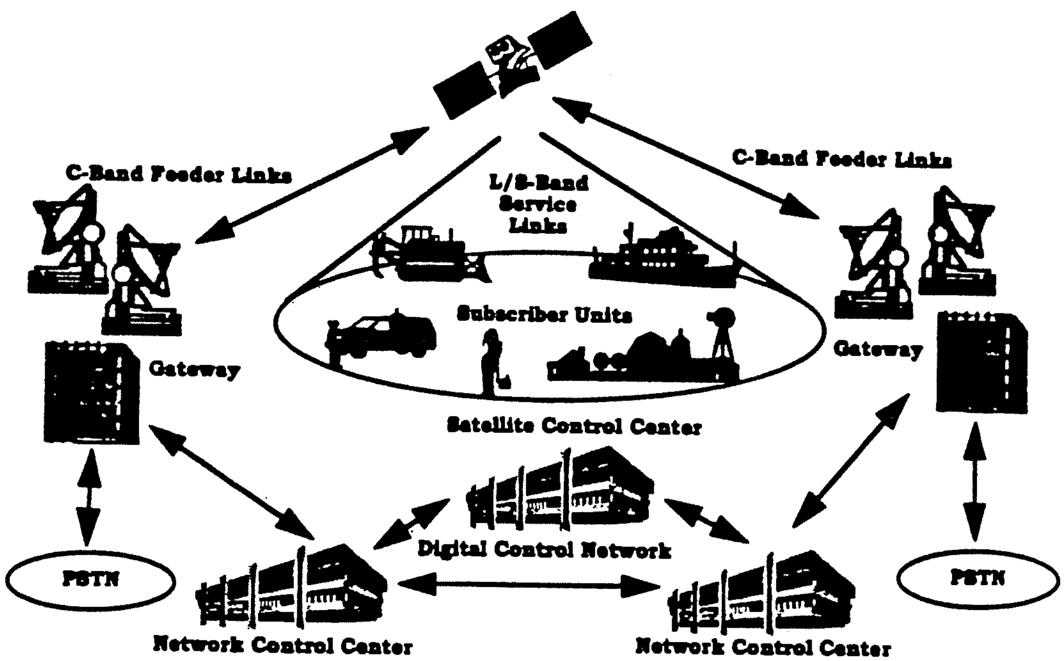

FIGURE 1: CONSTELLATION SYSTEM FACILITIES

Each Constellation satellite is capable of generating 32 receive beams in the 1610-1626.5 MHz band and 32 transmit beams in the 2483.5-2500 MHz band. The C-band feeder link antenna beams proposed at 5050-5250 MHz (uplink) and 6825-7025 MHz (downlink) are Earth coverage to allow multiple gateway Earth stations to be located without system-imposed constraints.

The satellites will be used to provide voice, data and facsimile services using code division multiple access techniques. Position determination service will be available in the Constellation system as described in the 1991 Application, and as required by the Commission's rules.[28]

One or more gateway Earth stations, which provide connection between the Constellation subscribers and the PSTN, will be located in the countries served by the Constellation system.[29] These gateways will be constructed and operated by the National Service Provider(s) ("NSP(s)") in each country, and typically consist of three or more steerable 6-meter diameter antennas and associated transmitters and receivers together with a control center where the baseband processing and switching equipment is located. Constellation also plans to equip gateways with telemetry receivers and telecommand transmitters, and connect this equipment via a digital control network

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[28] See Application of Constellation, Appendix B at 7-8. However, precise determination of a subscriber's position is no longer a requirement for demand assignment and handovers as indicated. In addition, the use of wideband spread spectrum signals no longer requires the precise Doppler correction scheme using gateway feedback described in the 1991 Application that was necessary in order to closely space the narrowband QPSK r.f. carriers in a 500 kHz bandwidth.

[29] It is also possible for several, small, adjacent countries to share a single gateway Earth station.

with the Satellite Control Center ("SCC"). Regional Network Control Centers ("NCCs") will coordinate system resources (frequencies, powers, codes) among the gateways in response to changing traffic levels in the system.

The use of CDMA and the increase in number of beams at L/S-band substantially improves the service capacities of the Constellation system, compared to the initial proposal. Subscriber units will still utilize small and simple, nearly omnidirectional, low gain antennas (typically 3 dBi),[30] but the power needed to close the link is significantly reduced. In addition, higher link margins and dynamic power control on both inbound and outbound links will be provided to improve service to users whose path to the satellite is undergoing fading conditions. Subscriber units can be installed in vehicles, easily hand carried or installed at fixed locations in providing a full range of mobile and rural telephony, data and facsimile services.

(5) Frequency Plan: Figure 2 illustrates the basic Constellation frequency plan. All of the detailed information required by §25.114(c)(5) is contained in Section 2 of Exhibit 1.

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[30] With the increase in the number of antenna beams and use of adaptive power control, Constellation does not require the range compensation antenna pattern illustrated in Figure B-1 (Appendix B) for all of its subscriber terminals. Use of antennas with such patterns can improve the efficiency of the Constellation system, but other types of non-directional antennas can also be accommodated within the Constellation system.

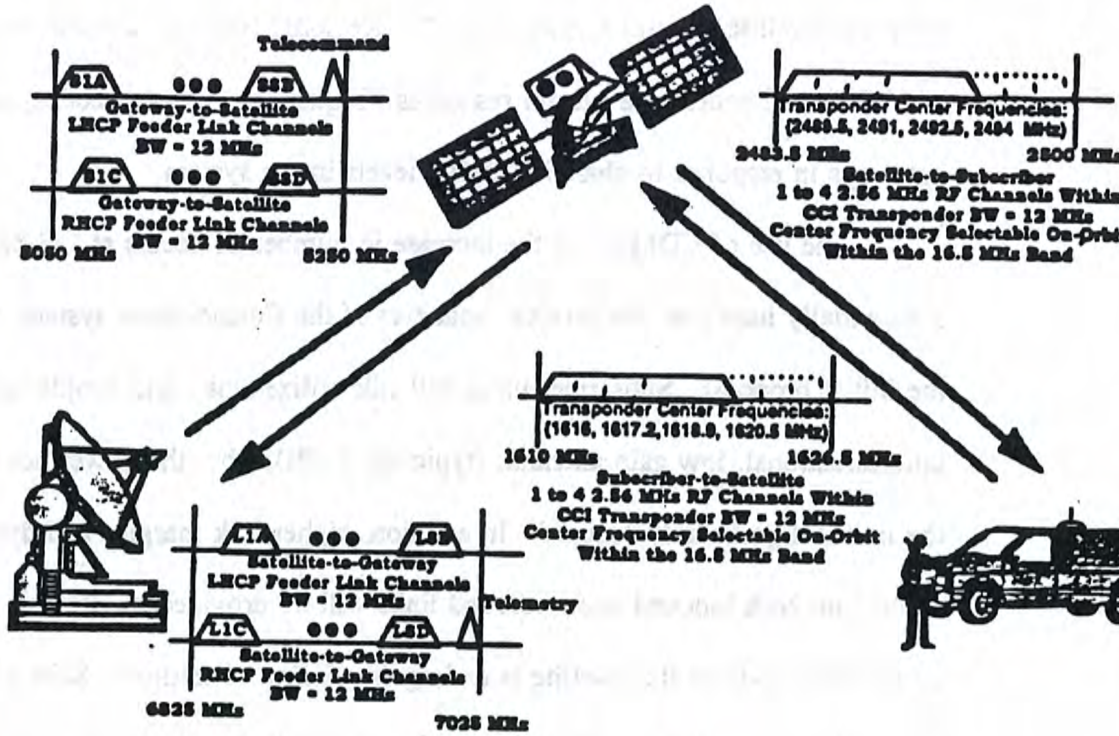

FIGURE 2: CONSTELLATION FREQUENCY PLAN

Constellation's L-band frequency plan is designed to provide operational flexibility under the constraints placed on Constellation's use of different parts of the band due to sharing with other radio services and with other satellite systems. The Commission's L-band assignment plan assigns the top 5.15 MHz to a single FDMA/TDMA system and the bottom 11.35 MHz band to multiple CDMA systems. As a result, Constellation's inbound transponder has a bandwidth of 12 MHz so that signals in the non-CDMA portion of the band can be filtered out while providing a flat passband up to the edge of the CDMA segment at 1621.35 MHz.[31]

[31] Use of 12 MHz bandwidth also reduces the amount of feeder link bandwidth required.

The center frequency of the L-band transponder can be switched after launch so that the transponder can be shifted across the 16.5 MHz allocated bandwidth. The normal center frequency is at 1616 MHz, corresponding to the Commission's basic L-band assignment plan. The center frequency can be switched to 1617.2 MHz under the Commission's interim plan, if necessary, to protect Glonass operations below 1610 MHz from out-of-band emissions, or to 1618.9 MHz or 1620.5 MHz to utilize the unencumbered top part of the band in the event no FDMA/TDMA system is implemented.

The satellite power system is sized to provide at end of life the amount of power needed by the satellite to operate at the current S-Band power flux density ("PFD") limit over a 2.56 MHz band. This is to ensure that the Constellation satellite is not subjected to excessive interference from another co-frequency satellite operating at the PFD limit.

For operational flexibility in satisfying time and geographical variations in traffic demand, the bandwidth of the outbound C-to-S Band transponder has been selected at 12 MHz. This allows Constellation to operate on several different frequencies within the transponder to maximize capacity under peak beam traffic conditions.

The center frequency of the S-band transponder can be switched after launch so that the transponder can be shifted across the 16.5 MHz allocated bandwidth. The transponder center frequencies can be moved across the middle 6.5 MHz of the allocated band in four 2.1 MHz steps, corresponding to center frequencies of 2488.5, 2490.6, 2492.7, and 2494.8 MHz.

(6) Orbit Information: The Constellation system consists of 46 operational satellites in 8 orbital planes. Plane 1 is an equatorial ring of satellites in circular orbit with 0°

inclination. Planes 2 through 8 comprise a 7-by-5 satellite Walker constellation[32] with nominal 62° inclination. Table 1 provides the orbital parameters required by §25.114(c)(6)(ii) of the Commission's rules.[33] With respect to §25.144(c)(6)(iii), the feeder link frequencies requested by Constellation are 5050-5250 MHz (Earth-to-space) and 6825-7025 MHz (space-to-Earth).

Parameter	Orbital Plane							
	1	2	3	4	5	6	7	8
Satellites/ Plane	11	5	5	5	5	5	5	5
Apogee (km)	1,965	2,035	2,035	2,035	2,035	2,035	2,035	2,035
Perigee (km)	1,965	2,035	2,035	2,035	2,035	2,035	2,035	2,035
Inclination	0°	62°	62°	62°	62°	62°	62°	62°
Period (minutes)	126.4	128.0	128.0	128.0	128.0	128.0	128.0	128.0
Argument(s) of Perigee (degrees)	0	0	0	0	0	0	0	0
Right Ascension of Ascending Node	40.53	40.53	-10.90	-62.32	-113.75	-165.18	-216.61	-268.04
Active Service Arc	0-360°	0-360°	0-360°	0-360°	0-360°	0-360°	0-360°	0-360°

TABLE 1: ORBITAL PARAMETERS OF THE CONSTELLATION SYSTEM

(7) Antenna Contours: The satellites will have separate L-band and S-band active array antennas, each generating 32 antenna beams. The operational C-band feeder link

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32 I.e., 7 orbital planes with 5 satellites in each plane.

33 With respect to §25.114(c)(6)(iii), the showing mentioned in §§25.203(j) and (k) is not applicable to Earth coverage feeder link antenna beams, such as the ones being proposed by Constellation in the C-band frequencies requested by Constellation. Those provisions are applicable only to steerable, narrow-beam antennas proposed by certain other applicants 20/30 MHz.

satellite antennas will provide Earth coverage. Predicted space station antenna gain contours are presented in the Annex to Exhibit 1 in the format specified by §25.114(c)(7) of the Commission's rules.

(8) Earth Stations: As described in the Application of Constellation,[34] there are two basic types of Earth stations in the Constellation system: gateway Earth stations (or simply gateways) and mobile Earth stations (often referred to as "subscriber units" in this filing) used by the individual customers of the Constellation system.

In Constellation's initial application, Constellation indicated that a technical operational control center ("TOCC"), collocated with the telemetry, tracking and command ("TT&C") Earth station, would play a significant role in the call-by-call operation of the Constellation system. However, under the current Constellation system architecture, these functions have been distributed to other elements of the system.

With the use of CDMA throughout the Constellation system, centralized control of individual call set-up and routing are no longer required. For the most part, call routing and set-up are handled independently by each gateway Earth station, with regional NCCs responsible for adjusting the system resources (i.e., frequencies, codes, power) among gateways as traffic conditions change over time. Except for supporting roamer identification, NCCs are not involved in call-by-call operations. In addition, Constellation does not require a master TT&C Earth station since gateways will be equipped to receive telemetry from the satellite and to transmit telecommands to the

[34] See Application of Constellation at Appendices B and C.

satellite in view under control of the SCC. A digital control network is used to transfer this data between the SCC and gateways.

The gateway Earth stations track the satellites as they pass within view. They provide outbound signaling and control channels in each beam and acquire and process inbound signaling packets. The gateway Earth stations establish and maintain pilot and communications channels, which support beam-to-beam and satellite-to-satellite handovers,[35] correct Doppler and synchronize CDMA codes of the outbound links at the satellite, and provide dynamic tracking and outbound power control (individual link and satellite range compensation). Gateways accept outbound traffic from the PSTN and direct inbound traffic to the PSTN (or another subscriber unit) including all signaling and call supervision functions. They also communicate with the regional NCC to coordinate traffic routing and operations through the digital control network.

Subscriber Earth station units can be implemented with a variety of equipment and installation configurations conforming to the basic Constellation transmission and protocol specifications. In the outbound direction, the subscriber units acquire and track the S-band downlink signal. They demodulate, despread and error correct the digital data stream which is converted to audible speech by the vocoder or is routed to the data/fax peripheral. In the inbound direction, the subscriber unit transmits digitized speech or data/fax information along with control information. This data is error protected, upconverted to L-band and transmitted.

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[35] With multiple gateways capable of accessing the satellite with CDMA techniques, the gateway-to-gateway handovers mentioned in Appendix B, at 10-11, to the Application of Constellation are no longer required.

Constellation will issue basic subscriber unit specifications, and various vendors will be licensed by Constellation to customize and manufacture subscriber units subject to type approval process. Subscriber units will be sold by vendors in conjunction with an NSP, or the NSPs can package subscriber units as part of retail service offerings. The subscriber units are initially commissioned and registered by NSPs in the subscriber's home country and roaming is supported by the Constellation system.

Updated baseline transmission parameters for the gateway Earth stations and subscriber units are presented in Exhibit 2.

(9) Service Description: The basic service to be provided by the Constellation system is cellular-quality voice service, including voice bandwidth data and facsimile.[36] Exhibit 2 provides the technical parameters for these services and Constellation provided an estimate of the demand for its services in its 1991 application.[37] Constellation has been reviewing and updating its service demand estimates. Indeed, several new studies indicate a potential for an even larger market for satellite MSS services than that originally estimated by Constellation.

(10) Stationkeeping: The inclination of the orbital plane will be maintained within 0.02° and the eccentricity within 0.002 over the satellite lifetime. The antenna axis attitude will be maintained within ± 2°. This increase in demand for Constellation's service is reflected in the higher predicted revenues set forth in Exhibit 3.

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[36] Position determination will be provided as described in Appendix B of the Application of Constellation at 7-8.

[37] See Application of Constellation at Appendix D.

(11) Power Flux Density: Exhibit 2 provides PFD calculations for the S-band downlinks. As can be seen, each beam can be operated at a PFD level that does not exceed the value specified in RR 2566, and thus no coordination is required with respect to terrestrial services under Resolution 46.

PFD calculations are also presented in Exhibit 2 for the 6825-7025 MHz band proposed for Constellation's space-to-Earth feeder links. In this case, it is assumed that the PFD limits specified in RR 2566 would be applied to this band if allocated for downlink transmissions from the satellites. The PFD levels are substantially lower than the limits specified in RR 2566.

(12) Launch Arrangements: Constellation will arrange for launching its satellites from commercially available options including Proton, Atlas, Delta and Ariane. Constellation will initially establish its system by launching six satellites at a time into an orbital plane. Replenishment satellites will be launched on smaller vehicles, such as the Taurus, as needed.

(13) TT&C Arrangements: Constellation will install telemetry receivers and telecommand transmitters in most, if not all, gateway Earth stations that will be operated remotely by the Constellation SCC in order to have real-time access to all of the operational Constellation satellites. Specific TT&C transmission parameters are presented in Exhibit 1, Section 4.

(14) Space Station Characteristics: The Constellation satellites have a hexagonally shaped structure with a 70.5" maximum height and 42.4" maximum diameter. The satellite weighs 521.8 kg. Three solar arrays, each 140 square feet in area, provide the 1.8

kilowatts of prime power needed by the satellite at end of life. The satellite is three-axis stabilized. Additional details are provided in Exhibit 1.

(15) Offshore Service: The Constellation satellites are capable of providing continuous service to Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands as required by §25.143(b)(2)(iii) of the rules.

(16) Growth/Replacement Satellites: Constellation is proposing to establish a system of 46 operational satellites and 8 in-orbit spare satellites. Construction, launch and operation of replacement and in-orbit spare satellites are governed by §§25.143(c) and (d) of the rules.

(17) Cost and Revenues: Exhibit 3 provides a revised schedule of estimated costs and revenues[38] for the Constellation system covering the start-up and initial generation of satellites, including a detailed schedule of (a) estimated investment costs and operating costs by year, (b) annual depreciation, (c) maintenance and operating costs, and (d) estimated annual revenues, on a year-by-year basis over the estimated design lifetime of the satellites, as required by §25.144(c)(17). In addition, this schedule includes the detailed schedule of (1) the estimated costs of construction, launch and any other initial expenses, and (2) the estimated operating expenses for one year after launch as required by §25.140(c).

(18) Financial Qualifications: Exhibit 4 provides the documentation needed to demonstrate the financial qualifications of Constellation in the manner specified by the

[38] The schedule in Exhibit 3 conservatively assumes that the Constellation system is funded entirely by equity. The financial results will be significantly improved with the more likely system funding by a mix of debt and equity.

rules adopted in the Commission's Report and Order. A detailed review of Constellation's financial qualification is provided at page 35 infra.

(19) Legal Qualifications: Attached as Exhibit 5 is a current FCC Form 430 (Licensee Qualification Report).

(20) Regulatory Classification: Constellation will not operate its system as a common carrier. Constellation will sell satellite capacity on a wholesale basis to a number of resellers around the world. These resellers will be authorized to sell various Constellation services to end users. Contractual relationships between Constellation and the resellers will be undertaken on an individually negotiated arms-length basis. Since Constellation will not provide service directly to end users and will only sell services on a wholesale basis pursuant to individually negotiated contracts, it will not function as a common carrier.[39]

(21) Milestones: Given the relatively large number of satellites to be constructed (i.e., 54) and launches to be conducted (i.e., 9), it is impractical to provide a precise schedule for commencing and completing the construction, launching and placing into service of each satellite in the Constellation system. Paragraph 189 of the Report and Order provides a more practical means of specifying implementation milestones for a LEO system. Because of the uncertainty over the feeder links to be assigned to the Constellation system,[40] Constellation is basing its proposed milestones from the date of an "unconditional" authorization including definitive feeder link frequency assignments.

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[39] See Report and Order at ¶¶ 171-181.

[40] See Report and Order at ¶ 66.

Accordingly, the following milestones are proposed. For the first two satellites to be launched, Constellation will begin construction within one year of an unconditional authorization and complete construction within four years of that grant. With respect to the other 52 satellites Constellation will begin construction of them within three years of an unconditional authorization. The entire Constellation system will be operational within six years of an unconditional authorization. This milestone schedule for the Constellation system is fully consistent with the requirements specified in the Report and Order.

(22) Public Interest: In the 1991 Application, Constellation made a compelling case for why the public interest would be served by a grant of its application.[41] Constellation showed that its system would provide a cost effective means to determine the technical viability of LEO satellite systems and the scope and breadth of the market for services provided over such systems. It further demonstrated that its system design promotes multiple entry and competition, will enable new and innovative telecommunications services to be provided to the public, that its system would promote U.S. leadership in the development of telecommunications technologies and services, and that grant of its application would be in the national interest. Additional public interest considerations justifying a grant of Constellation's application are presented in Section V below.

IV. Constellation Is Fully Qualified To Receive An Authorization In The 1.6/2.4 GHz MSS Service.

In §25.143(b) of its rules, the Commission sets forth the requirements to be satisfied in order to demonstrate an applicant's technical, legal and financial

[41] See Application of Constellation at 22-29.

qualifications to receive an authorization in the 1.6/2.4 GHz Mobile-Satellite Service. In the following paragraphs, Constellation demonstrates that is has met all of the requirements of subsections (1) through (3) of this rule and is therefore fully qualified to receive a blanket system authorization in the 1.6/2.4 GHz MSS.

General. Subsection (1) requires a detailed system description, setting forth all pertinent technical and operational aspects of the proposed system and the technical, legal and financial qualifications of the applicant. In particular, Constellation has satisfied these requirements by providing in Section III above all of the information as specified in §25.114 of the Commission's rules.

Technical. Constellation will satisfy the technical requirements of §25.143(b)(2). With respect to item (i), the satellite configuration of the Constellation system employs only non-geostationary satellites in circular orbits that provide the same degree of coverage of the northern and southern hemispheres.

With respect to items (ii) and (iii), at least one satellite will be visible above the horizon at an elevation angle of at least 5° for at least 18 hours a day at all locations as far north as 70° latitude and as far south as 55° latitude, and at least one satellite will be visible above the horizon at an elevation angle of at least 5° at all times throughout the fifty states, Puerto Rico and the U.S. Virgin Islands.

For the purposes of showing compliance with these coverage requirements, Constellation performed a computer simulation of its system using a commercially available software package.[42] Visibility statistics were generated at a series of test points for the orbital parameters specified in Table 2, including reference points at 10° increments of latitude between 0° and 90° latitude, and at a set of test points to define the boundaries of the United States. These visibility statistics demonstrate that both the global and United States coverage requirements are satisfied by Constellation's proposed orbital configuration. In particular, Table 2 provides the visibility statistics generated for the United States test points listed in the first column of the table. The second column indicates the length of the simulation run, and the third column indicates the number of minutes that the computer simulation detected at least one satellite visible at the test point with an elevation angle of 5° or more. The fourth column indicates that at least one Constellation satellite is visible with at least a 5° elevation of the time.

Test Point	Simulation Run Minutes	5° Visibility Minutes	% Time Coverage Met
northern tip of Maine (47.5°, 68.33°)	1,440	1,440	100%
northwestern tip of Washington state (48.95°N, 122.92°W)	1,440	1,440	100%
San Diego, California (32.72°N, 117.17°W)	1,440	1,440	100%
Key West, Florida (24.68°N, 81.78°W)	1,440	1,440	100%
Hilo, Hawaii (19.73°N, 155.02°W)	1,440	1,440	100%
Point Barrow, Alaska (71.38°N, 156.48°W)	1,440	1,440	100%
San Juan, Puerto Rico (18.5°N, 66.17°W)	1,440	1,440	100%

TABLE 2: UNITED STATES VISIBILITY STATISTICS

[42] The software package, known as the Satellite Tool Kit, was developed by Analytical Graphics, Inc.

The simulation runs were also conducted for a set of 10 test points at a longitude of 95° West and latitudes between 0° and 90° in 10° increments. The duration of the simulation runs was 1,440 minutes, and in each case and in each case at least one satellite was visible at each test points with an elevation angle of at least 5° for 1,440 minutes (or 100.0 % of the time).

With respect to item (iv), Constellation's system will not cause unacceptable interference to other authorized users of the spectrum and its space stations will comply with the requirements specified in §25.213 of the Commission's rules.

With respect to sharing with radio astronomy, Constellation will protect radio astronomy sites as required by §25.213(a).[43] With respect to spurious emissions in the 4990-5000 MHz band, Constellation will insure that the S-band transmit filter will provide at least sufficient attenuation in order to keep the out-of-band emissions below the level specified in §25.213(a)(3).[44]

With respect to protection of the radionavigation-satellite service in the 1574.397-1576.443 MHz band, Constellation will require that all user terminals that access its system comply with the requirements of §25.213(b) of the rules.

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[43] See Application of Constellation at Appendix B, at 7-8, for a discussion of the position determination capabilities of the Constellation system.

[44] The maximum S-band PFD is -142 dB(W/m ^{2}/4kHz) which corresponds to -178 dB(W/M ^{2}/Hz). To achieve the -241 dB(W/m ^{2}/Hz) PFD level at 4990-5000 MHz specified in §25.213(a)(4), 63 dB of attenuation is required. The S-band output filter will provide 30 dB of attenuation and the $\sin^2 x/x^2$ spectrum rolloff of the 2.56 MHz bandwidth transmissions will provide another 80 dB of attenuation Taken together, these factors are more than sufficient to satisfy this rule requirement.

With respect to §25.213(c) of the rules concerning the protection of the radionavigation-satellite service in the 1610-1626.5 MHz band under RR 732, emissions from the subscriber terminals in the Constellation system will not exceed -15 dBW/4 kHz.[45] Coordination of the Constellation system under Resolution 46 will insure that harmful interference is not caused to any such systems operating in the band.

With respect to §25.213(c) of the rules concerning the fixed service operating in certain countries under RR 730, subscriber units operating in adjacent countries will be coordinated with the countries listed in that footnote pursuant to the international Radio Regulations to insure that harmful interference is not caused to such facilities.

Financial. The financial showing requirements are specified in §25.143(b)(3) of the rules. This section requires Constellation to demonstrate its financial qualifications to hold a 1.6/2.4 GHz MSS license in the form specified in §§25.140(c) and (d). The information required by §25.140(c), i.e., estimated investment and first year operating costs, is provided in Exhibit 3. In summary, the total investment required to construct and launch the entire Constellation system of 46 operational and 8 in-orbit spare satellites is estimated to be $1.695 billion. The cost of operating the system for one year after the launch of the first satellite is estimated to be $26.4 million. Section 25.140(d) requires that the applicant and its corporate parents

[45] The -15 dBW/4kHz EIRP density limit corresponds to +13 dBW EIRP for the 2.56 MHz Constellation signal. With a 3 dBi subscriber unit antenna gain, the maximum permissible power level would be 10 watts. Constellation's subscriber units will operate with only a fraction of this power.

demonstrate current assets and operating income sufficient to satisfy the required investment and first year operating costs. As required by §25.140(d), Exhibit 4 contains current balance sheets of two of Constellation's corporate parents (Bell Atlantic and E-Systems) on which it is relying to demonstrate its financial qualifications,[46] together with letters from corporate officers of each of these companies demonstrating management commitment to financially support the construction, launch and operation of the Constellation system. E-Systems and Bell Atlantic have combined current assets of approximately $4.620 billion and operating income of approximately $3.0 billion totalling more than approximately $7.6 billion, which is more than sufficient to satisfy the Commission's financial qualification requirements. As indicated earlier in this Amendment, the Constellation LEO system is inherently international in scope. The system will reflect ownership from major telecommunication entities outside the United States. Telebrás has indicated its intent to be a major shareholder in the venture. A letter to this effect and its balance sheet are contained in Exhibit 4 and 8, respectively,

V. The Public Interest Would Be Served By A Grant Of Constellation's Application.

Although Constellation demonstrated in 1991 that the public interest would be served by a grant of its application, the public interests are even better served with the amendments proposed in this filing.

[46] Verification of this information is supplied by the auditors of Bell Atlantic and E-Systems to those companies. Annual Reports are contained in Exhibit 6 and 7.

A. Constellation's Amended System Proposal Promotes Multiple Entry And The Development Of A Competitive Market For MSS/RDSS Services.

Until now, the public has had few, if any, choices in the supply of mobile satellite services. Geostationary satellites, whether operated by Inmarsat or to be launched by the American Mobile Satellite Corporation, provide high priced service to large and costly user terminals. While this service might be effective for ocean-going ships, scheduled air lines, and large trucks, LEO MSS technology is needed to bring the costs down to the level where satellite technology is a viable source of basic telecommunications services in rural areas and a viable complement to ground-based mobile radio systems for the general public.

The Constellation system will provide a competitive source of supply of low cost, high quality service to the American public and users throughout the world. Such competition will result in new service offerings as the full capabilities of LEO MSS technology are brought into the market. Moreover, the Constellation system is particularly capable of providing basic, low cost communications services to areas of the world not effectively served by conventional terrestrial communications systems.

Moreover, the Constellation system is compatible with the operation of additional MSS LEO systems in the same band. Unlike geostationary MSS systems, and the proposed FDMA/TDMA LEO system, both of which require exclusive frequency assignments because they can not tolerate co-channel interference, the use of CDMA techniques in the Constellation system allows multiple CDMA systems to be licensed to use the same band.

B. Constellation's Proposed System Will Make Efficient Use Of The Spectrum.

Constellation has modified its satellite design to achieve a high degree of frequency re-use by means of active satellite antenna arrays in the L-Band and S-Bands links to its users. These arrays produce 32 spot beams within the satellite coverage area, and frequencies can be re-used in adjacent beams with the CDMA architecture of the Constellation system. The resulting satellite is capable of providing well over a thousand voice circuits in a bandwidth of 2.56 MHz with conservative link margins. Use of CDMA promotes flexibility in gateway and subscriber access to the Constellation system and improves sharing feasibility with other systems and radio services. By utilizing 12 MHz transponders at L and S-band, Constellation has also designed its satellites to reduce its feeder link requirements to further improve spectrum efficiency.

C. Constellation's Proposed System Will Provide Urgently Needed Services.

A large percentage of the world's population lives in rural areas where it is not economical to construct ground-based telephone lines to provide basic telecommunications services. Constellation's system is designed to address these communications needs at an early date. In particular, Constellation's plan to initially establish an equatorial plane of satellites is focused on providing basic telecommunications in this part of the world.

Even in more developed countries, there is a need for wide area service that extends beyond the limits of terrestrial mobile radio and cellular systems so that subscribers can always be reached no matter where they are at the moment. Such service coverage is not currently available at an affordable price, except for low speed data services. Constellation's LEO MSS system will meet this need with a range of voice, data and facsimile services at a price to the user which is significantly lower than current satellite services.

D. Constellation's System Will Enhance American Competitiveness And Contribute To The Nation's Economy.

LEO MSS systems offer a great opportunity to commercialize technology originally developed for the defense industry. Constellation's technical partners have tremendous experience in all of the various technologies needed to construct and operate a LEO MSS system. The modified satellite design proposed in this amendment reflects these capabilities. Inevitably, LEO MSS systems, as inherently global businesses, will require global participation in their construction and operation. Constellation has been successful in obtaining partners to fund and operate the system. Consequently, Constellation is now fully qualified to receive a license from the Commission and well poised to provide leadership in implementing a global mobile satellite system.

VI. Certification

The undersigned, individually and for the applicant, certifies that the statements made in this application are true, complete and correct to the best of his knowledge and belief, and are made in good faith.

VII. Conclusion

Constellation believes that for all of the above reasons the grant of its application, as amended, will serve the public interest, and requests the Commission to promptly grant this application and authorize Constellation to construct, launch and operate a LEO satellite system in the 1610-1626.5 MHz and 2483.5-2500 MHz bands. Constellation also requests a conditional feeder link authorization in the 5050-5250 MHz (Earth-to-space) and 6825-7025 MHz (space-to-Earth) bands.

Respectfully submitted,

CONSTELLATION COMMUNICATIONS, INC.

Bruce D. Kraselsky

Bruce D. Kraselsky, Chairman and CEO
10530 Rosehaven Street, Suite 410
Fairfax, Virginia 22030
(703) 352-1733

Of Counsel:

Robert A. Mazer, Esq.
Rosenman & Colin
1300 19th Street, N.W., Suite 200
Washington, DC 20036
(202) 463-7177

November 16, 1994

ENGINEERS' CERTIFICATION

We hereby certify that we are the technically qualified persons responsible for preparation of the engineering information contained in this application, that we are familiar with Part 25 of the Commission's rules, that we have either prepared or reviewed the engineering information submitted in this Application, and that it is complete and accurate to the best of our knowledge.

Dated: this 15th day of November, 1994

Malcolm Rucj Uffelman
Vice President, E-Systems, Inc.

Ronald J. Lepkowski
Constellation Communications, Inc.

TABLE OF EXHIBITS

Anti-Drug Abuse Act Certification

The applicant certifies that no party to the application is subject to denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse of Act of 1988 U.S.C. §853A.

Bruce D. Kraselsky
Bruce D. Kraselsky
Chairman and Chief Executive Officer
Constellation Communications, Inc.
10530 Rosehaven Street, Suite 410
Fairfax, Virginia 22030
(703) 357-1733

Exhibit 1

Satellite Description

1.0 General Description

The Constellation satellites are designed to operate at a nominal orbital altitude of 2000 km. Each spacecraft will have a design life of at least 5 years and will have sufficient redundancy and fuel reserves to meet all mission objectives with high reliability. Figure 1 shows the various components of the Constellation spacecraft.

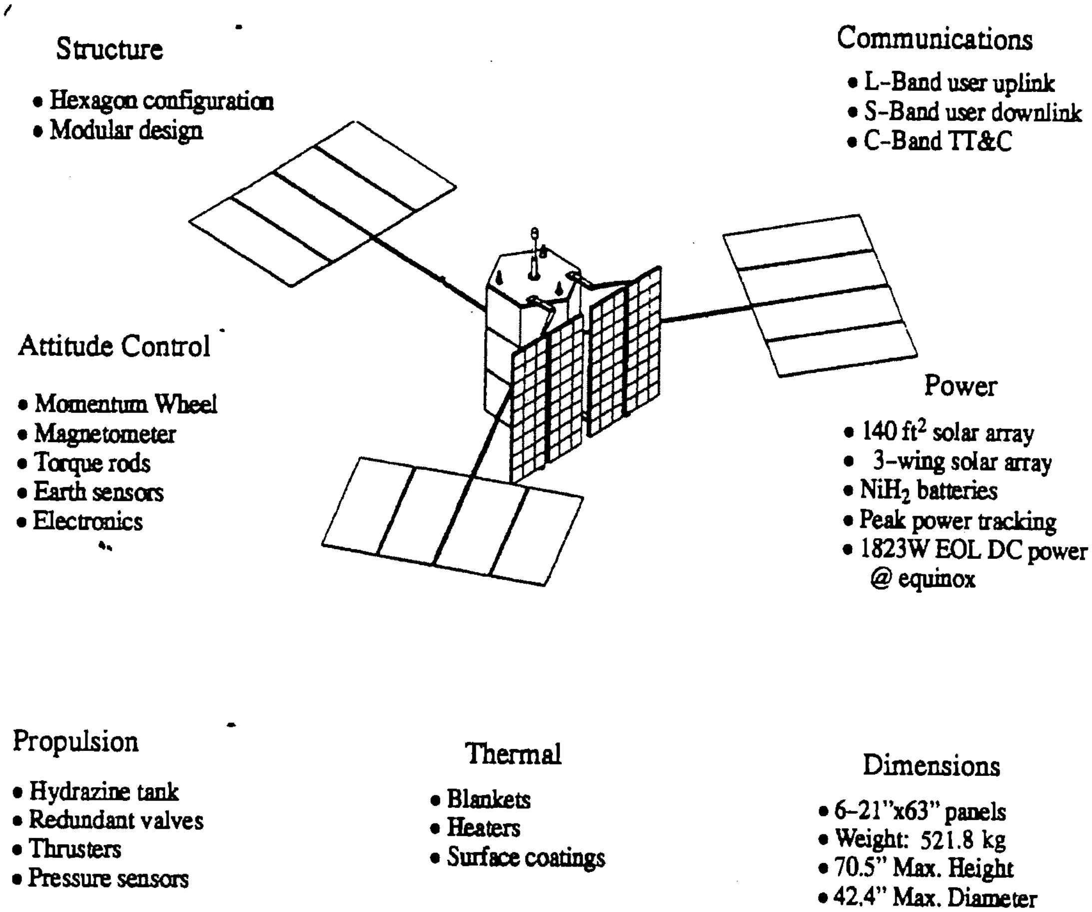


Figure 1 Constellation Satellite Components

The Constellation satellite bus utilizes state-of-the-art proven designs which are heritage to many of Martin Marietta Astro Space satellites. Many bus components have flight heritage either with Astro Space, NASA, or other satellite vendors. The functional block diagram of the Constellation spacecraft is presented in Figure 2.

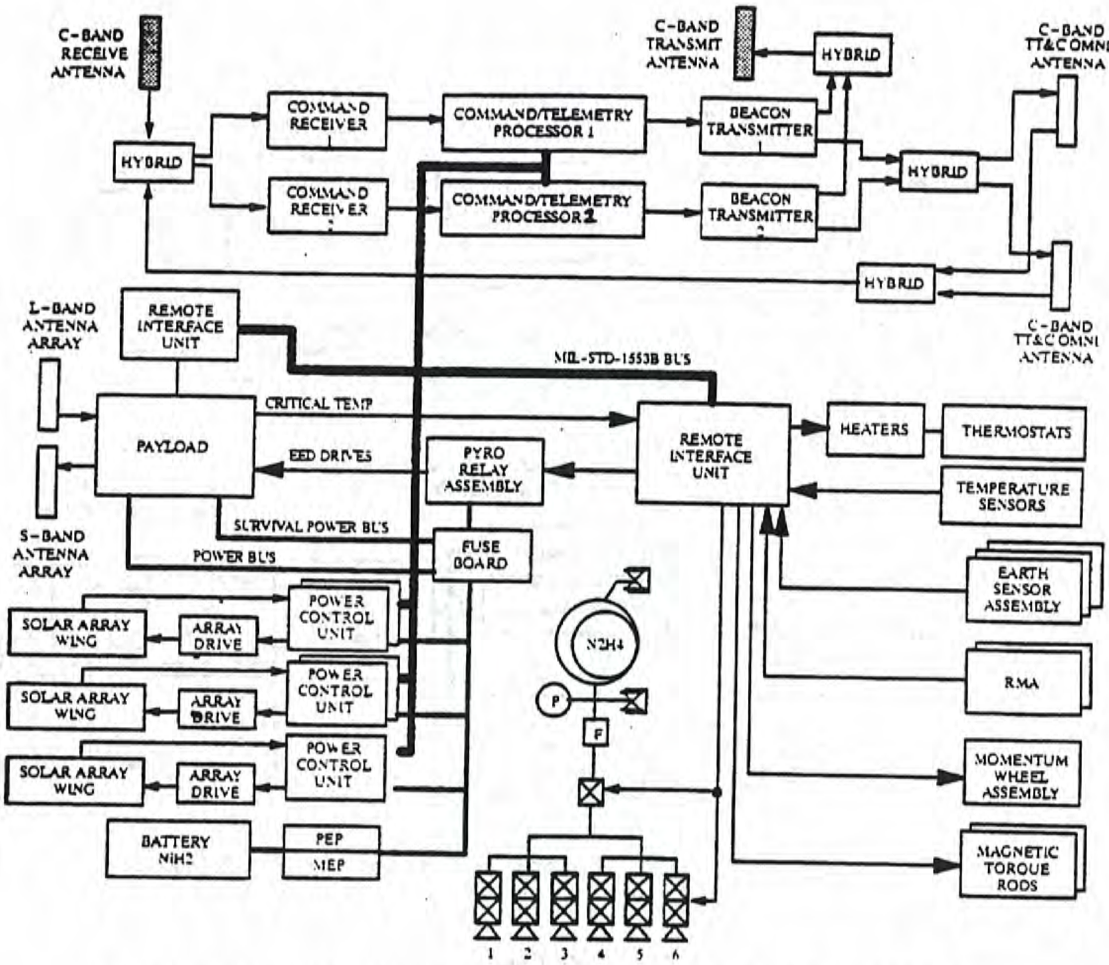


Figure 2 Constellation Satellite Functional Block Diagram

2.0 Communications System

The communications system provides the transponders needed to establish the communications path between Constellation's subscribers and the gateway earth stations. The Constellation satellites provide 32 inbound transponders that provide the path from the subscriber terminals transmitting at L-band to the gateway receiving at C-band (6825-7025 MHz), and 32 outbound transponders that provide the path from the gateway transmitting at C-band (5050-5250 MHz) to the subscriber terminals receiving at S-band. All of these transponders are simple frequency changing transponders.

The antenna system, which is described in more detail in Section 3.0, consists of a active phased arrays generating 32 separate beams in L-band and 32 beams in S-band. The C-band feeder link transmitting and receiving antenna beams are earth coverage. A functional block diagram of the communications system is presented in Figure 3.

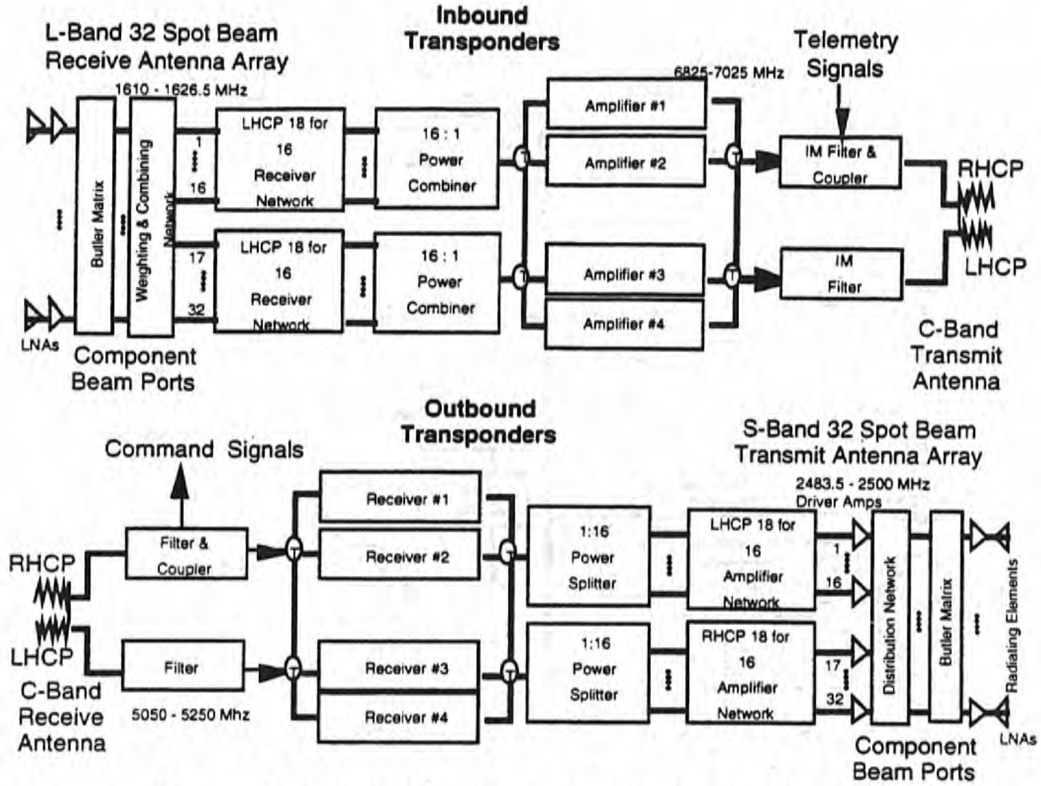


Figure 3 Communications System Block Diagram

Each inbound transponder is associated with one of the 32 L-band receiving antenna beams. Each inbound transponder has a bandwidth of 12 MHz, but the center frequency can be switched to one of four frequencies so that operations can be conducted on any frequency within the 1610-1626.5 MHz band. The feeder link frequency assigned to the transponder is fixed, however, a fixed but separate combination of frequency and polarization is assigned to each L-band beam feederlink. The signals transmitted by the subscriber terminals are received and amplified by the L-band active phased array and processed through the transponder. One group of 16 transponders is combined on a frequency division multiplex basis for transmission by the RHCP downlink C-band final amplifier and the other group of 16 transponders is combined on a frequency division multiplex basis for transmission by the LHCP downlink C-band final amplifier. For reliability, 18 for 16 transponder redundancy is provided. Together with telemetry, the total downlink feeder link spectrum required is 200 MHz.

Each outbound transponder is associated with one of the 32 S-band transmitting antenna beams. Each inbound transponder has a bandwidth of 12 MHz, but the center frequency can be switched to one of four frequencies so that operations can be conducted on any frequency within the 2483.5-2500 MHz band. A separate combination of frequency and polarization is assigned to the C-band feeder link for each of the S-band beams. The RHCP feeder link receiver receives the feeder links associated with one group of 16 transponders that are accessed by gateways using FDMA transmissions, and the LHCP feeder link receiver receives the feeder links associated with the other group of 16 transponders also accessed by gateways using FDMA. The signals are amplified and processed by separate transponders and applied to the S-band active phased array for transmission to the subscriber units at S-band. For reliability, 18 for 16 transponder redundancy is provided. Together with telecommand, the total uplink feeder link spectrum required is 200 MHz.

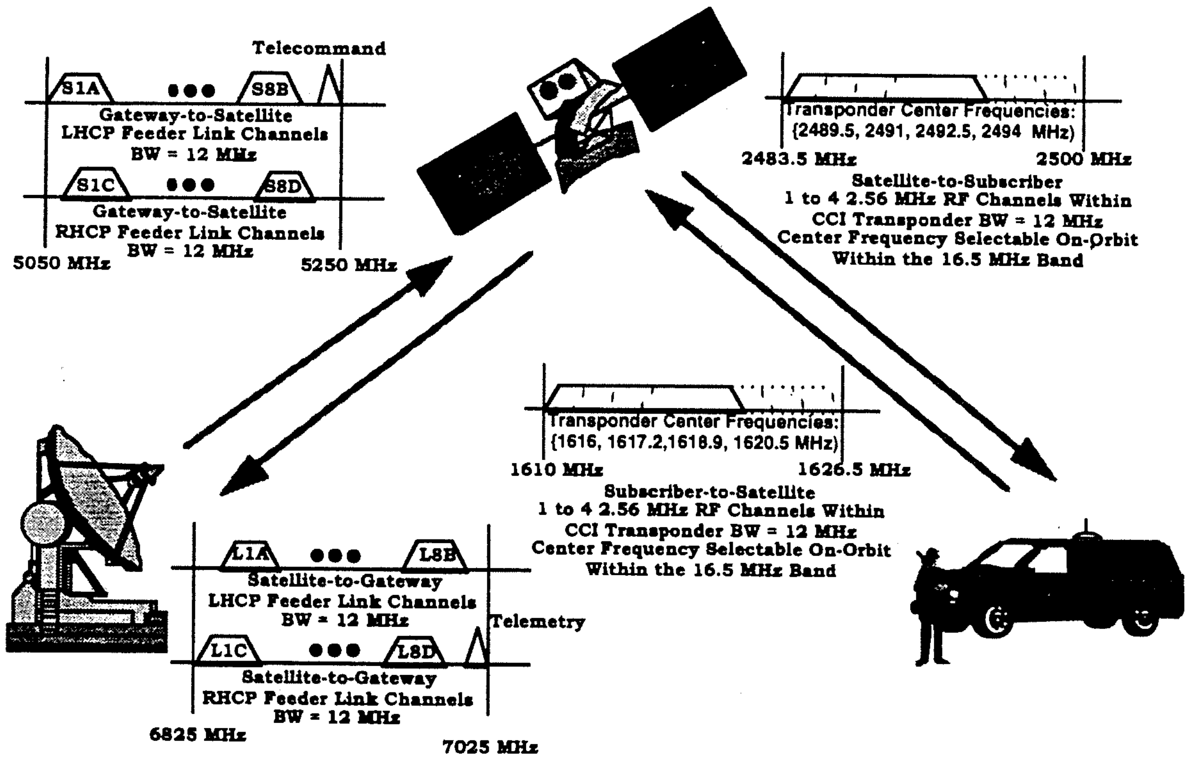


Figure 4 Frequency Plan

The detailed frequency plan for the Constellation satellites is presented in Tables 1-A and 1-B. Transponders are identified by their associated L-band and S-band beams. Table 2 provides a summary of the communications system.

Transponder	Receive Frequency (MHz)	Polarization	Transmit Frequency (MHz)	Polarization	Bandwidth (MHz)
L1A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6837	LHCP	12
L2A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6849	LHCP	12
L3A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6861	LHCP	12
L4A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6873	LHCP	12
L5A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6885	LHCP	12
L6A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6897	LHCP	12
L7A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6909	LHCP	12
L8A	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6921	LHCP	12
L1B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6933	LHCP	12
L2B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6945	LHCP	12
L3B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6957	LHCP	12
L4B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6969	LHCP	12
L5B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6981	LHCP	12
L6B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6993	LHCP	12
L7B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	7005	LHCP	12
L8B	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	7017	LHCP	12
L1C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6831	RHCP	12
L2C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6843	RHCP	12
L3C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6855	RHCP	12
L4C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6867	RHCP	12
L5C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6879	RHCP	12
L6C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6891	RHCP	12
L7C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6903	RHCP	12
L8C	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6915	RHCP	12
L1D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6927	RHCP	12
L2D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6939	RHCP	12
L3D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6951	RHCP	12
L4D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6963	RHCP	12
L5D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6975	RHCP	12
L6D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6987	RHCP	12
L7D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	6999	RHCP	12
L8D	switchable: {1616, 1617.2, 1618.9 or 1620.5}	LHCP	7011	RHCP	12
Telemetry	not applicable	n/a	7024	RHCP	2

Table 1-A. Frequency Plan (Inbound Transponders)

Transponder	Receive Frequency (MHz)	Polarization	Transmit Frequency (MHz)	Polarization	Bandwidth (MHz)
S1A	5056	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S2A	5068	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S3A	5080	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S4A	5092	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S5A	5104	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S6A	5116	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S7A	5128	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S8A	5140	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S1B	5152	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S2B	5164	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S3B	5176	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S4B	5188	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S5B	5200	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S6B	5212	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S7B	5224	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S8B	5236	LHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S1C	5062	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S2C	5074	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S3C	5086	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S4C	5098	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S5C	5110	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S6C	5122	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S7C	5134	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S8C	5146	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S1D	5158	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S2D	5170	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S3D	5182	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S4D	5194	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S5D	5206	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S6D	5218	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S7D	5230	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
S8D	5242	RHCP	switchable: {2489.5, 2491, 2492.5 or 2494}	RHCP	12
Telecommand	5249	LHCP	not applicable	n/a	2

Table 1-B. Frequency Plan (Outbound Transponders)

Because receiving and final transmitting amplifiers are an integral part of the active phased array antennas used for the subscriber links, there are no L-band receiving line losses and no S-band transmitting line losses associated with this portion of the transponders. There is 3.25 dB of loss between the output of the C-band transmitter and the C-band antenna. There is 1.5 dB of loss between the C-band antenna and the C-band receiver. The transponders will be operated in a linear mode of operation in order to support CDMA transmissions, and not in a saturated mode. As a result, the saturation flux density is not applicable. The transponder gain will be adjustable over a range of 16 dB in 1 dB steps. Channel filter characteristics are still under development, but the IF ±1 dB bandwidth will be at least 10.7 MHz, while the RF filters will have a ±1 dB bandwidth of 16.5 MHz.

	Inbound	Outbound
Number of transponders	32	32
Bandwidth	12 MHz	12 MHz
Type	simple frequency changing	simple frequency changing
Receive Frequency Range	1610-1626.5 MHz	5050-5250 MHz
Receiving System Noise Temperate	460 K (nominal)	575 K (nominal)
Maximum Receiving Antenna Gain	14.6 to 20.5 dBi (see Section 3.0)	1 dBi (Earth coverage)
Transmit Frequency Range	6825-7025 MHz	2483.5-2500 MHz
Transmitter Power	(see Section 3.0)	24 watts
Maximum Transmitting Antenna Gain	1 dBi (Earth coverage)	17.2 to 24.4 dBi (see Section 3.0)
Emission designators	2M56G1D 2M56G1E	2M56G1D 2M56G1E
Transponder Gain	90.7 dB (nominal)	96.8 dB (nominal)

Table 2. Communications System Parameters

3.0 Satellite Antennas

The satellite antennas that communicate with the subscriber units are solid state, phased arrays designed to have 32 beams that cover each individual cell with sufficient pattern roll-off to minimize interference with surrounding cells. The phased array antennas provide minimum size, precise pattern control and optimum efficiency . Figure 5 depicts the labeling scheme to be used for the idealized L and S-Band beams (satellite movement is in the direction of the arrow). The beam patterns in Sectors B, C and D are symmetric reflections of the same numbered pattern in Sector A. Table 3 provides the beam parameters. The actual predicted antenna contours are presented in the Annex to this exhibit.

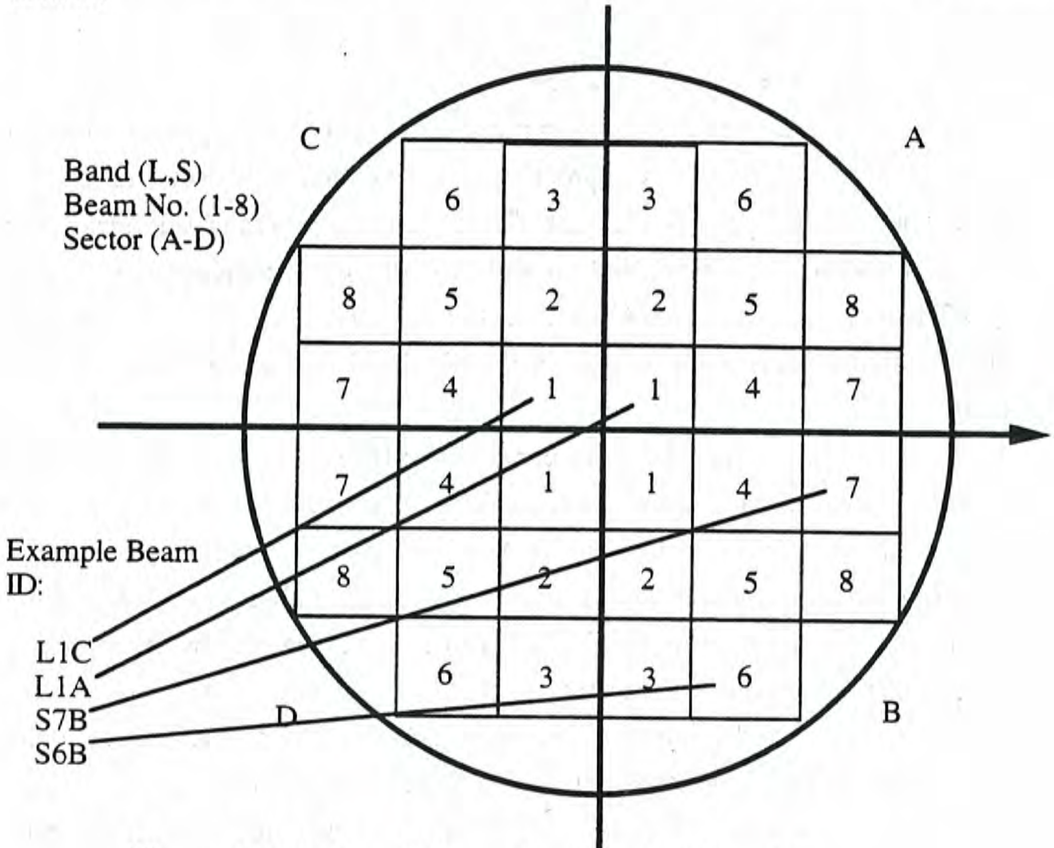


Figure 5 Labeling Scheme for L and S Band Beam Patterns

Beam Number	1	2	3	4	5	6	7	8
Boresight Elevation	67.4	45.7	28.4	43.9	34.3	22.9	26.1	21.7
Boresight Range	2,123	2,589	3,184	2,580	2,917	3,490	3,304	3,563
Peak L-Band Gain	14.6	18.8	17.5	17.5	20.5	18.6	18.2	19.5
Peak L-Band G/T	-12.0	-7.9	-9.1	-9.1	-6.1	-8.1	-8.4	-7.1
Peak S-Band Gain	17.2	19.4	22.8	20.2	21.4	24.4	23.5	23.9

Table 3 Beam Parameters

Separate transmit and receive arrays provide independent optimization of the antenna patterns for each frequency band, increase isolation between transmit and receive channels, and reduce overall weight and prime power requirements. Each array creates 32 fixed beams by combining one or more component beams to create a composite beam that covers a particular cell with uniform gain while providing the needed isolation between cells that reuse identical CDMA codes. One aperture is utilized simultaneously by all 32 beams resulting in minimum antenna size.

The L-band receive antenna consist of an 8x8 array of micro strip patch elements. The patch elements are appropriately fed to obtain LHCP polarization. Each radiating element has its own 45 dB gain, GaAs monolithic microwave integrated circuit (MMIC), low-noise amplifier (LNA) immediately behind it to achieve lowest possible noise figure. The outputs of the 64 LNA's connect to a beam forming circuit consisting of 16 Butler matrices (eight in azimuth, eight in elevation) and a weighting and combining network.

The S-band transmit antenna is a 16x16 array of micro strip patch elements. The patch elements are appropriately fed to obtain right-hand circular polarization. Each radiating element has its own 0.5 Watt, GaAs MMIC, power amplifier immediately behind it to achieve maximum efficiency and minimum loss. The individual amplifiers are fed by a beam forming circuit consisting of 32 Butler matrices (sixteen in azimuth, sixteen in elevation) and a beam distribution network.

The satellite global coverage for C-Band Gateway communication links are obtained by using two Quadrifilar Helix antenna. Separate antennas are used for transmission and reception. The antenna contours for these antenna are shown in the Annex to this exhibit.

4.0 Telemetry, Tracking and Command (TT&C) System

The Constellation TT&C System operates at C-Band. The functional block diagram of the Constellation system TT&C components is shown in Figure 6. TT&C transmission parameters are shown in Table 4.

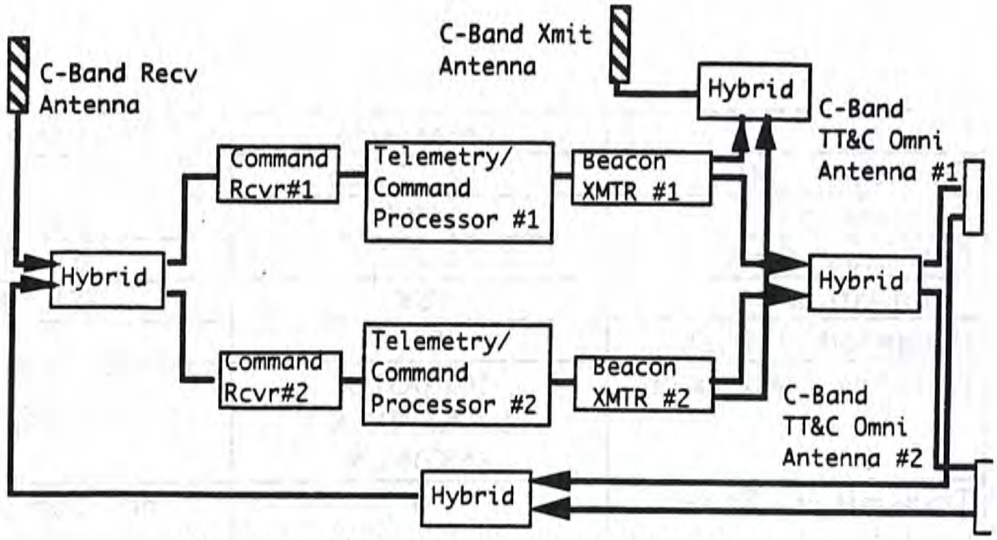


Figure 6 TT&C Component Block Diagram

Command signals are received through either of two omni antennas during transfer orbit and emergencies. During normal mission operations, commands are received through the payload receive antenna. The antenna paths are permanently connected together through RF hybrid couplers. The RF hybrids split the uplink signal to the two receivers. Both receivers are always on and equally accessible. Commands are processed by the command/telemetry processor (CTP) and transmitted to the remote interface units (RIUs) for command decoding and distribution through a Mil-Std 1553B data bus.

The RIUs collect digital and analog telemetry from all parts of the spacecraft. Interfaces between the RIUs and the CTP are provided using the 1553 data bus. The CTP collects the telemetry and forms it into a continuous data stream, which is then applied to one or both beacon transmitters. During normal mission operations, the beacon outputs are radiated to the ground through the payload transmit antenna. During transfer orbit and emergencies, the beacon outputs are applied to the two omni antennas.

The ranging between the ground station and the spacecraft is accomplished by sequential modulation tones on the uplink. The spacecraft command receivers demodulate the tones and remodulate then onto the beacon transmitters. On the ground, the range between the ground station and spacecraft is estimated by measuring the phase shift between the transmitted tone and the received tone.

	Telemetry	Telecommand
Frequency (MHz)	7023-7025	5248-5250
Polarization	LHCP	RHCP
Data Rate (bps)	4096	1025
Modulation	PSK	FSK/FM
Bandwidth (MHz)	0.5	1.5
Emission Designators	10K0G1D 500KF9DXX 25K0N0N	2K50F1D 1M50F9DXX
Transmitter Power (watts)	6	not applicable
Receiving System Temp (K)	not applicable	398
Antenna Gain (dBi)	-1.0	-1.0

Table 4 TT&C Parameters

5.0 Attitude Control System

The spacecraft will be designed to maintain antenna pointing within +/- 0.2 degrees from the nominal pointing direction using the Martin Marietta designed "Stabilite" three-axis attitude control technique. The closed loop system will utilize a momentum wheel that provides gyroscopic stiffness along the pitch (orbit normal) axis while momentum adjustments based on infrared earth sensor inputs maintain pointing about the pitch axis. Continuous control of the spacecraft pitch axis alignment to the orbit normal is accomplished via magnetic torquing in reaction to error signals from the roll sensing circuitry of the earth sensor and control electronics. A block diagram of the attitude control system is shown in Figure 7.

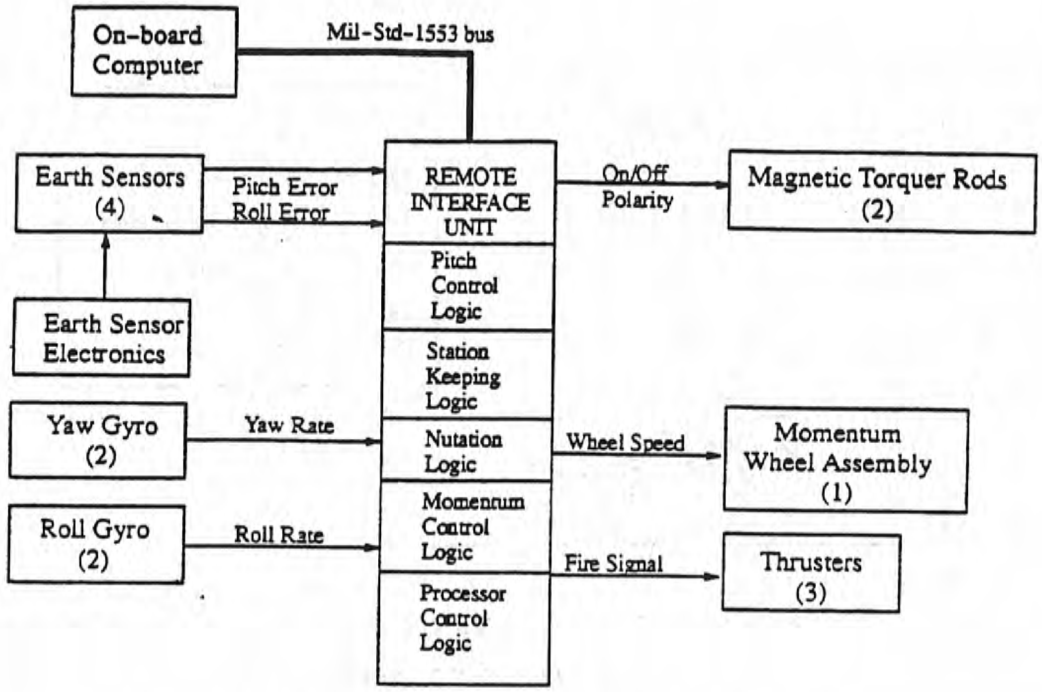


Figure 7 Attitude Control System Block Diagram

The attitude control system will also control the spacecraft during the drift orbit; that is from the launch vehicle separation through acquisition and placement in its operational station. Prior to acquisition while the spacecraft is spinning, nutations will be sensed by gyros and spin stability will be maintained by firing thrusters.

6.0 Reaction Control System

The Constellation spacecraft will perform launch dispersion, orbital trim and orbital phasing maneuvers upon injection. A simple monopropellant Reaction Control System will be provided to perform these maneuvers. As shown in Figure 8, these system will be comprised of a tank with a surface tension propellant management device, an isolation valve, a filter, six Rocket Engine Assemblies (REAs) and two service valves. Upon separation from the launch adapter and deployment device, each spacecraft will be individually commanded to perform orbit acquisition, trim and phasing maneuvers.

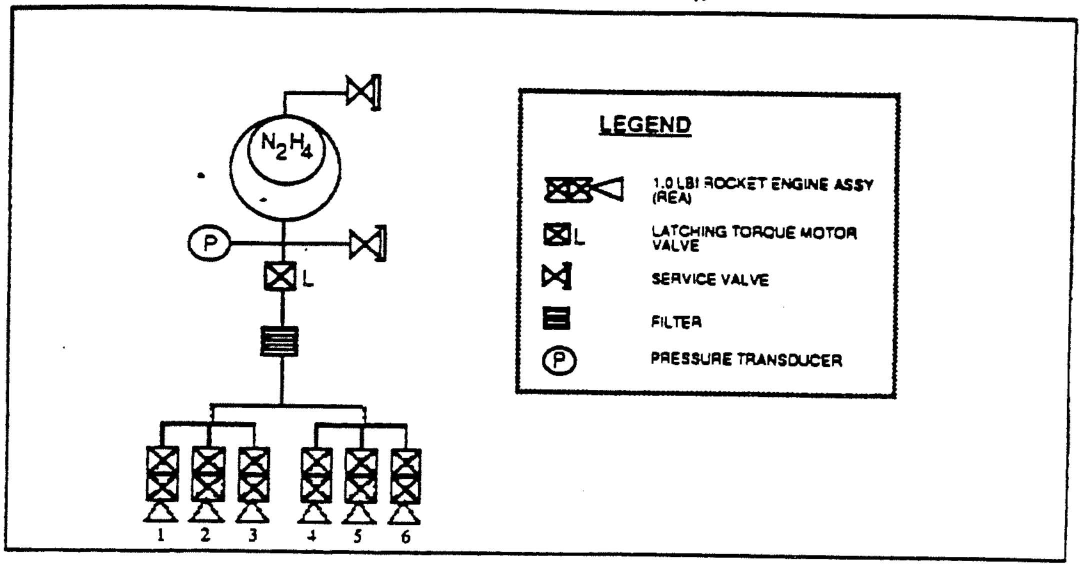


Figure 8 Reaction Control Subsystem Block Diagram

The standard mission profile requires the propellant shown in Table 5. Orbit insertion delta-V assumes the worst case dispersions and all rephasing maneuvers. Inter-orbit phasing of the spacecraft will be maintained within the system designed mean anomaly. In-plane rephasing covers operations after a satellite fails until a replacement is available. The grave yard orbit will be at 2200 km.

Maneuver	kg Hydrazine
Insertion	7
Stationkeeping	12
In-plane rephasing	2
Disposal	19
Margin	4
Total Fuel	44

Table 5 Fuel Budget

Given the initial orbital parameters, the highest expected deviations in each parameter are small. In reference to inertial space, orbit plane, (measured by the Right Ascension of the Ascending Node), will process at -2.2° per day and will not be corrected. The Constellation spacecraft orbit will be maintained to .02° of inclination and .002 eccentricity over the mission life.

7.0 Electrical Power System

The Space Payload Platform (SPP) Electrical Power Subsystem (EPS) provides energy generation, energy storage, power conversion, regulation and distribution. The EPS provides all spacecraft instruments and subsystem housekeeping equipment with +28 Vdc unregulated bus voltage during all phases of the spacecraft mission. During the sunlight period, energy from the solar arrays is transferred to the bus through multiple slip rings in the solar array drive and a power control unit. The power control unit maximizes the energy delivered to the bus by driving the solar arrays to operate at their maximum power point. Energy is then distributed to the housekeeping and payload equipment in addition to the batteries for charging. During the eclipse periods, energy is deliver to the bus via a single battery system connected directly to the main bus. A functional block diagram of the EPS is shown in Figure 9.

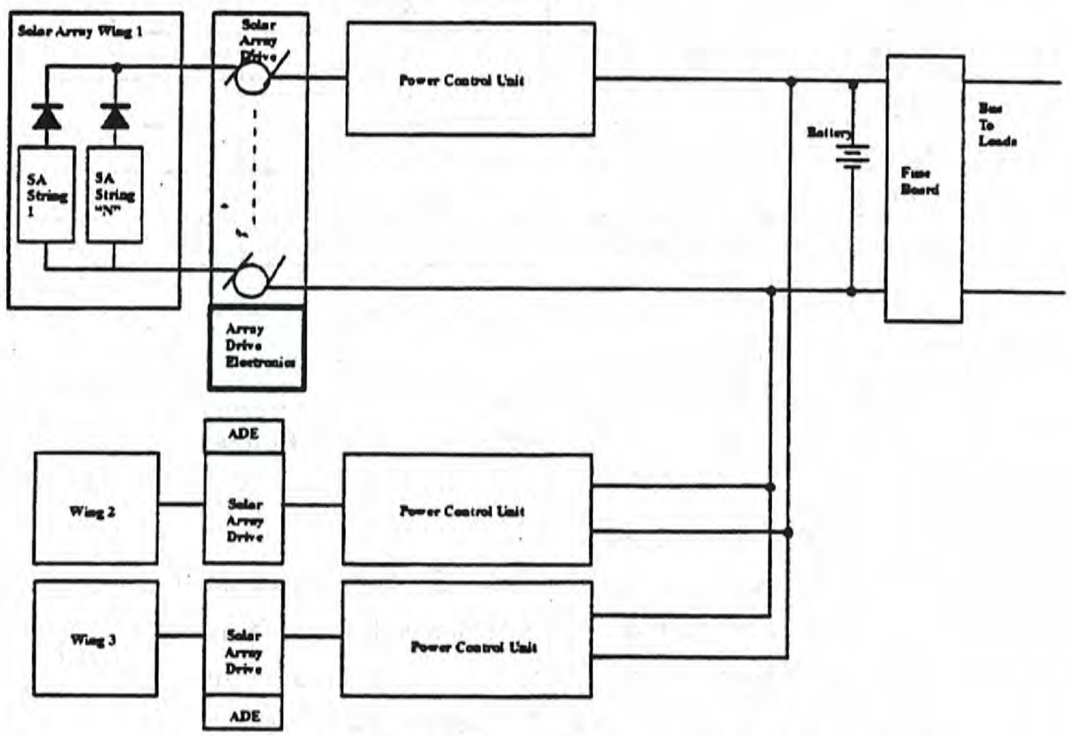


Figure 9 Electrical Power Subsystem Block Diagram

The EPS utilizes three gallium-arsenide solar array wings attached to the spacecraft 120° apart from each other to supply power to the spacecraft bus during sunlight periods while a single nickel hydrogen battery provides the necessary bus power during all ascent, eclipse and peak loading phases. The power control units operate in peak power tracking mode optimizing the power output of the solar array at all times adjusting the operating point of the array to move to the maximum power point. The unregulated bus voltage is controlled by the single NiH_2 battery connected directly to the bus. The single NiH_2 battery is capable of supplying 1065W to the bus during the eclipse period without exceeding the maximum Depth-of-Discharge suggested of 40%. The solar arrays are sized to provide all the necessary payload, housekeeping and battery recharge power required. Table 6 presents the power budget summary.

	Eclipse Power (watts)	Equinox Power (watts)
Payload	800	800
Thermal	67	67
TT&C	59	59
Power	11.7	143
Attitude Control	73.5	73.5
On-board Payload Support	14	14
Harness Loss	39	16
Battery Charge	--------	470
Totals	1064.2	1642.5
Solar Array Capability EOL	--------	1823.4
Margin (watts) EOL	--------	180.9
Margin % EOL	--------	9.9
Solar Array Capability BOL	--------	2201.4

Table 6 Constellation Power Budget

8.0 Satellite Lifetime and Reliability

The operational lifetime of each Constellation satellite is determined by a number of factors, including solar array degradation, battery life, accuracy of initial orbital insertion and station-keeping fuel consumption, and parts and/or subsystem failure. The following design objectives apply to the Constellation satellites:

- Solar array degradation: ≥ 5 years
- Fuel consumption: 7 years
- Random parts failure: ≥ 5 years

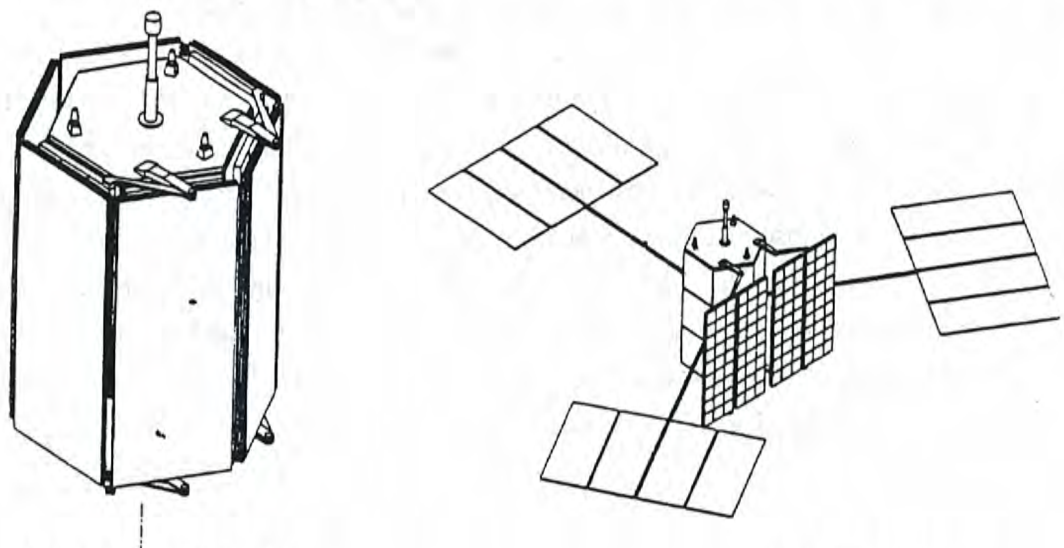
Redundancy will be provided on critical hardware as required by reliability analyses, flight heritage on other satellites, and parts failure predictions based upon the latest vendor and publicly available information.

The Constellation satellites will be designed for a five year median lifetime taking into account all failure modes. Redundant subsystems and station-keeping fuel will be provided to achieve a probability of 90% that the spacecraft will meet all of its design objectives five years after launch.

The Constellation satellites will be designed to tolerate all environmental radiation effects throughout the mission life of the satellites. Sufficiently radiation hardened parts will be selected to ensure full operation throughout the mission life at the 2000km orbit altitude.

9.0 Satellite Physical Characteristics

The Constellation spacecraft structure is of modular design with a hexagonal cross section as shown in Figure 10.



Launch Configuration Fully Deployed

Figure 10 Constellation Spacecraft

During launch, the solar arrays and L and S band antenna arrays are folded around the hexagonal bus. These arrays are unfurled when fully deployed on orbit. The height and cross section can vary with little design and tooling costs if required to meet mission and launch vehicle needs. The structure provides the physical interface with the launch vehicle and the payload. This module is a hexagon structure that provides the mounting area for the satellite housekeeping, power, TT&C, propulsion, attitude control equipment and payload equipment. It is currently planned that all panels will be composed of a bonded sandwich utilizing 2024-T81-aluminum alloy skins, 5056 aluminum alloy honeycomb and Cytech FM73 adhesive. All honeycomb is perforated to allow air to escape during launch ascent.

The center of the bus module consists of six (6) panels arranged in a hexagon along with six (6) radial bulkhead panels. The panels are bonded together into a single assembly using 6061-T6 aluminum brackets. The radial bulkheads transmit loads from the outer equipment panels to the center hexagon through shear. The six (6) equipment panels form the outer hexagon when attached to the bus module using post bonded fittings. The removable equipment panels are where most of the bus and payload equipment will be installed.

The base panel attaches to the center hex panels using bond-on 6061-T6 brackets. Equipment panels and the adapter ring attach to the base panel using post bonded machined fittings. Some equipment may be installed on the base panel. The adapter ring transfers the satellite loading to the launch vehicle. It is a separate assembly composed of a machined 7075-T73 aluminum alloy forging. The adapter ring can be easily modified to suit launch vehicle constraints with minimum impact to the satellite.

The structure has been designed for ease of manufacturability and for maximum producibility. All material is easily obtainable and well understood. Part lists have been reduced and standardized. Liberal tolerances, high strength margins, a modular construction and "assembly fasteners" keeps tooling/tooling changes simple and to a minimum. All inserts are post bonded and can be located to any design with little impact to the spacecraft schedule. Inspection criteria are simple and easy to document. The ease and flexible manufacturing allows for very quick build cycles for the bus module. Additionally, materials can be prestocked and production flows set up for large orders to even further reduce cycle time. Table 7 is the mass property summary for the Constellation satellite system.

Subsystem	Mass (kg)
Payload	206.4
Mechanical	76.9
Thermal	4.6
Power	117.9
Attitude Control	20
Reaction Control	7.9
TT&C	28
On Board Payload Support	3.8
Harness	12.3
Fuel	44
Total	521.8

Table 7 Mass summary for the Constellation satellite system.

10.0 Thermal Control

The Thermal Control Subsystem (TCS) consists of all the spacecraft elements associated with maintaining the equipment and structures within a predetermined range of temperatures. All critical TCS components are redundant. Many non-critical components, such as numerous temperature sensors, are functionally redundant. This makes the thermal design immune to any single-point failures. The highly dissipative and/or tightly controlled equipment are mounted to the north and south spacecraft radiators. The other surfaces, which can experience direct solar input during a regular period in each orbit, are mostly blanketed.

The thermal design provides temperature margins from pre-launch to EOL for all units and subsystems above and below the respective minimum and maximum component qualification temperatures, under the worst-case combinations of external environmental fluxes, thermo-optical properties, unit power dissipation seasonal conditions, and diurnal effects. This margin is maintained over the mission life of the spacecraft at each end of the temperature range under all conditions, environments, and degradation experienced by the spacecraft, including fully operating, partially operating, and non-operating payload modes. All temperature predictions include uncertainty added to the minimum and maximum raw computer temperature predictions, except for heater controlled equipment. Heater controlled equipment maintains the margin by sizing the heaters to provide more power than required at worst case conditions.

Multiple layers of plastic film with separators between each layer are used. All blanket layers are grounded to the satellite structure. Each radiator surface is constructed from individual Optical Solar Reflector (OSR) tiles bonded to the external panel skin. OSRs are used to provide favorable radiator surface properties, which are low solar absorptivity, and high emissivity. If required, heat pipes will be used to spread heat on the radiator panels for more efficient heat rejection. Heat transport capability margin is provided to ensure acceptable operation. This design margin also ensures that performance of the heat pipe network will not be compromised in the event of a single-pipe failure. In the unlikely event of a heat pipe failure, the components mounted on the failed pipe will not exceed their qualification temperature limits.

Each of the payload units and assemblies is designed to withstand the specified temperature limits and environments. Detailed thermal analysis is performed at the unit and/or subassembly level to ensure that all unit and subassembly components and materials can successfully perform under all simulated worst-case environments. For mission specific equipment, qualification-level testing will be performed. Design and analysis verification is accomplished by environmental thermal vacuum testing.

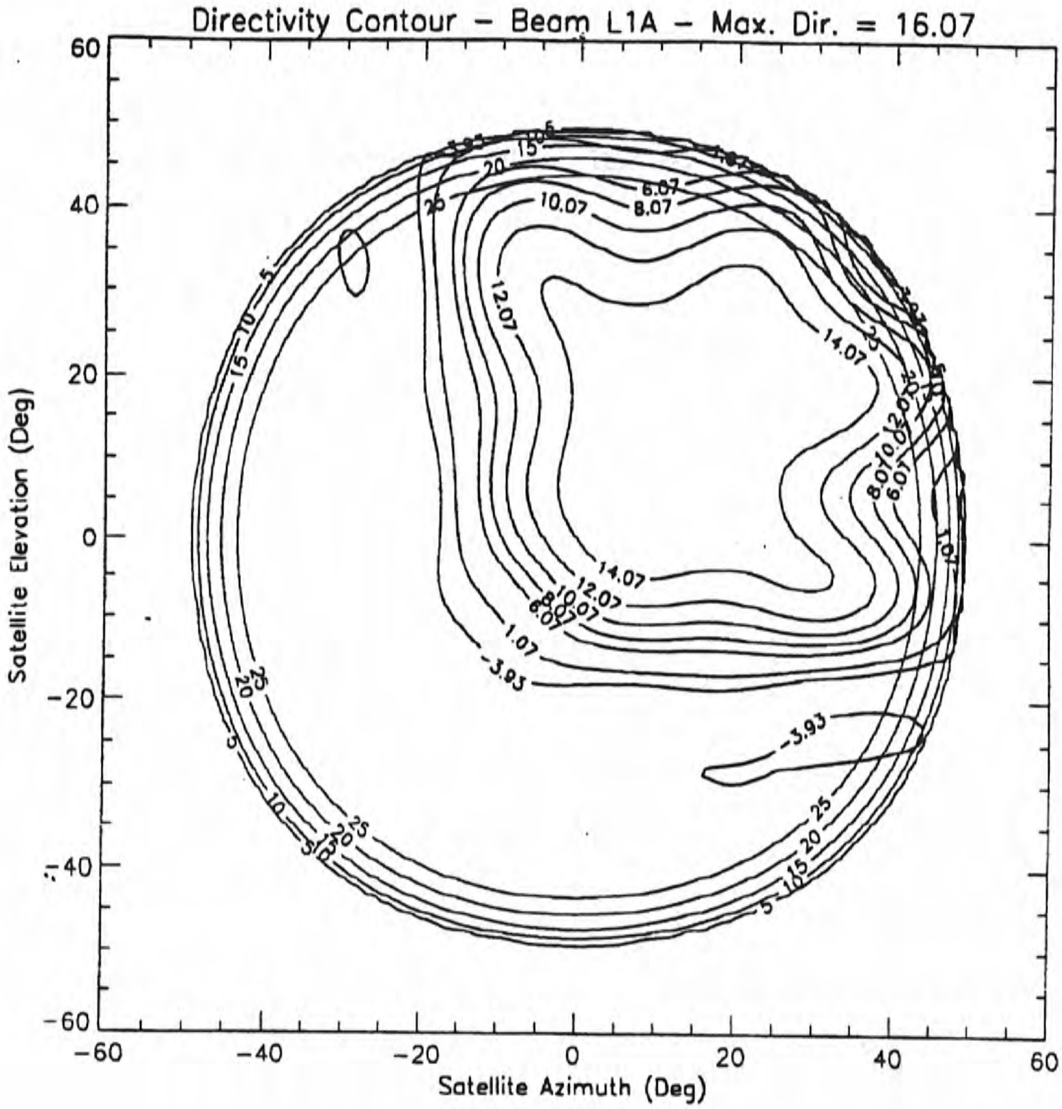
The proper functioning of the thermal design will be proven in the course of a thorough verification program. This program will include spacecraft, subsystem, and unit level thermal modeling in addition to a rigorous comprehensive test program. A major component of the spacecraft-level testing is the thermal balance test performed during proto-flight system-level thermal vacuum testing. This thermal balance testing provides the data required to correlate the detailed thermal math model. The correlated thermal math model will then be used to predict final, refined on-orbit temperatures.

11.0 Launch Vehicle Options

The Constellation satellites are being designed to permit the launch of six satellites at a time when initially establishing a plane of satellites. This configuration is planned to be compatible with Proton, Ariane 44L, Atlas II AS and the Delta II Launch vehicles. The satellite will also be compatible with the OSC Taurus LV for replenishment options.

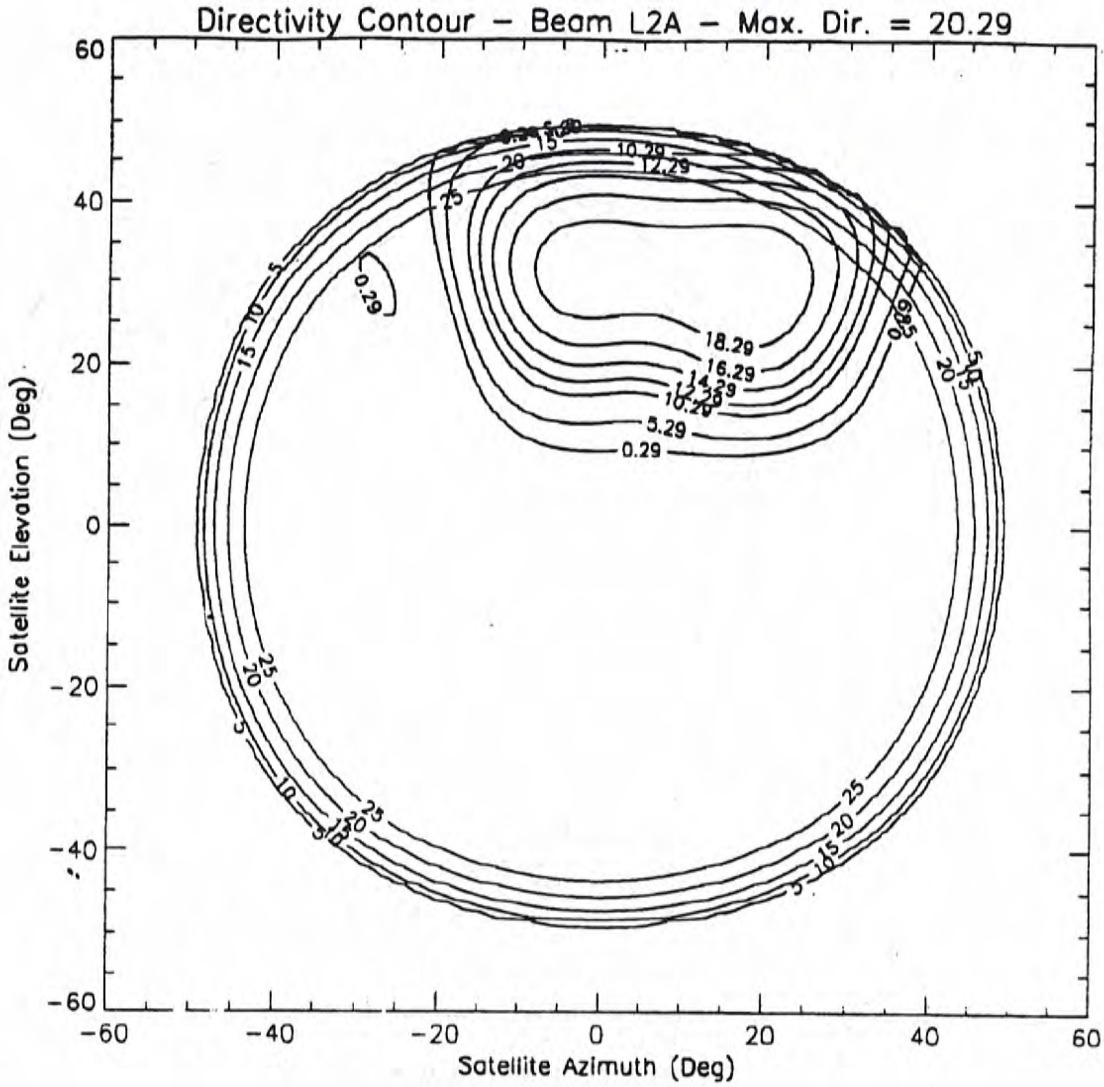
ANNEX

SATELLITE ANTENNA CONTOURS



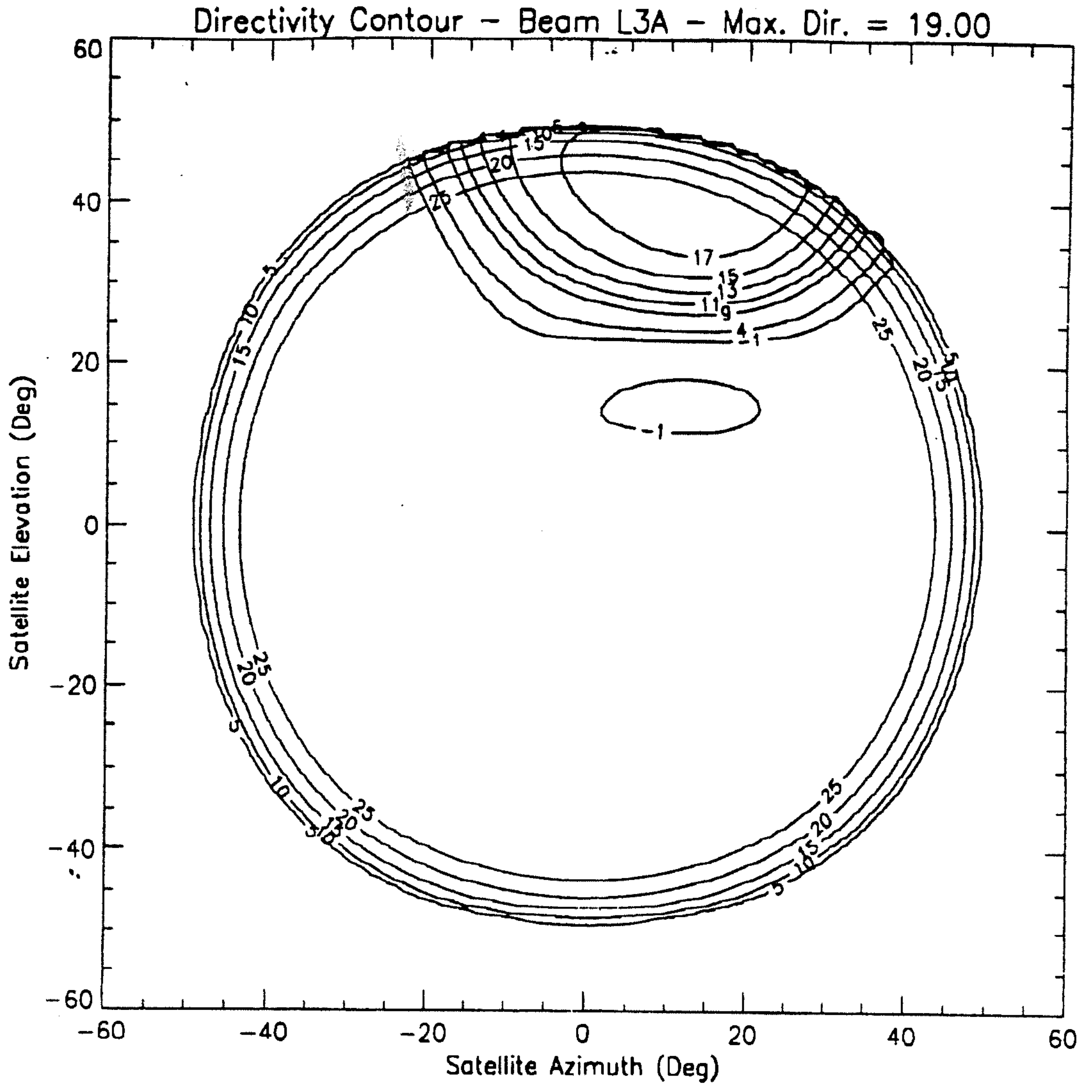
Contour	Directivity	Gain
Peak	16.07	14.57
- 2	14.07	12.57
- 4	12.07	10.57
- 6	10.07	8.57
- 8	8.07	6.57
-10	6.07	4.57
-15	1.07	-0.43
-20	-3.93	-5.43

Figure A.1: Directivity Contours for Beam L1A



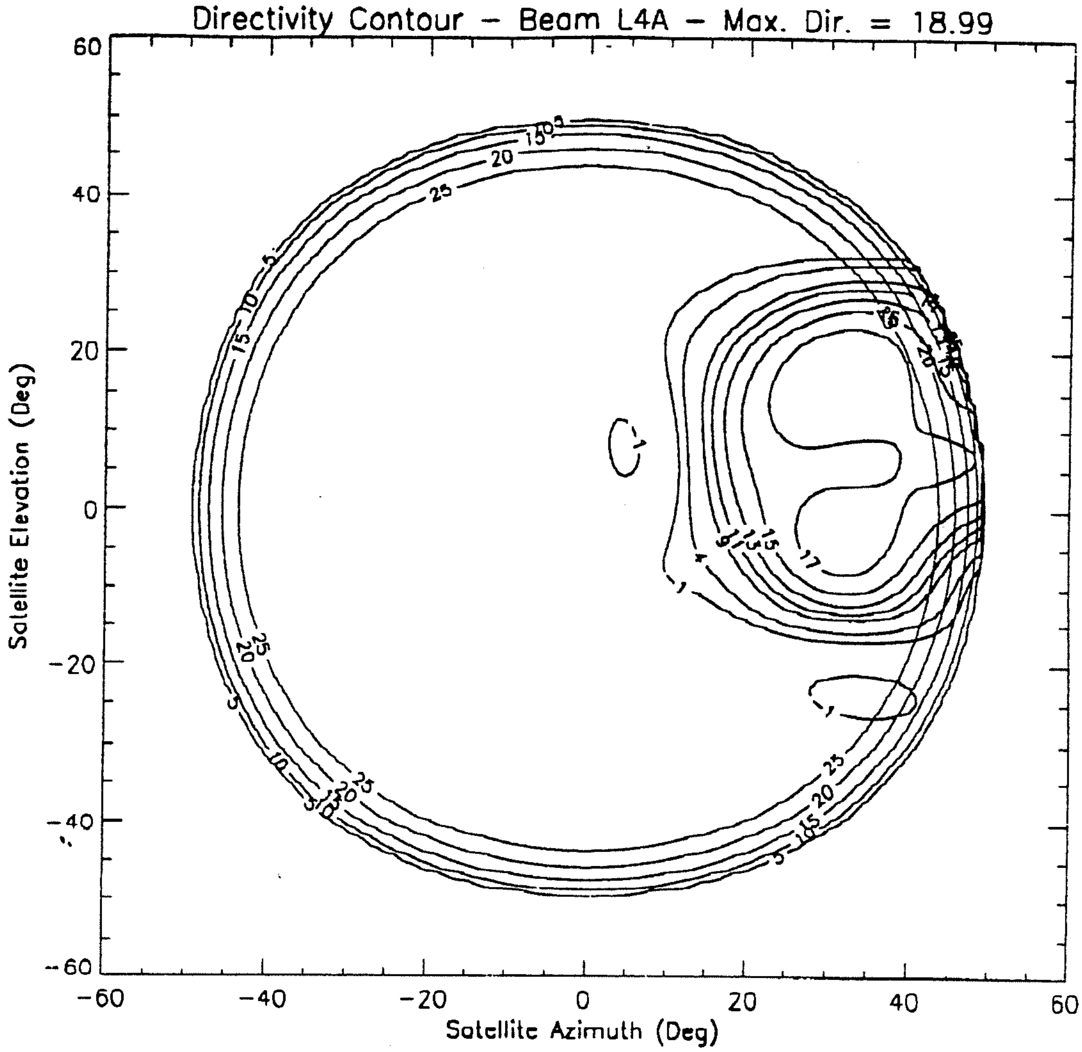
Contour	Directivity	Gain
Peak	20.29	18.79
- 2	18.29	16.79
- 4	16.29	14.79
- 6	14.29	12.79
- 8	12.29	10.79
- 10	10.29	8.79
- 15	5.29	3.79
- 20	0.29	-1.21

Figure A.2: Directivity Contours for Beam L2A



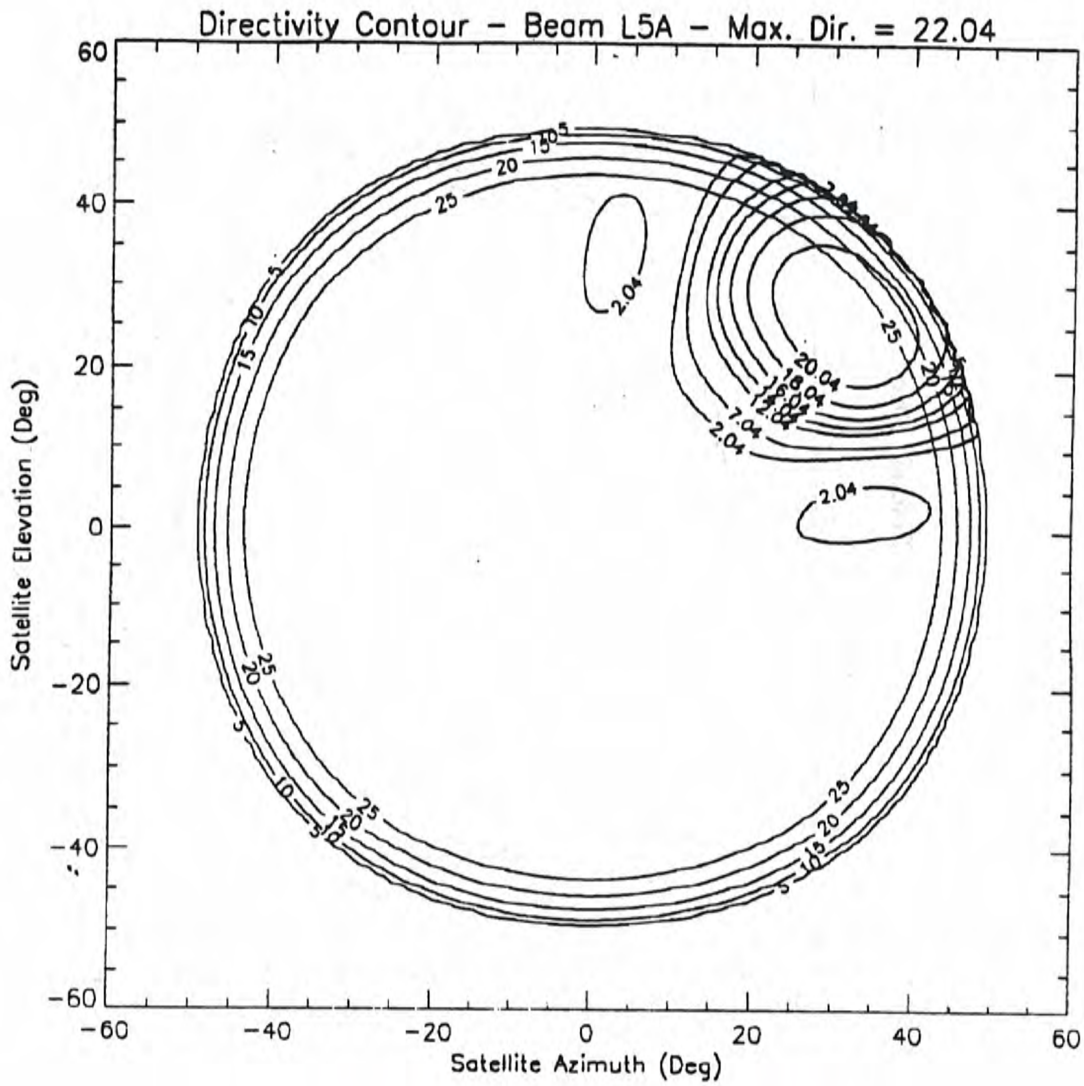
Contour	Directivity	Gain
Peak	19.00	17.50
- 2	17.00	15.50
- 4	15.00	13.50
- 6	13.00	11.50
- 8	11.00	9.50
-10	9.00	7.50
-15	4.00	2.50
-20	-1.00	-2.50

Figure A.3: Directivity Contours for Beam L3A



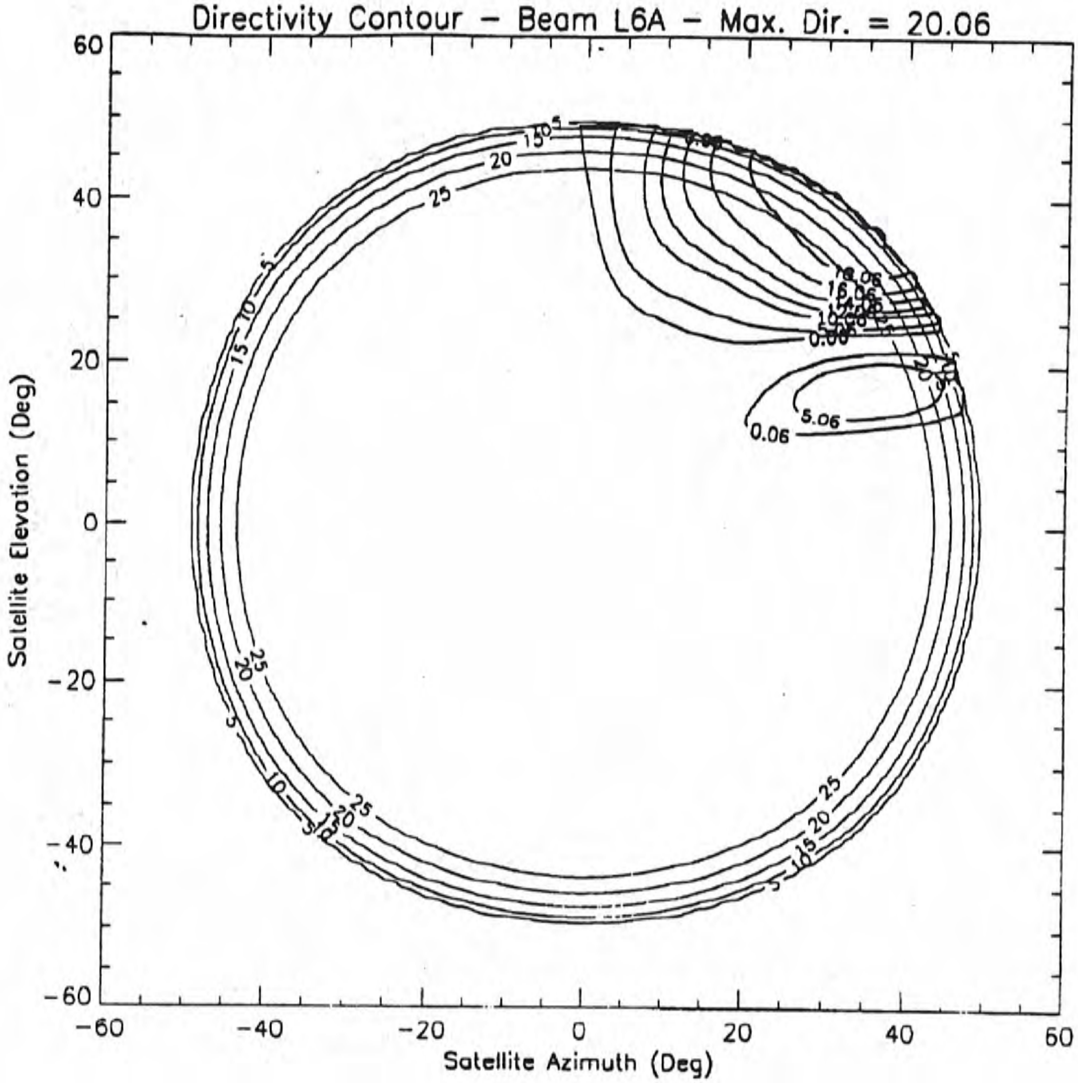
Contour	Directivity	Gain
Peak	18.99	17.49
- 2	16.99	15.49
- 4	14.99	13.49
- 6	12.99	11.49
- 8	10.99	9.49
-10	8.99	7.49
-15	3.99	2.49
-20	-0.99	-2.49

Figure A.4: Directivity Contours for Beam L4A



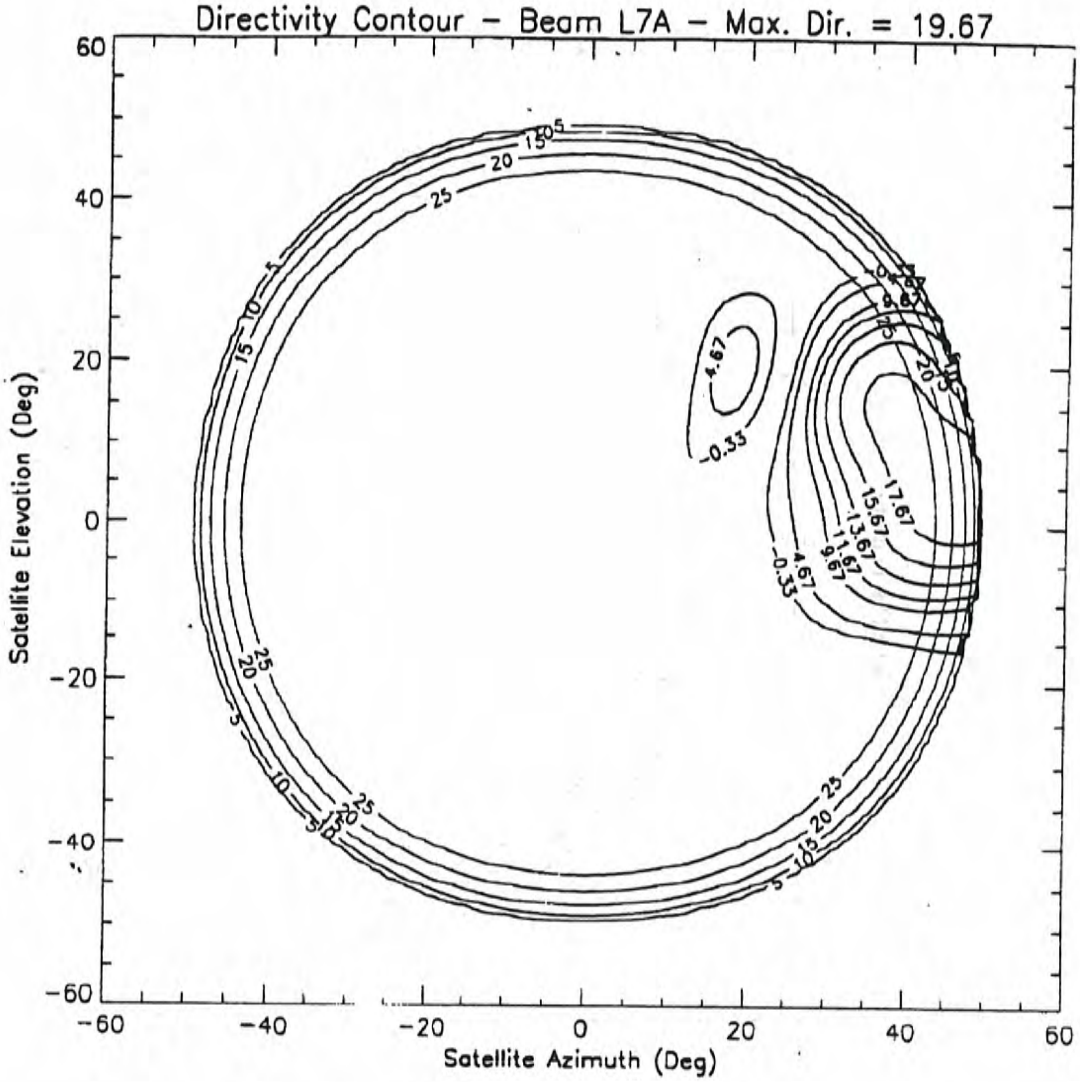
Contour	Directivity	Gain
Peak	22.04	20.54
- 2	20.04	18.54
- 4	18.04	16.54
- 6	16.04	14.54
- 8	14.04	12.54
- 10	12.04	10.54
- 15	7.04	5.54
- 20	2.04	0.54

Figure A.5: Directivity Contours for Beam L5A



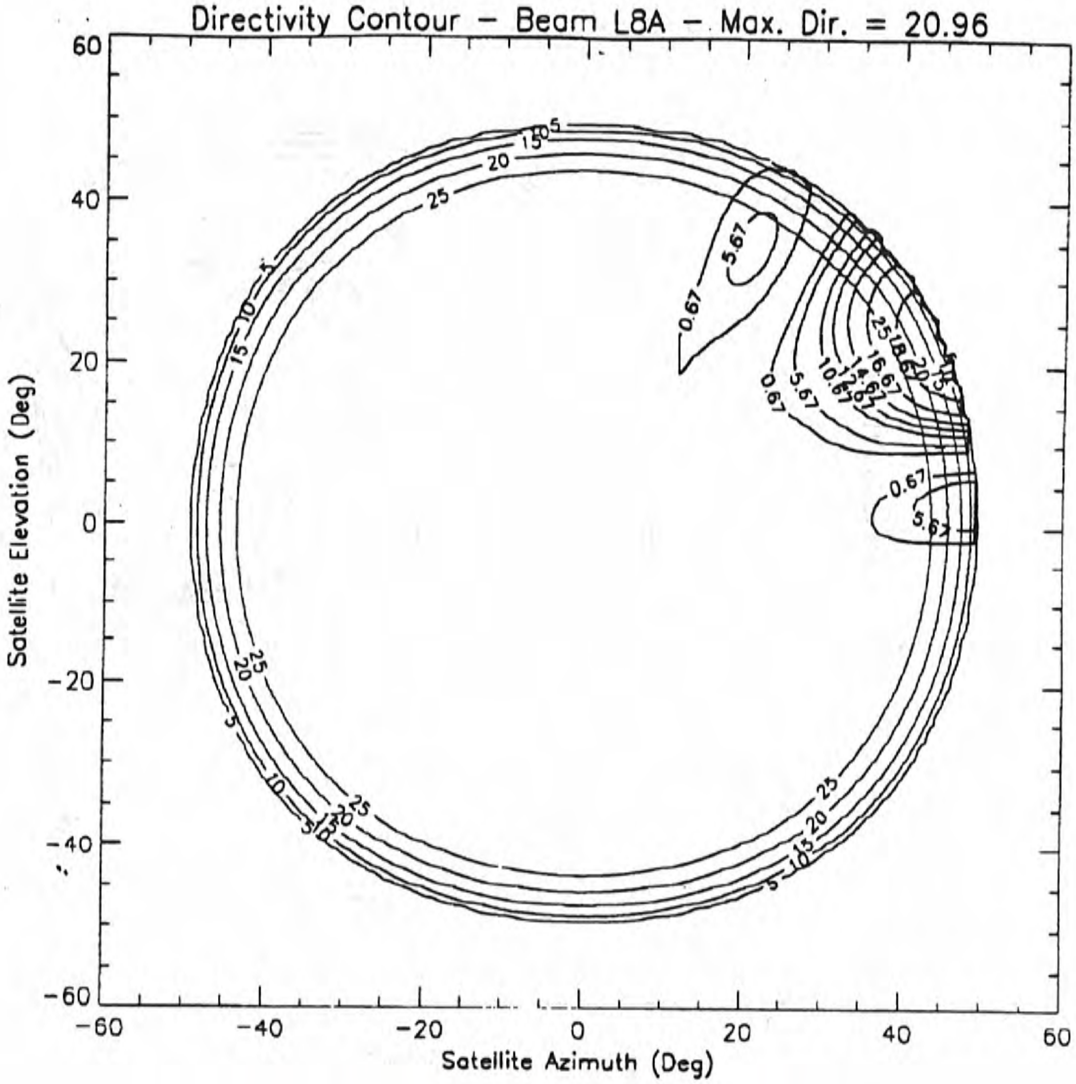
Contour	Directivity	Gain
Peak	20.06	18.56
- 2	18.06	16.56
- 4	16.06	14.56
- 6	14.06	12.56
- 8	12.06	10.56
- 1 0	10.06	8.56
- 1 5	5.06	3.56
- 2 0	0.06	-1.44

Figure A.6: Directivity Contours for Beam L6A



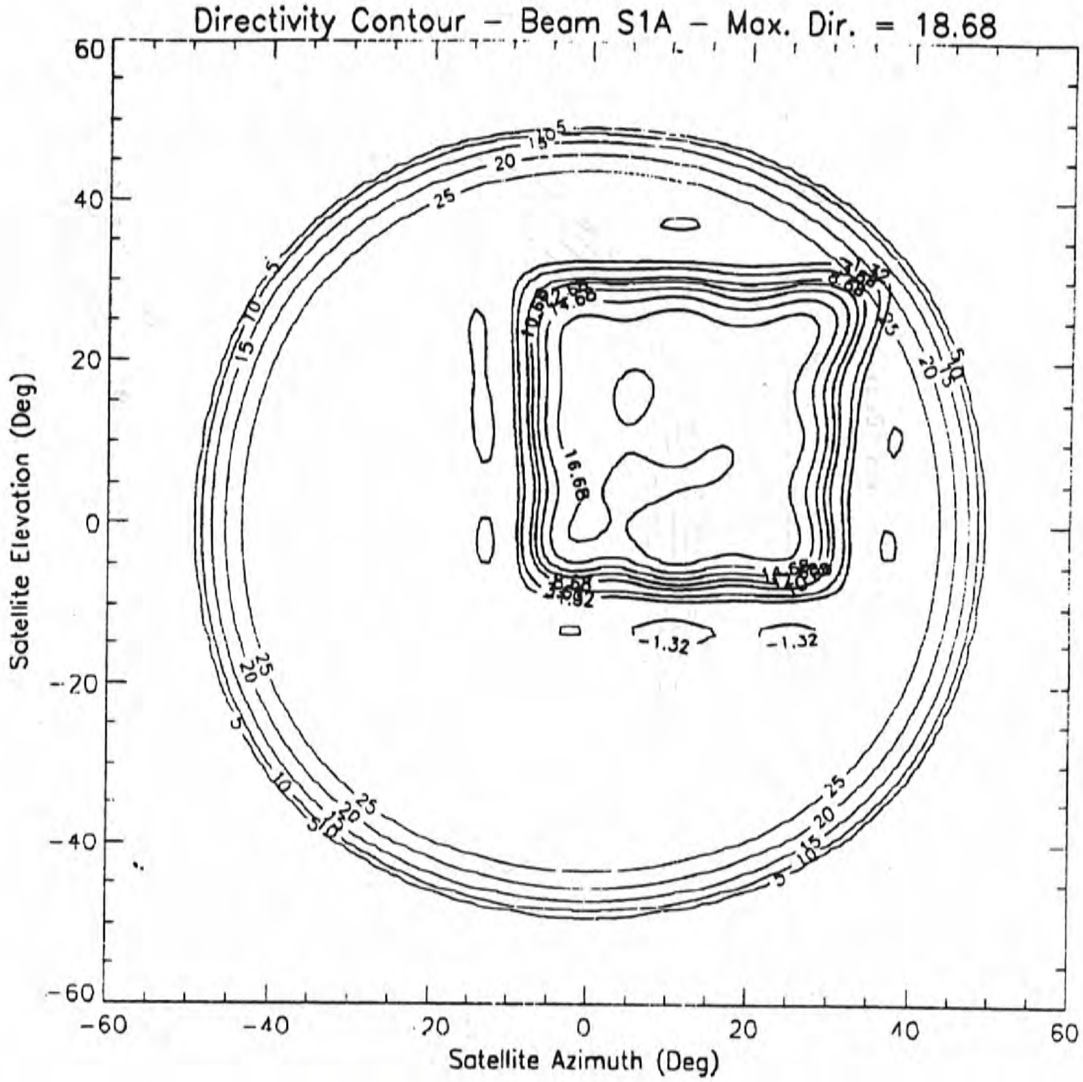
Contour	Directivity	Gain
Peak	19.67	18.17
- 2	17.67	16.17
- 4	15.67	14.17
- 6	13.67	12.17
- 8	11.67	10.17
-10	9.67	8.17
-15	4.67	3.17
-20	-0.33	-1.83

Figure A.7: Directivity Contours for Beam L7A



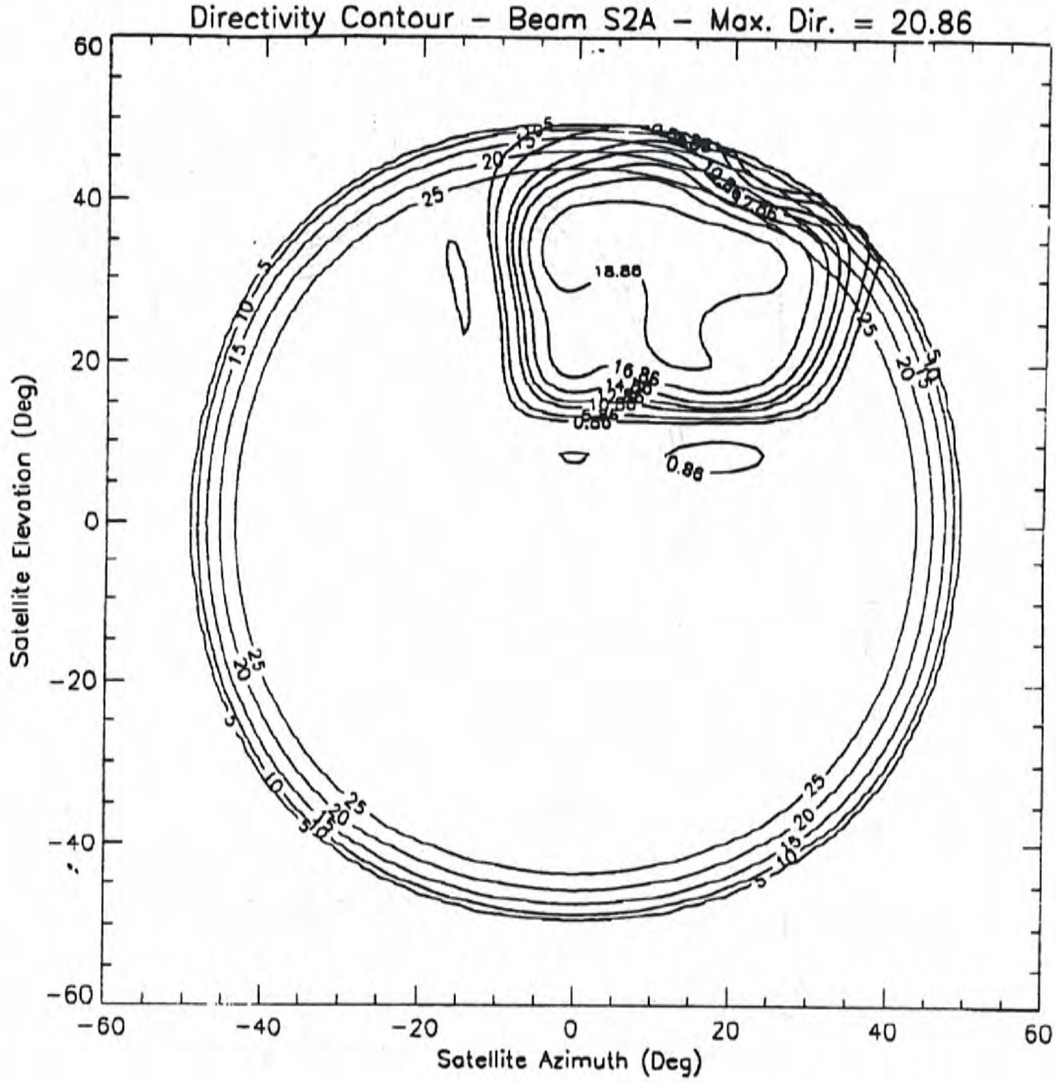
Contour	Directivity	Gain
Peak	20.96	19.46
- 2	18.67	17.17
- 4	16.67	15.17
- 6	14.67	13.17
- 8	12.67	11.17
-10	10.67	9.17
-15	5.67	4.17
-20	0.67	-0.83

Figure A.8: Directivity Contours for Beam L8A



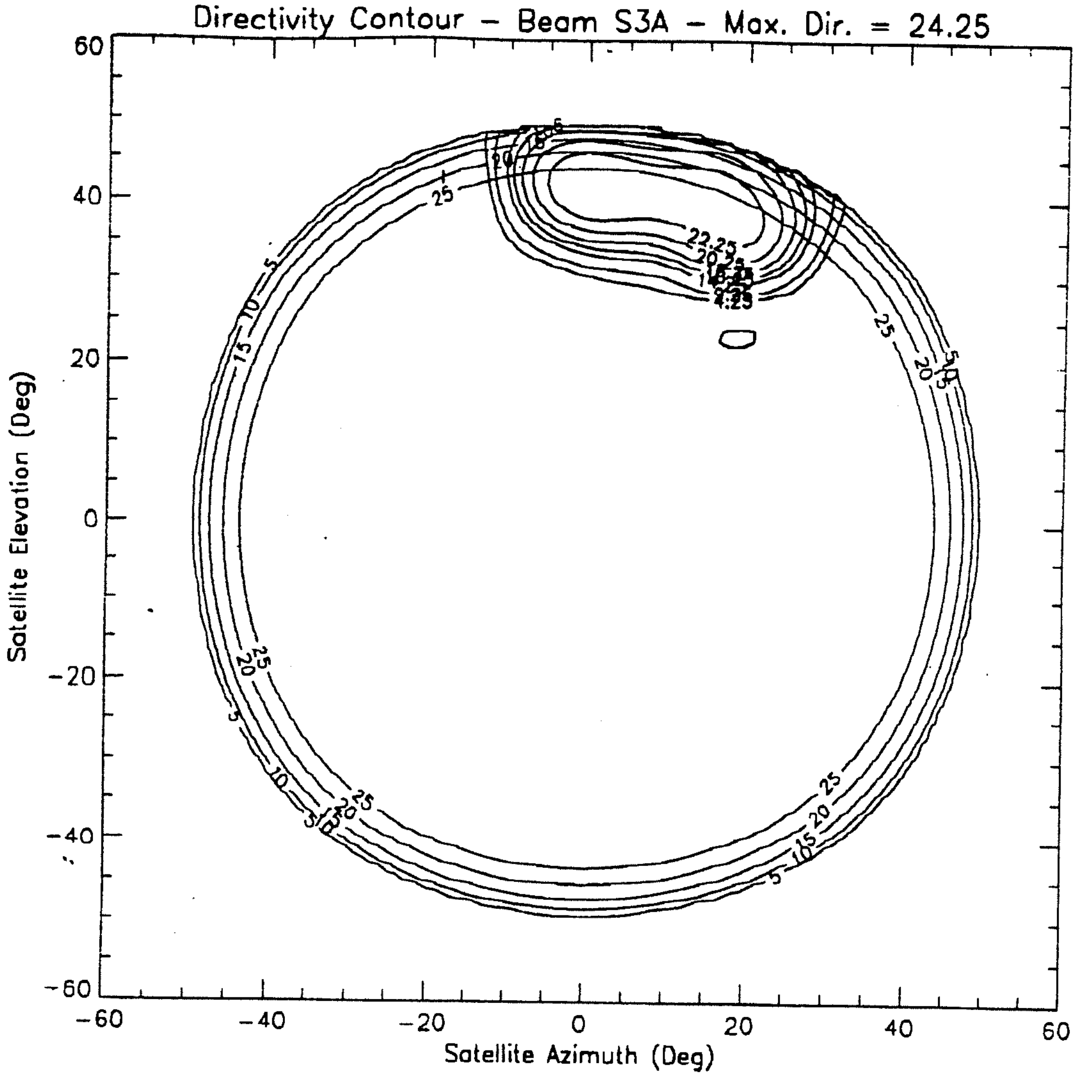
Contour	Directivity	Gain
Peak	18.68	17.18
- 2	16.68	15.18
- 4	14.68	13.18
- 6	12.68	11.18
- 8	10.68	9.18
-10	8.68	7.18
-15	3.68	2.18
-20	-1.32	-2.82

Figure A.9: Directivity Contours for Beam S1A



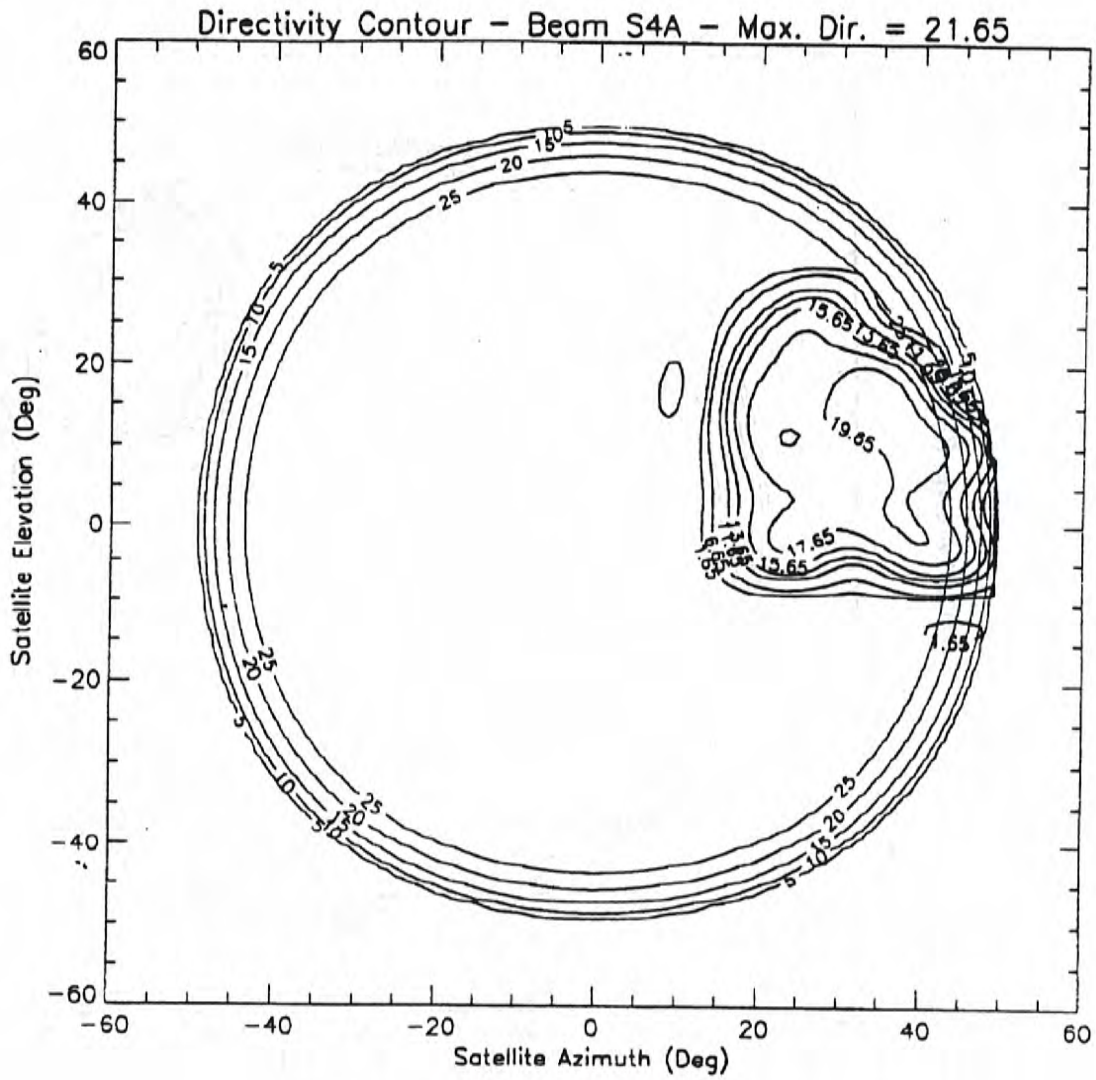
Contour	Directivity	Gain
Peak	20.86	19.36
- 2	18.86	17.36
- 4	16.86	15.36
- 6	14.86	13.36
- 8	12.86	11.36
-10	10.86	9.36
-15	5.86	4.36
-20	0.86	-0.64

Figure A.10: Directivity Contours for Beam S2A



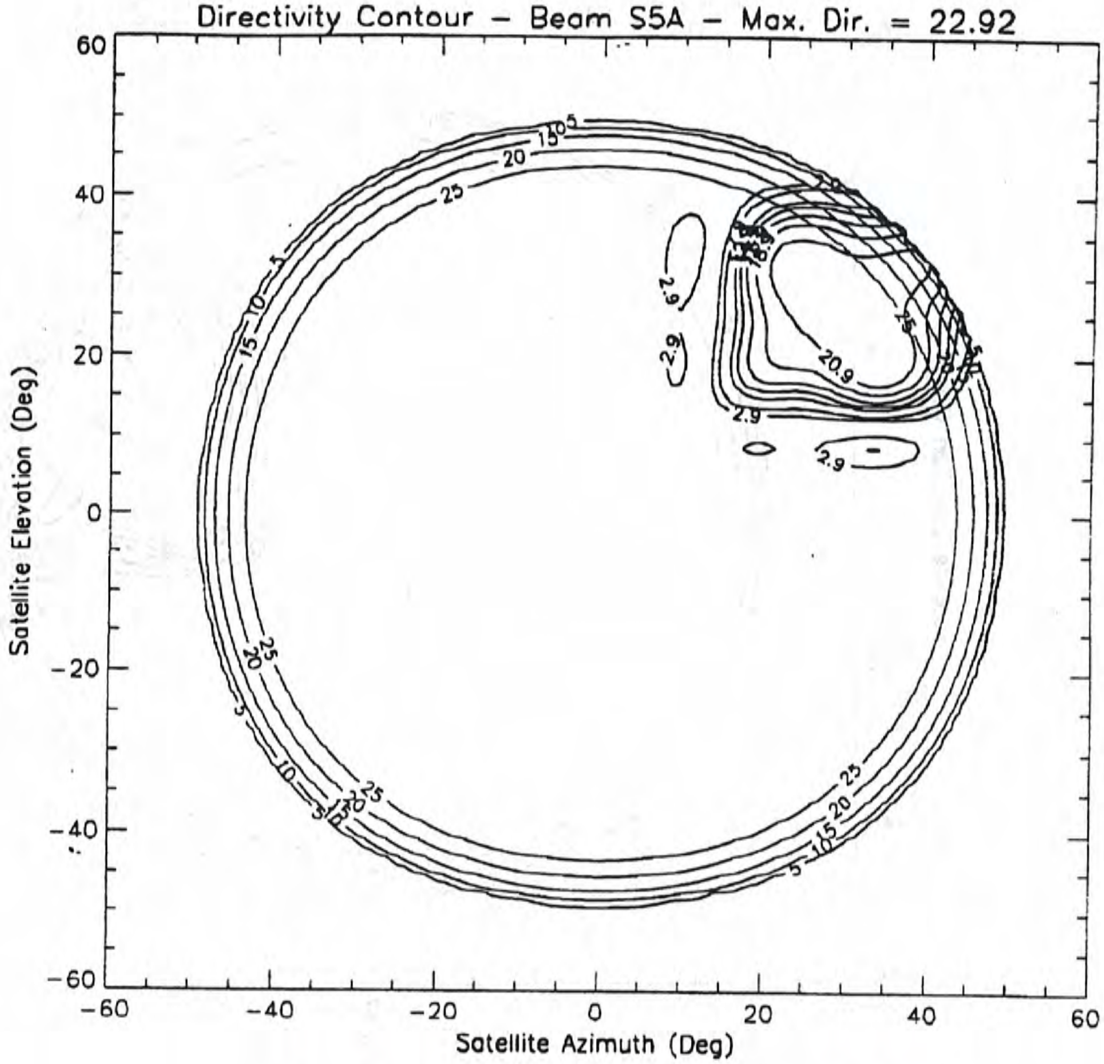
Contour	Directivity	Gain
Peak	24.25	22.25
- 2	22.25	20.25
- 4	20.25	18.25
- 6	18.25	16.25
- 8	16.25	14.25
- 1 0	14.25	12.25
- 1 5	9.25	7.25
- 2 0	4.25	2.25

Figure A.11: Directivity Contours for Beam S3A



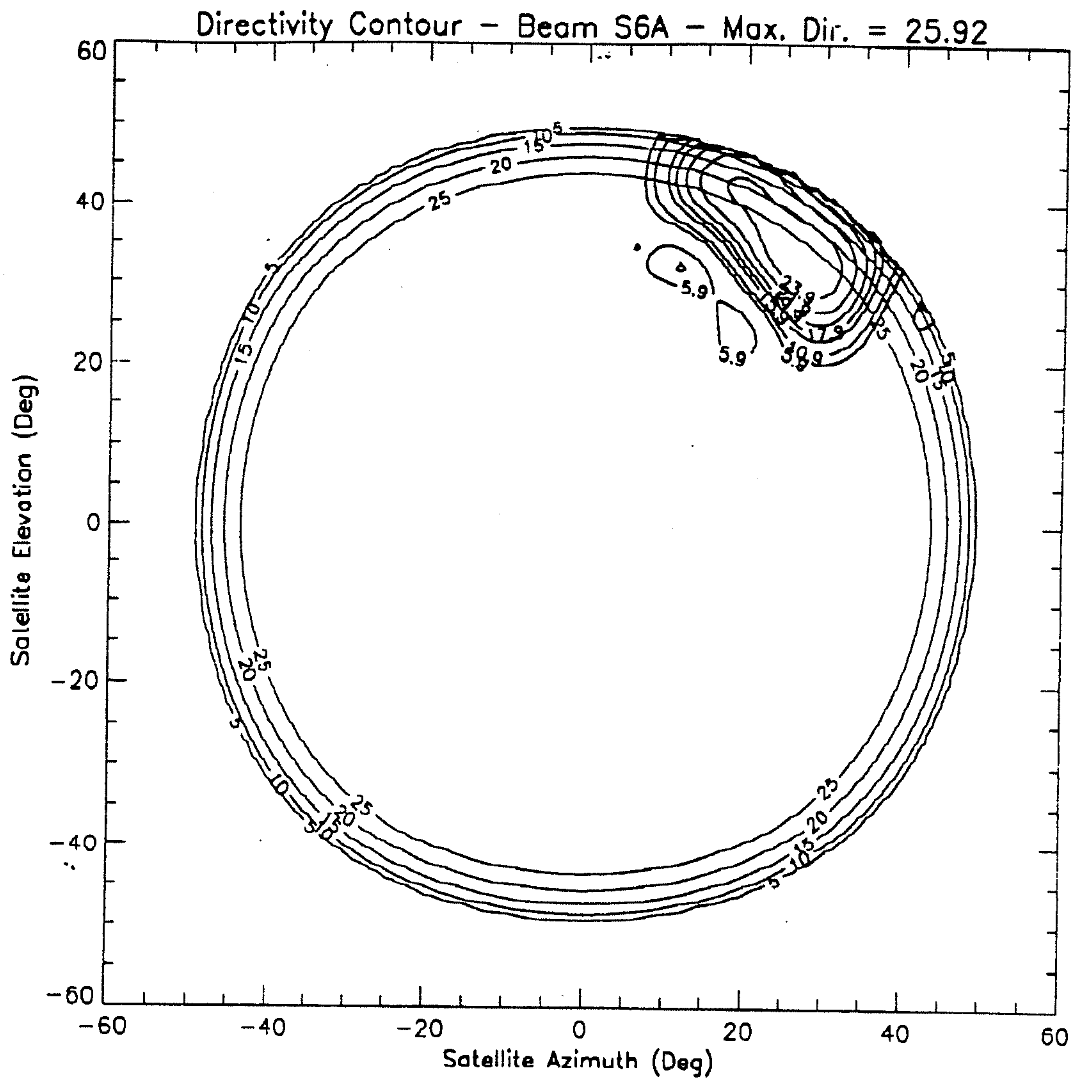
Contour	Directivity	Gain
Peak	21.65	20.15
- 2	19.65	18.15
- 4	17.65	16.15
- 6	15.65	14.15
- 8	13.65	12.15
-10	11.65	10.15
-15	6.65	5.15
-20	1.65	0.15

Figure A.12: Directivity Contours for Beam S4A



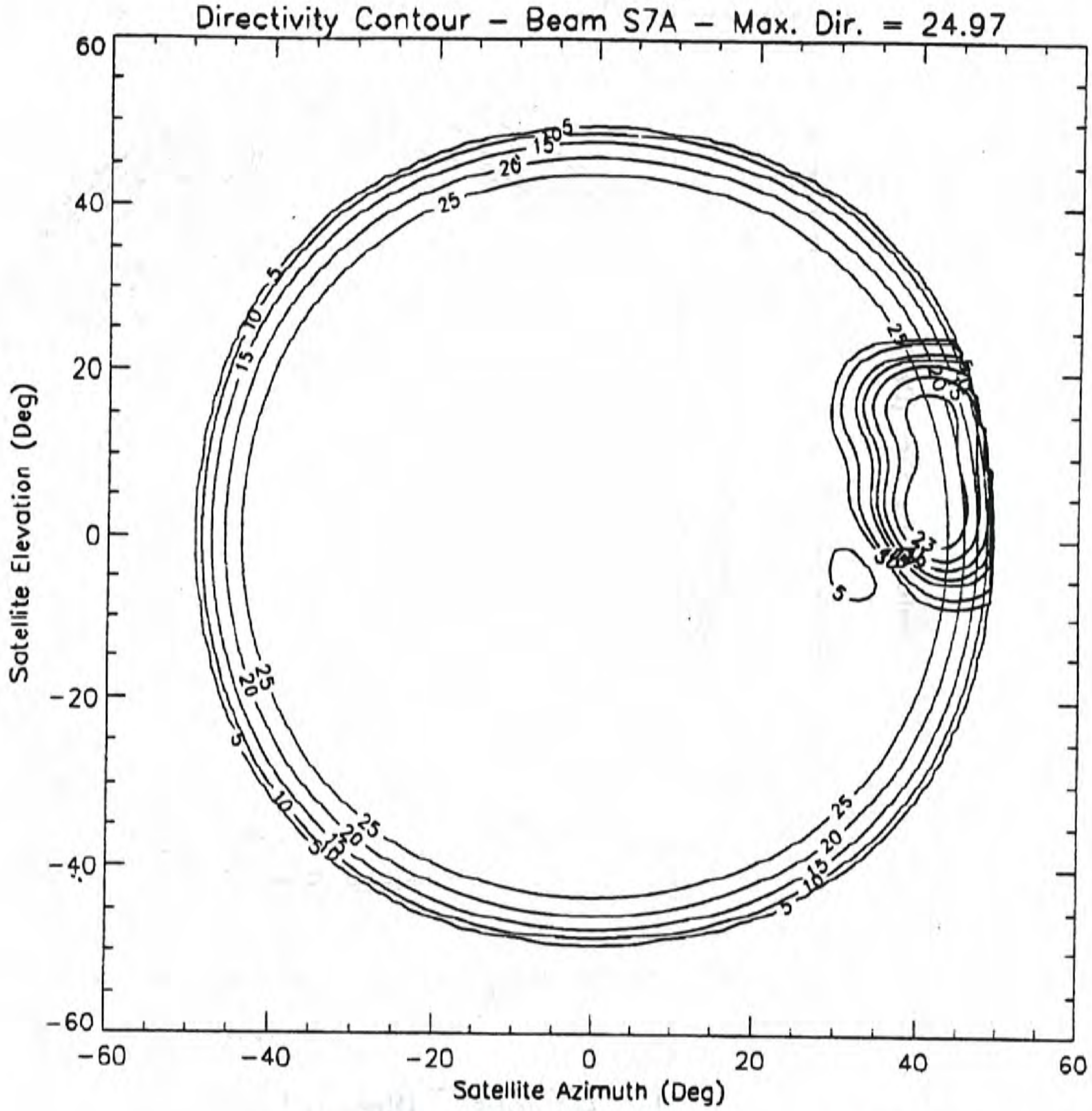
Contour	Directivity	Gain
Peak	22.92	21.42
- 2	20.92	19.42
- 4	18.92	17.42
- 6	16.92	15.42
- 8	14.92	13.42
- 1 0	12.92	11.42
- 1 5	7.92	6.42
- 2 0	2.92	1.42

Figure A.13: Directivity Contours for Beam S5A



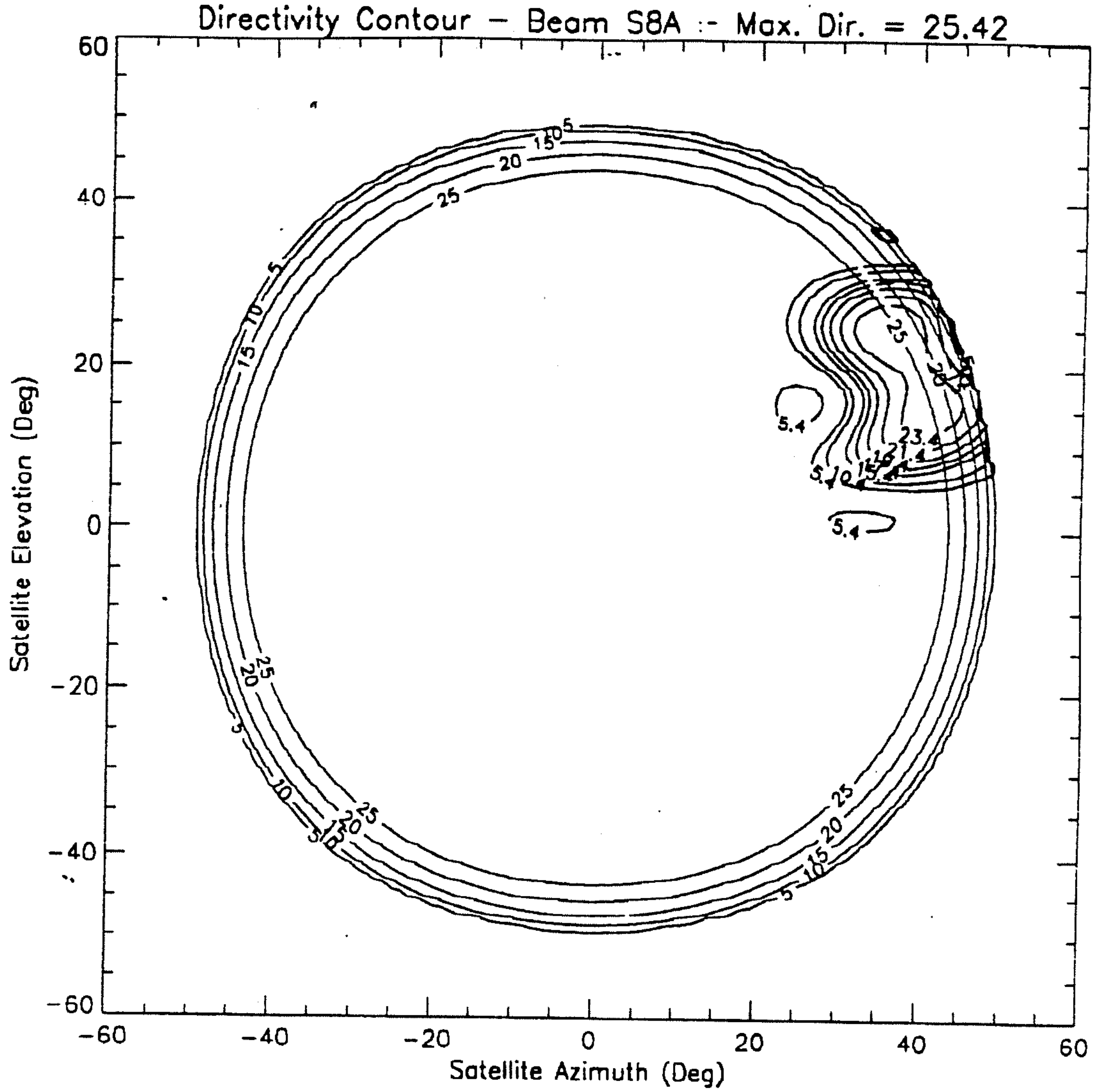
Contour	Directivity	Gain
Peak	25.92	24.42
- 2	23.92	22.42
- 4	21.92	20.42
- 6	19.92	18.42
- 8	17.92	16.42
- 10	15.92	14.42
- 15	10.92	9.42
- 20	5.92	4.42

Figure A.14: Directivity Contours for Beam S6A



Contour	Directivity	Gain
Peak	24.97	23.47
- 2	22.97	21.47
- 4	20.97	19.47
- 6	18.97	17.47
- 8	16.97	15.47
- 10	14.97	13.47
- 15	9.97	8.47
- 20	4.97	3.47

Figure A.15: Directivity Contours for Beam S7A



Contour	Directivity	Gain
Peak	25.42	23.92
- 2	23.42	21.92
- 4	21.42	19.92
- 6	19.42	17.92
- 8	17.42	15.92
-10	15.42	13.92
-15	10.42	8.92
-20	5.42	3.92

Figure A.16: Directivity Contours for Beam S8A

Constellation C-Band Receive Antenna

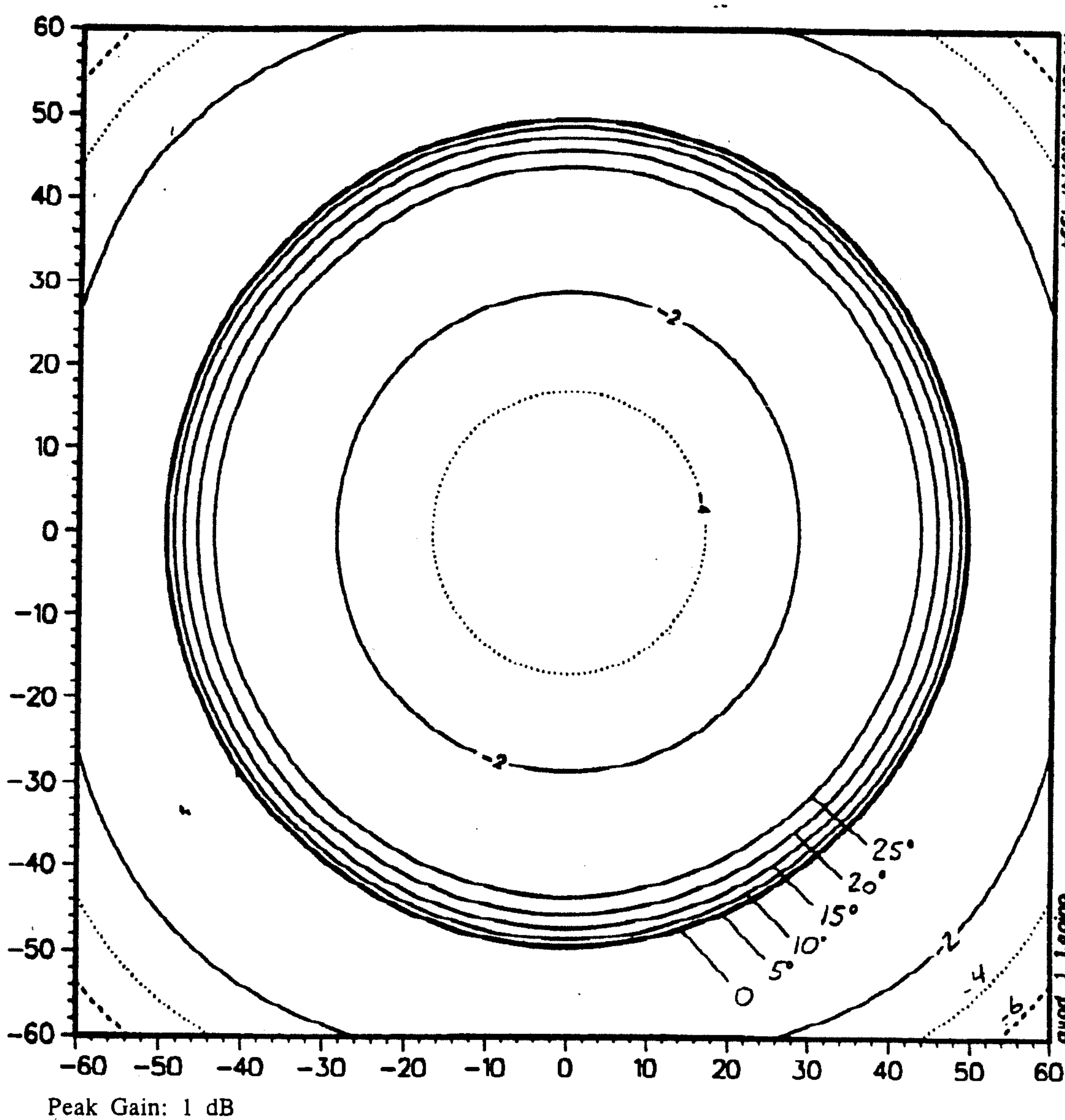
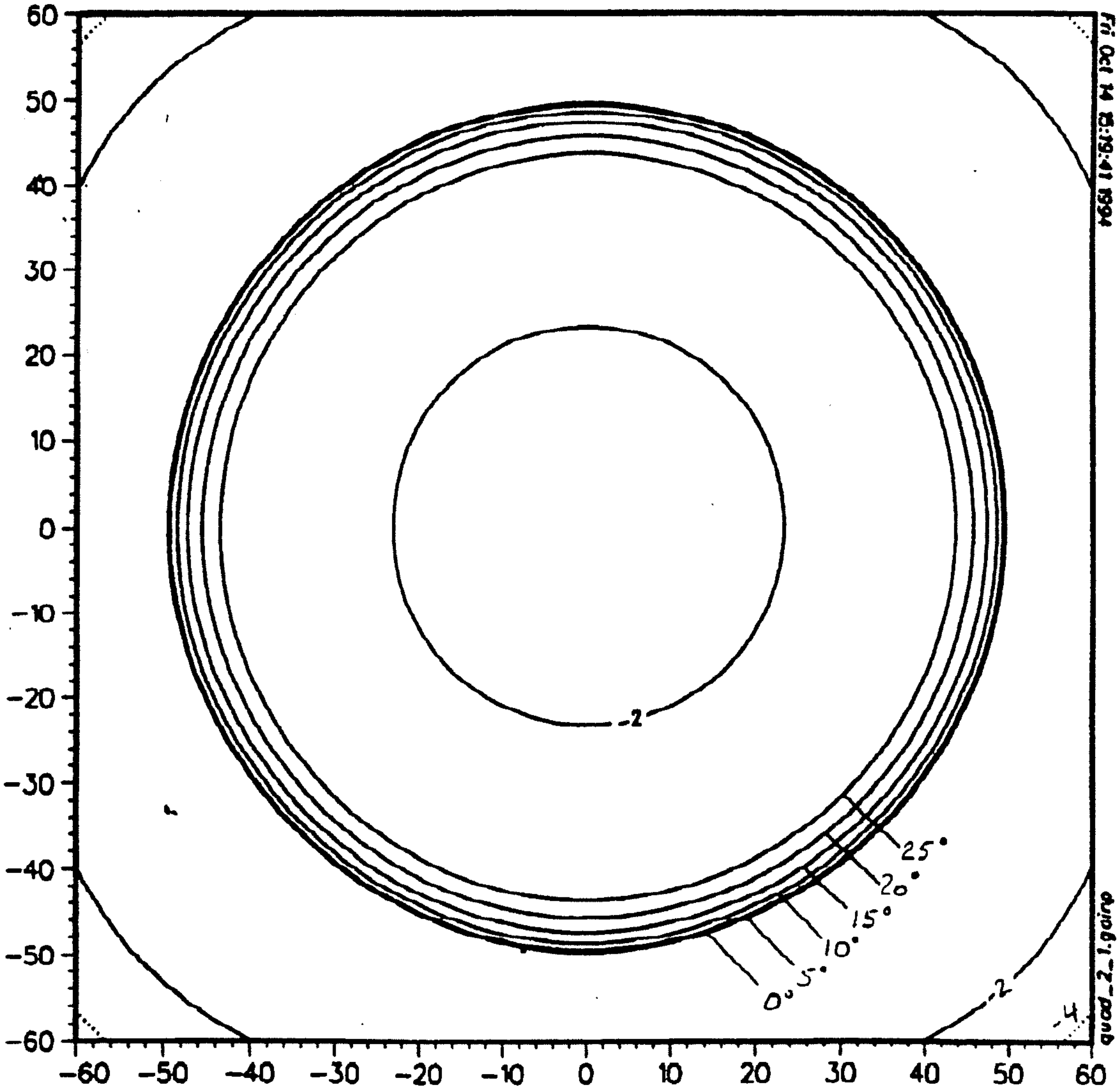


Figure A.19: C-Band Receive Antenna Gain Contours

Constellation C-Band Transmit Antenna



Peak Gain: 1 dB

Figure A.20: C-Band Transmit Antenna Gain Contours

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for the engineering information prepared by Martin Marietta Astro Space contained in this Exhibit 1 - Satellite Description, that I have either prepared or reviewed such information, and that it is complete and accurate to the best of my knowledge.

Dated: November 14, 1994

David Budd
Manager, Commercial Advanced Applications
Martin Marietta Astro Space
P.O. Box 800
Princeton, NJ 08543

TEXAS INSTRUMENTS

ENGINEERING CERTIFICATION

I hereby certify that I am the technically qualified person responsible for preparation of the phased array antenna engineering information contained in this Exhibit 1 - Satellite Description, that I have either prepared or reviewed such information contained in this exhibit, and that it is complete and accurate to the best of my knowledge.

Dated: November 10, 1994

Thomas S. Watson

Thomas S. Watson
Texas Instruments Incorporated
6600 Chase Oaks Boulevard
Plano, TX 75023

Exhibit 2

System Transmission Parameters

CONSTELLATION SYSTEM TRANSMISSION PARAMETERS

1. TRANSMISSION SERVICES AND PERFORMANCE

The Constellation system provides two basic types of transmission services. One service is near toll-quality digital voice communications between the satellite system subscribers and the public switched telephone network or between two satellite system subscribers. The second type of service provided by Constellation is digital data (voice bandwidth data and facsimile) at an information rate up to 2400 bits/second. Once a call is established, the circuit can be automatically switched between either of these transmission modes. The technical description and performance objectives for the basic Constellation transmission channel is summarized in Table 1. Code division multiple access ("CDMA") will be used in both the outbound (gateway earth station-to-subscriber) and the inbound (subscriber-to-gateway earth station) directions.

	Voice	Data/Facsimile
Baseband data rate	4800 bps - vocoder 200 bps - signaling 5000 bps - total	2400 bps - data 100 bps - signaling 2500 bps - total
Forward Error Correction (FEC)	Convolutional rate 1/2, K=7 6-8 bit quantization Viterbi soft decision	Convolutional rate 1/4, K=7 6-8 bit quantization Viterbi soft decision
Coded data rate	10 kbps	
Baseband Modulation	Offset QPSK	
Code Division Multiple Access (CDMA)	Outbound: synchronized Walsh codes masked with beam code Inbound: augmented Gold codes	
CDMA data rate	256 chips/coded bit, 2.56 Mchips/second (total)	
Emission designators	2M56G1E	2M56G1D
Bit Error Rate (BER)	10^{-3}	10^{-6}
Required Eb/No	2.8 dB	4.2 dB

Table 1. Basic Channel Parameters

2. TRANSMISSION CHARACTERISTICS

A detailed description of the Constellation space stations is presented in Exhibit 1. The communications payload is described in Section 2 and detailed antenna gain patterns are provided in the Annex to Exhibit 1. The Constellation satellites operate with simple frequency changing ("bent pipe") transponders. Each transponder has a 12 MHz bandwidth, but the center frequency of the transponder can be switched in orbit over the entire 16.5 MHz allocated at 1610-1626.5 MHz (L-band) for uplinks from user terminals and 2483.5-2500 MHz (S-band) for downlinks to user terminals. Figure 1 illustrates the Constellation frequency plan.

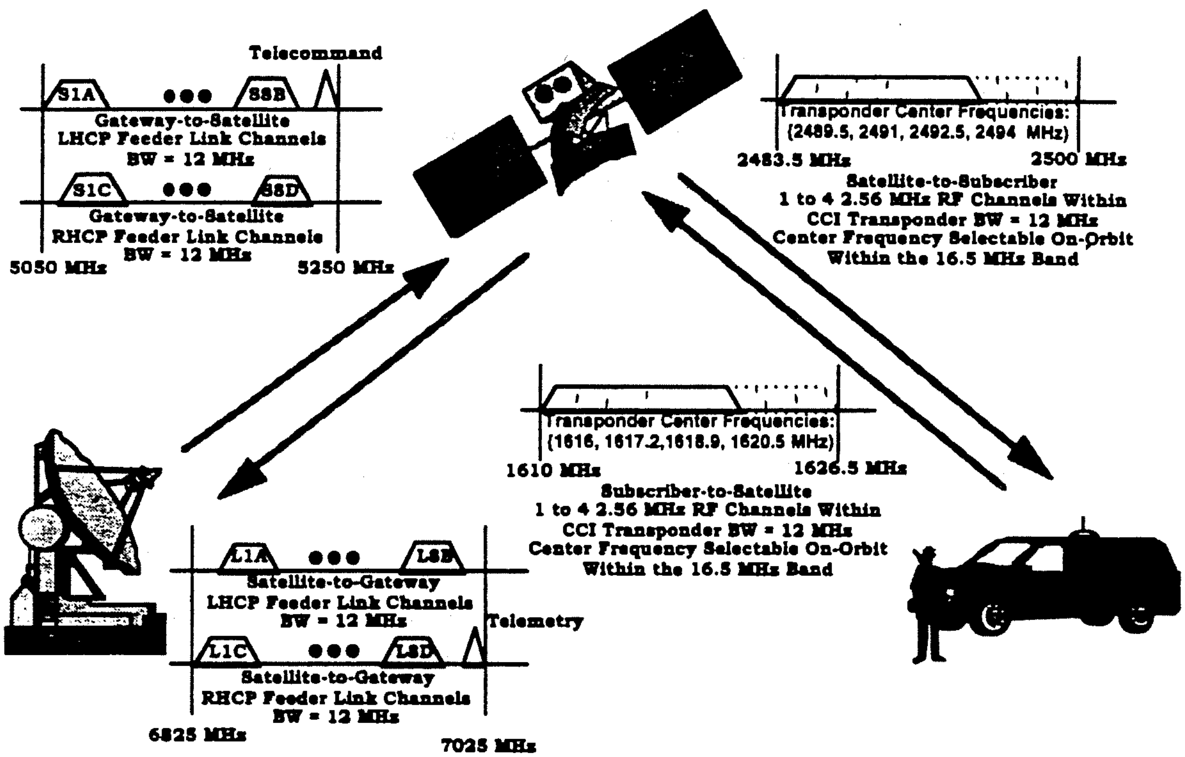


Figure 1. Constellation System Frequency Plan

The Constellation satellites carry an S-Band transmitting antenna array and an L-Band receiving antenna array. Each array creates 32 beams, divided into 4 symmetrical sectors of 8 beams each. Table 2 provides a summary of the L-band and S-band spot beam parameters.

Beam Number	1	2	3	4	5	6	7	8
Boresight Elevation (degrees)	67.4	45.7	28.4	43.9	34.3	22.9	26.1	21.7
Boresight Range (km)	2,123	2,589	3,184	2,580	2,917	3,490	3,304	3,563
Peak L-Band Gain (dBi)	14.6	18.8	17.5	17.5	20.5	18.6	18.2	19.5
Peak L-Band G/T (dBK^{-1})	-12.0	-7.9	-9.1	-9.1	-6.1	-8.1	-8.4	-7.1
Peak S-Band Gain 'dBi)	17.2	19.4	22.8	20.2	21.4	24.4	23.5	23.9

Table 2. Spot Beam Parameters

The ground segment radio facilities operating in the Constellation system consist of the gateway earth stations and the subscriber earth stations. The gateway earth stations provide the point of interconnection between Constellation's LEO satellite system and the public switched telephone network. Each gateway can access each L-band and S-band spot beam by transmitting and receiving on the C-band feeder link frequency assigned to each spot beam. Typical transmission parameters for the gateway earth station facilities are provided in Table 3 below.

	Transmit	Receive
Antenna size/type	Steerable 6 meter diameter reflector antennas (typically 3 antennas per gateway site)	
Min. elevation angle	5°	5°
Frequency Range	5050-5250 MHz	6825-7025 MHz
Polarization	RHCP, LHCP	
Efficiency	55%	55%
Beamwidth	0.69°	0.52°
Gain	47.7 dBi	50.2 dBi
Receiving System Noise Temp & G/T	NA	93 K 30.5 dB(K^{-1})
Max. Transmitter Power	100 watts	NA

Table 3. Baseline Gateway Earth Station Parameters

A variety of subscriber earth station units will be used in the Constellation system, including vehicle mounted units, portable and handheld units, and fixed terminals. Specific implementation details will vary from customer application to application and among subscriber unit manufacturers. Although there may be some variation in transmission parameters among different models, Table 4 provides baseline transmission parameters that are typical of the subscriber terminals to be operated in the Constellation system. The maximum subscriber unit transmitter power includes 10 dB of dynamic power control.

	Transmit	Receive
Antenna type	Non-directional	
Frequency Range	1610-1626.5 MHz	2483.5-2500 MHz
Polarization	RHCP	LHCP
Gain	3 dBi (nominal)	3 dBi (nominal)
Receiving System Noise Temp & G/T	NA	324 K -21.6 dB(K^{-1})
Power Control	10 dB	NA
Max. Transmitter Power	3 watts (nominal)	NA

Table 4. Baseline Subscriber Earth Station Parameters

3. LINK PERFORMANCE AND CAPACITY

Figures 4 and 5 illustrate the reference link budget analyses for (gateway earth station-to-subscriber) and the inbound (subscriber-to-gateway earth station) transponders operating in the Constellation system.

Each downlink beam at S-band has an operating bandwidth of 12 MHz in which one or more CDMA radio frequency ("RF") channels can be operated on a frequency division multiple access ("FDMA") basis, each with a bandwidth of 2.56 MHz. The center frequency of each S-band transponder is selectable within the 16.5 MHz tunable bandwidth in four frequency steps. The aggregate CDMA transmit power in any 2.56 MHz per beam is set at a level that holds the received power flux spectral density at a maximum of -142 dBW/m^2-4kHz or such lower value as is specified in RR 2566 for elevation angles below 25°.

Each uplink beam at L-band has an operating bandwidth of 12 MHz in which one or more CDMA RF channels can be operated on an FDMA basis, each with a bandwidth of 2.56 MHz. The center frequency of each L-band transponder is selectable within the 16.5 MHz tunable bandwidth in four frequency steps.

Adaptive power control (10 dB dynamic range) is provided in both the outbound and inbound directions. The power control system will be designed to minimize excess operating margins to users, to increase system capacity, and to allow service to be provided to users encountering foilage obstructions or other impairments in the satellite-user path. The effects of power control are not explicitly reflected in the reference link budgets. However, the relatively high average link margins reflected in the reference link budgets provide for a distribution of users between clear line-of-sight paths to the satellite and paths that are obstructed or faded.

The reference outbound and inbound link budgets presented in Tables 5 and 6 assume that there are 16 active signals being transmitted through the transponder (corresponding to 32 voice circuits with a 50% voice activity factor). This corresponds to a total of 1,024 circuits for 32 beams. The effects of internal code noise (but not external interference from other systems) and other performance impairments are included in these reference link budgets. With an average link margin over 3 dB and the various impairments included in the link analyses, Constellation believes that the 1,024 circuit satellite capacity indicated by these reference link budgets is conservative, and that a significantly higher capacity will be achieved with further refinement and optimization of system transmission parameters.

4. POWER FLUX DENSITY CALCULATIONS

Constellation plans to operate its satellites using CDMA. As a result there will be multiple carriers operating in each transponder on the same frequencies. In addition, the power level of each signal can be adaptively controlled to use the minimum amount of power needed to close each link under time varying propagation or fading conditions. For this reason, power flux density ("PFD") calculations are based on statistical aggregate power levels within the transponder rather than on the peak power of a single RF carrier.

Pursuant to RR 753F, coordination of space stations in the mobile-satellite and radiodetermination-satellite services with respect to terrestrial services is required only if the PFD produced at the Earth's surface exceeds the limits in RR 2566. The PFD limits specified in RR 2566 are as follows:

-152 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

-152 + 0.5 (δ-5) dB(W/m^2) in any 4 kHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane;

-142 dB(W/m^2) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Beam Number	1	2	3	4	5	6	7	8
Elevation Angle (°)	67.4	45.7	28.4	43.9	34.3	22.9	26.1	21.7
Range (km)	2123	2589	3184	2580	2917	3490	3304	3563
Uplink Frequency (MHz)	5200	5200	5200	5200	5200	5200	5200	5200
Transmit Power Per User (watts)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TX Antenna Gain (dBi)	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7
Transmit EIRP (dBW)	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2
Gateway Antenna Tracking Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Misc. Uplink Losses (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Path Loss (dB)	173.3	175.0	176.8	175.0	176.1	177.6	177.2	177.8
RX Antenna Gain (dBi)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RX Power Level (dBW)	-135.1	-136.8	-138.6	-136.8	-137.9	-139.4	-138.9	-139.6
Noise Density (dBW/Hz)	-201.0	-201.0	-201.0	-201.0	-201.0	-201.0	-201.0	-201.0
Uplink C/No (dB-Hz)	65.9	64.2	62.4	64.2	63.1	61.6	62.1	61.4
Downlink Frequency (MHz)	2491.75	2491.75	2491.75	2491.75	2491.75	2491.75	2491.75	2491.75
Power per user (dBW)	-5.7	-6.2	-7.8	-6.9	-7.2	-9.7	-8.2	-9.6
TX Antenna EOC (-3 dB) Gain (dBi)	14.2	16.4	19.8	17.2	18.4	21.4	20.5	20.9
EIRP per user (dBW)	8.4	10.2	12.0	10.2	11.2	11.7	12.3	11.3
Satellite Antenna Pointing Loss (dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous Downlink Losses (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Path Loss (dB)	166.9	168.6	170.4	168.6	169.7	171.2	170.8	171.4
RX Antenna Gain (dBi)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RX Power Level (dBW)	-156.6	-156.6	-156.6	-156.5	-156.6	-157.6	-156.6	-158.2
Noise Density (dBW/Hz)	-203.5	-203.5	-203.5	-203.5	-203.5	-203.5	-203.5	-203.5
Downlink C/No (dB-Hz)	46.9	46.9	46.9	47.0	46.9	45.9	46.9	45.3
Code and Adj Beam Noise Factor (numerical)	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Code Noise Density @ User (dBW/Hz)	-211.4	-211.4	-211.4	-211.3	-211.4	-212.4	-211.4	-213.0
Code Noise C/Io (dB-Hz)	54.8	54.8	54.8	54.8	54.8	54.8	54.8	54.8
Link C/No (dB-Hz)	46.2	46.2	46.2	46.3	46.2	45.3	46.2	44.7
Eb/No (dB)	9.2	9.2	9.2	9.3	9.2	8.3	9.2	7.7
Matched Filter Loss (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Demodulator Implementation Loss (dB)	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Required Eb/No (dB)	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Margin (dB)	3.7	3.7	3.6	3.7	3.6	2.7	3.6	2.2

Table 5. Reference Outbound Link Budget

Beam Number	1	2	3	4	5	6	7	8
Elevation Angle (°)	67.4	45.7	28.4	43.9	34.3	22.9	26.1	21.7
Range (km)	2123	2589	3184	2580	2917	3490	3304	3563
Uplink Frequency (MHz)	1618.25	1618.25	1618.25	1618.25	1618.25	1618.25	1618.25	1618.25
Transmit Power Per Carrier (watts)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TX Antenna Gain (dBi)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Transmit EIRP (dBW)	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7	-2.7
Misc. Uplink Losses (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Path Loss (dB)	163.2	164.9	166.7	164.9	165.9	167.5	167.0	167.7
Satellite Antenna Pointing Loss (dB)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RX Antenna EOC (-3 dB) Gain (dBi)	11.6	15.8	14.5	14.5	17.5	15.6	15.2	16.5
RX Power Level (dBW)	-154.9	-152.4	-155.5	-153.7	-151.7	-155.3	-155.2	-154.5
Noise Density (dBW/Hz)	-202.0	-202.0	-202.0	-202.0	-202.0	-201.9	-202.0	-202.0
Uplink C/No (dB-Hz)	47.1	49.6	46.5	48.3	50.2	46.7	46.9	47.5
Downlink Frequency (MHz)	6975.00	6975.00	6975.00	6975.00	6975.00	6975.00	6975.00	6975.00
Power per carrier (dBW)	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TX Antenna Gain (dBi)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carrier EIRP (dBW)	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5	-8.5
Miscellaneous Downlink Losses (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Path Loss (dB)	175.9	177.6	179.4	177.6	178.6	180.2	179.7	180.4
Gateway Antenna Tracking Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RX Antenna Gain (dBi)	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
Line Loss (dB)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
RX Power Level (dBW)	-136.2	-137.9	-139.7	-137.9	-138.9	-140.5	-140.0	-140.7
Noise Density (dBW/Hz)	-208.9	-208.9	-208.9	-208.9	-208.9	-208.9	-208.9	-208.9
Downlink C/No (dB-Hz)	72.8	71.0	69.2	71.1	70.0	68.4	68.9	68.3
Code and Adj Beam Noise Factor (numerical)	2.06	2.06	2.06	2.06	2.06	2.06	2.06	2.06
Code Noise Density @ User (dBW/Hz)	-185.2	-187.0	-188.8	-186.9	-188.0	-189.6	-189.1	-189.7
Code Noise C/Io (dB-Hz)	49.1	49.1	49.1	49.1	49.1	49.1	49.1	49.1
Link C/No (dB-Hz)	45.0	46.3	44.6	45.7	46.6	44.7	44.8	45.2
Eb/No (dB)	8.0	9.3	7.6	8.7	9.6	7.7	7.8	8.2
Matched Filter Loss (dB)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Demodulator Implementation Loss (dB)	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Required Eb/No (dB)	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Margin (dB)	2.9	4.3	2.5	3.6	4.6	2.7	2.8	3.1

Table 6. Reference Inbound Link Budget

Constellation proposes to operate its satellites in such a way as to avoid triggering any coordination requirements with terrestrial services pursuant to Resolution 46 by limiting the PFD produced by its satellites in the 2483.5-2500 MHz band to the current limits specified in RR 2566 or to any less restrictive values (i.e. higher PFD levels that do not trigger coordination requirements) that may be adopted by future World Radio Conferences.

The reference outbound link budgets in Table 5 are based on an aggregate S-Band transmit power being apportioned among 16 active transmissions within any 2.5 MHz band at any instant within the beam. Using this aggregate transmit power and the peak antenna beam gain, the calculations in Table 7 show that the RR 2566 limits are not exceeded.

Beam Number	1	2	3	4	5	6	7	8
Tx Power (watts)	4.3	3.8	2.7	3.2	3.0	1.7	2.4	1.7
Tx Max gain (dBi)	17.2	19.4	22.8	20.2	21.4	24.4	23.5	23.9
EIRP (dBW)	23.5	25.2	27.0	25.2	26.2	26.8	27.3	26.3
Range (km)	2,123	2,589	3,184	2,580	2,917	3,490	3,304	3,563
PFD	-142.0	-142.0	-142.0	-142.0	-142.0	-143.1	-142.0	-143.7
Angle of Arrival	67.4	45.7	28.4	43.9	34.3	22.9	26.1	21.7
PFD limit	-142.0	-142.0	-142.0	-142.0	-142.0	-143.1	-142.0	-143.7
Excess PFD (dB)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7. S-Band PFD Calculations

For the C-Band downlink, Constellation is proposing to utilize the 6825-7025 MHz band. If this, or another band between 3400 MHz and 7750 MHz, are allocated for LEO system feeder links, the PFD limits of RR 2566 are likely to be applicable.

The inbound reference link budget in Table 6 indicates that a signal level of -10 dBW is sufficient to maintain the C-band downlink C/N_o at the gateway earth station sufficiently high so as to have a negligible effect on the overall link E_b/N_o. Table 8 presents the results of these C-Band PFD calculations based on 16 active transmissions in any 2.5 MHz band within the beam. As can be seen from these calculations, the power or number of signals can be increased by a factor of forty or more without exceeding the RR 2566 PFD limits.

Angle of Arrival	0	5	10	15	20	25	35	45	55	65	75	90
Range (km)	5,428	4,902	4,434	4,025	3,671	3,368	2,891	2,550	2,312	2,152	2,053	2,000
Satellite Angle	49.6	49.3	48.6	47.3	45.7	43.6	38.6	32.6	25.9	18.8	11.4	0.0
Power/user (dBW)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
Number of users	16	16	16	16	16	16	16	16	16	16	16	16
Total Power dBW/2.5 MHz	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total Power dBW/4 kHz	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9	-25.9
Antenna Gain (dBi)	2.1	2.1	2.1	2.1	2.1	2.0	1.8	1.2	0.6	0.0	-0.4	-0.8
EIRP/4 kHz	-23.8	-23.8	-23.8	-23.8	-23.8	-23.9	-24.2	-24.7	-25.3	-25.9	-26.3	-26.7
Spreading (dB/m^2)	145.7	144.8	143.9	143.1	142.3	141.5	140.2	139.1	138.3	137.6	137.2	137.0
PFD (dBW/ m^2-4kHz)	-169.5	-168.6	-167.7	-166.9	-166.1	-165.5	-164.4	-163.8	-163.6	-163.6	-163.6	-163.7
RR 2566 Limit	-152.0	-152.0	-149.5	-147.0	-144.5	-142.0	-142.0	-142.0	-142.0	-142.0	-142.0	-142.0
Excess PFD (dB)	-17.5	-16.6	-18.2	-19.9	-21.6	-23.5	-22.4	-21.8	-21.6	-21.6	-21.6	-21.7

Table 8. C-Band PFD Calculations

Exhibit 3

Cost and Revenue Schedule

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Investment Schedule ($millions)													
Initial System													
Non-recurring costs	$10.0	$10.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Satellite Costs	$57.7	$59.4	$91.8	$157.6	$227.2	$200.6	$68.9	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Launch Costs	$0.0	$63.7	$93.1	$33.8	$188.5	$275.1	$104.8	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Control Segment Costs	$0.0	$0.0	$5.5	$1.1	$3.5	$2.4	$2.5	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total Annual Investment	$67.7	$133.1	$190.4	$192.5	$419.2	$478.1	$176.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Cumulative Investment	$67.7	$200.7	$391.1	$583.6	$1,002.8	$1,480.9	$1,657.0	$1,657.0	$1,657.0	$1,657.0	$1,657.0	$1,657.0	$1,657.0
Replenishment													
Satellite Costs	$0.0	$0.0	$0.0	$0.0	$0.0	$15.6	$32.1	$49.5	$51.0	$52.5	$54.1	$55.7	$57.4
Launch Costs	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$10.3	$28.6	$29.5	$30.4	$31.3	$32.2	$33.2
Total Annual Investment	$0.0	$0.0	$0.0	$0.0	$0.0	$15.6	$42.4	$78.2	$80.5	$82.9	$85.4	$88.0	$90.6
Cumulative Investment	$0.0	$0.0	$0.0	$0.0	$0.0	$15.6	$57.9	$136.1	$216.6	$299.5	$384.9	$472.9	$563.5
Total Investment	$67.7	$133.1	$190.4	$192.5	$419.2	$493.7	$218.5	$78.2	$80.5	$82.9	$85.4	$88.0	$90.6
Cumulative Investment	$67.7	$200.7	$391.1	$583.6	$1,002.8	$1,496.4	$1,714.9	$1,793.0	$1,873.6	$1,956.5	$2,041.9	$2,129.9	$2,220.5

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Revenue Schedule ($millions)													
Annual Revenues				$96.0	$315.7	$613.5	$787.6	$1,073.8	$1,434.8	$1,588.7	$1,751.1	$1,922.6	$2,103.5
Annual Operating Expenses	$15.0	$17.0	$20.0	$26.4	$31.5	$38.2	$42.5	$71.8	$80.6	$83.4	$85.0	$86.7	$88.4
Operating Income	($15.0)	($17.0)	($20.0)	$69.6	$284.2	$575.3	$745.1	$1,001.9	$1,354.2	$1,505.2	$1,666.1	$1,835.9	$2,015.1
Depreciation	$0.0	$0.0	$63.6	$63.9	$97.9	$235.5	$306.6	$258.3	$273.0	$255.1	$133.8	$79.5	$82.1
Earnings before tax	($15.0)	($17.0)	($83.6)	$5.7	$186.3	$339.8	$438.5	$743.7	$1,081.2	$1,250.1	$1,532.2	$1,756.4	$1,933.0
Taxes	($6.0)	($6.8)	($33.4)	$2.3	$74.5	$135.9	$175.4	$297.5	$432.5	$500.0	$612.9	$702.5	$773.2
Net Income	($9.0)	($10.2)	($50.1)	$3.4	$111.8	$203.9	$263.1	$446.2	$648.7	$750.1	$919.3	$1,053.8	$1,159.8
Cumulative Net Income	($9.0)	($19.2)	($69.3)	($65.9)	$45.8	$249.7	$512.8	$959.0	$1,607.7	$2,357.8	$3,277.1	$4,330.9	$5,490.8

EXHIBIT 3. CCI INVESTMENT AND REVENUE SCHEDULE

Exhibit 5

FCC Form 430

FCC 430

FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

Approved by OMB
3060-0105
Expires 2/28/96

LICENSEE QUALIFICATION REPORT

See reverse side for information regarding public burden statement.

INSTRUCTIONS

A. The "Filer" of this report is defined to include: (1) An applicant, where this report is submitted in connection with applications for common carrier and satellite radio authority as required for such applications; or (2) A licensee or permittee, where this report is required by the Commission's Rules to be submitted on an annual basis.

B. Submit an original and one copy (sign original only) to the Federal Communications Commission, Washington, DC 20554. If more than one radio service is listed in item 6, submit an additional copy for each such additional service * this report is being submitted in connection with an application for radio authority, attach it to that application.

C. Do not submit a fee with this report.

1. Business Name and Address (Number, Street, State and ZIP Code) of Filer's Principal Office: Constellation Communications, Inc. 10530 Rosehaven Street, Suite 410 Fairfax, Virginia 22030	2. (Area Code) Telephone Number: (703) 352-1733 3. If this report supercedes a previously filed report, specify its date: June 3, 1991
4. Filer is (check one): ☐ Individual ☐ Partnership ☒ Corporation ☐ Other (Specify):	5. Under the laws of what State (or other jurisdiction) is the Filer organized? Delaware

6. List the common carrier and satellite radio services in which Filer has applied or is a current licensee or permittee:

7(a) Has the Filer or any party to this application had any FCC station license or permit revoked or had any application for permit, license or renewal denied by this Commission? *If "YES", attach as Exhibit I a statement giving call sign and file number of license or permit revoked and relating circumstances.* ☐ Yes ☒ No

(b) Has any court finally adjudged the Filer, or any person directly or indirectly controlling the Filer, 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 other means of unfair methods of competition? *If "YES", attach as Exhibit II a statement relating the facts.* ☐ Yes ☒ No

(c) Has the Filer, or any party to this application, or any person directly or indirectly controlling the Filer ever been convicted of a felony by any state or Federal Court? *If "YES", attach as Exhibit III a statement relating the facts.* ☐ Yes ☒ No

(d) Is the Filer, or any person directly or indirectly controlling the Filer, presently a party in any matter referred to items 7(b) and 7(c)? *If "YES", attach as Exhibit IV a statement relating the facts.* ☐ Yes ☒ No

8. Is the Filer, directly or indirectly, through stock ownership, contract or otherwise, currently interested in the ownership or control of any other radio stations licensed by this Commission? *If "YES", submit as Exhibit V the name of each such licensee and the licensee's relation to the Filer.* ☐ Yes ☒ No

If Filer is an individual (sole proprietorship) or partnership, answer the following and item 11:

9(a) Full Legal Name and Residential Address (Number, Street, State and ZIP Code) of Individual or Partners:	(b) Is individual or each member of a partnership a citizen of the United States? ☐ Yes ☐ No (c) Is individual or any member of a partnership a representative of an alien or of a foreign government? ☐ Yes ☐ No

If Filer is a corporation, answer the following and Item 11:

10(a) Attach as Exhibit VI the names, addresses, and citizenship of those stockholders owning of record and/or voting 10 percent or more of the Filer's voting stock and the percentages so held. In the case of fiduciary control, indicate the beneficiary(ies) or class of beneficiaries.

See Exhibit VI

(b) List below, or attach as Exhibit VII the names and addresses of the officers and directors of the Filer.

See Exhibit VII

(c) Is the Filer directly or indirectly controlled by any other corporation? ☐ Yes ☒ No

If "YES", attach as Exhibit VIII a statement (including organizational diagrams where appropriate) which fully and completely identifies the nature and extent of control. Include the following: (1) the address and primary business of the controlling corporation and any intermediate subsidiaries; (2) the names, addresses, and citizenship of those stockholders holding 10 percent or more of the controlling corporation's voting stock; (3) the approximate percentage of total voting stock held by each such stockholder; and (4) the names and addresses to the president and directors of the controlling corporation.

(d) Is any officer or director of the Filer an alien? ☐ Yes ☒ No

(e) Is more than one-fifth of the capital stock of the Filer owned of record or voted by aliens or their representatives, or by a foreign government or representative(s) thereof, or by a corporation organized under the laws of a foreign country? ☐ Yes ☒ No

(f) Is the Filer directly or indirectly controlled: (1) by any other corporation of which any officer or more than one-fourth of the directors are aliens, or (2) by any foreign corporation or corporation of which more than one-fourth of the capital stock is owned or voted by aliens or their representatives, or by a foreign government or representatives thereof. ☐ Yes ☒ No

(g) If any answer to questions (d), (e) or (f) is "YES", attach as Exhibit IX a statement identifying the aliens or foreign entities, their nationality, their relationship to the Filer, and the percentage of stock they own or vote.

11. CERTIFICATION

This report constitutes a material part of any application which cross-references it, and all statements made in the attached exhibits are a material part thereof. The ownership information contained in this report does not constitute an application for, or Commission approval of, any transfer of control or assignment of radio facilities. The undersigned, individually and for the Filer, hereby certifies that the statements made herein are true, complete and correct to the best of Filer's knowledge and belief, and are made in good faith.

WILLFUL FALSE STATEMENTS MADE ON THIS APPLICATION ARE PUNISHABLE BY FINE AND IMPRISONMENT (U.S. Code, Title 18, Section 1001) and/or REVOCATION OF ANY STATION LICENSE OR CONSTRUCTION PERMIT (U.S. Code, Title 47, Section 312(a)(1)).	Date 11/15/94	Filer *(Must correspond with that shown in item 1)* Constellation Communications, Inc.	Typed or Printed Name Bruce D. Kraselsky
	Signature Bruce D. Kraselsky		Title Chairman and Chief Executive Officer

NOTICE TO INDIVIDUALS REQUIRED BY THE PRIVACY ACT OF 1974 AND THE PAPERWORK REDUCTION ACT OF 1980

The solicitation of personal information requested in this form is to determine if you are qualified to become or remain a licensee in a common carrier or satellite radio service pursuant to the Communications Act of 1934, as amended. No authorization can be granted unless all information requested is provided. Your response is required to obtain the requested authorization or retain an authorization.

Public reporting burden for this collection of information is estimated to average 2 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Federal Communications Commission, Office of Managing Director, Washington, DC 20554, and to Office of Management and Budget, Paperwork Reduction Project (3060-0105), Washington, DC 20503.

CONSTELLATION COMMUNICATIONS, INC.
FCC Form 430
Question 10(b)

EXHIBIT VI

Listed below are names, addresses, and citizenship of those stockholders owning of record or voting 10 percent or more of the filer's voting stock and the percentage so held.

Names and Addresses	Percentage of Stock Stock Held	Citizenship
CTA Launch Services[1] 1521 West Branch Drive McLean, Virginia 22102	18.35	USA
E Systems, Inc.[2] 1200 Garland Road Garland, Texas 75042	30.7	USA

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1 The majority of outstanding stock of Microsat Launch Systems was purchased by CTA, Inc. in September of 1993. Microsat Launch Systems continues to operate as a corporation but has been renamed CTA Launch Systems. See Attachment A to this exhibit for a review of this transaction.

2 The stock issued by CCI to E Systems and other parties since the initial CCI application was filed with the FCC in June 1991 presently account for less than 50% of the outstanding CCI stock.

ATTACHMENT A

Contingent Request for Exemption from "Cut-off" Date Pursuant to §25.116(c)(2)

Gradual changes in the ownership of voting stock in Constellation Communications, Inc. ("Constellation") have occurred over the last three years. Constellation does not believe that these changes constitute a "substantial change in beneficial ownership or control" of Constellation under §25.116(b)(3) of the Commission's Rules or require a major amendment of Constellation's application. See Sewell, "Sale of FCC Authorizations" ("Sewell"), 43 Fed. Comm. L.J. 277, 311-12 (1990) (gradual changes in stock ownership over time do not require prior Commission approval even when more than 50 percent of the stock is held by new persons). However, "out of abundance of caution," see Satellite CD Radio, Inc., 9 FCC Rcd 2569, 2569 (CC Bur. 1994), and on a contingent basis, Constellation hereby requests an exemption, pursuant to §25.116(c)(2), from the rule's "cut-off" date requirement for major amendments, in the event that the Commission determines that an exemption is necessary.

Constellation filed its application on June 3, 1991. Originally, the following corporations held Constellation voting interests: Microsat Launch Systems, Inc. ("Microsat"), Defense Systems, Inc. ("DSI"), and Pacific Communication Science, Inc. ("PCSI"). Numerous other individuals and corporations also held Constellation stock, with no single entity controlling Constellation. Between 1992-94, CTA, Inc. acquired Microsat and DSI, and Cirrus Logic acquired PCSI. Additionally, E-Systems and Bell Atlantic purchased voting interests in Constellation.

As described below, the primary purpose of the sales of DSI (June 1992), Microsat (September 1993) and PCSI (March 1993) was not to acquire Constellation stock or Constellation's application.[1] Similarly, the E-System and Bell Atlantic acquisitions occurred over an extended period of time in 1993 and 1994.[2] Thus, Constellation believes that, although these acquisitions, taken together, exceed 50% of Constellation's voting stock, they were sufficiently separated in time that they ought not to be treated cumulatively, did not require prior reporting or approval by the Commission, and do not constitute a "substantial change" in Constellation's ownership under §25.116(b)(3). Sewell, supra.

Nevertheless, Constellation recognizes that the cumulative result of the three acquisitions is that more than 50% of Constellation's voting stock is now controlled by entities who were not original owners of Constellation. It is because of §25.116(b)(4)'s reference to the "cumulative effect" of an amendment that, to the extent the Commission deems necessary, Constellation is now requesting an exemption under §25.116(c)(2) for the DSI, Microsat and PCSI transfers because of the public interest benefits flowing from them.

Although §25.116 is relatively new, exemptions have been routinely granted under similar rules where the Commission determined that (1) the change in ownership or control is calculated "to further a legitimate business purpose" (rather than merely to

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1 DSI, Microsat and PCSI still operate as separate corporations and continue to be the owner of record of Constellation stock.

2 The newly issued stock sold to Bell Atlantic and E-Systems accounts for less than 50% of the outstanding stock of Constellation and, therefore, does not require prior Commission approval under §25.116.

acquire the pending application itself) and (2) the acquisition is in the public interest. The leading cases applying this test -- the latter two specifically involving §25.116 -- are Airsignal International, Inc., 81 FCC 2d 472 (1980); ISA Communications Services, Inc., 90 FCC 2d 938 (1982); STARSYS Global Positioning, Inc., 8 FCC Rcd 1662, 1663 ¶¶ 6-7 (CC Bur. 1993); and Satellite CD Radio, Inc., supra.

Consistent with these rulings, Constellation urges that the Microsat, DSI and PCSI sales were the incidental result of arm's-length transactions over which Constellation had no control and which were carried out for legitimate private business purposes wholly unrelated to Constellation's application. DSI, founded in 1978, is a spacecraft and sensor manufacturer. It has manufactured 22 small satellites for the Department of Defense and other federal customers. In June 1992, CTA, Inc. (a systems engineering and software development company) purchased a majority interest in DSI. This transaction was consummated to merge CTA's system engineering capabilities with DSI's manufacturing capabilities and was concluded on a bilateral basis between CTA and DSI. Constellation was not consulted. PCSI was founded in 1987 and specializes in telecommunication systems and software engineering, digital voice and signal processing and transmission engineering. In March 1993, Cirrus Logic, Inc. purchased a majority interest in PCSI. Cirrus Logic is a semiconductor manufacturer and was interested in acquiring PCSI's telecommunications capability. Again, Constellation was not consulted. Microsat, founded in 1988 to develop a small launch vehicle, was awarded a contract in 1991 by Ballistic Missile Defense Organization to develop launch vehicles to compete with the Pegasus rocket. Fifteen months after the DSI/CTA transaction was consummated, CTA purchased Microsat. This transaction was designed to provide CTA with launch services to support DSI activities. Again, Constellation's approval was not sought. None of these three unrelated transactions -- consummated over a 15-month period -- was for purposes of acquiring Constellation stock. Rather, each was concluded for reasons totally unrelated to Constellation. The Constellation stock was only an incidental asset of these three companies.[3]

In contrast to these three transactions, the E-Systems and Bell Atlantic acquisitions of Constellation stock were for the purpose of bringing greater financial strength[4] to Constellation as well as significant technical expertise. These transactions were consummated for the specific purpose of bringing equity investment into Constellation. In this respect, Constellation has taken a path identical to other Big LEO applicants in attracting investors to foster implementation of their LEO proposals. This is the very type of investment that the Commission has encouraged.[5]

In sum, Constellation urges that the DSI, PCSI and Microsat acquisitions, even if analyzed cumulatively, are fully consistent with §25.116(c)(2), because each meets the Airsignal tests of legitimate purpose and public interest benefit. Hence, Constellation

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3 The circumstances in the present situation provide a much more compelling case than in the Airsignal line of cases for either not requiring Commission approval of the various transactions or granting of an exemption to §25.116 since in the Airsignal line of cases the facts revolved around a single transaction in which a buyer bought an entire company. Here, there are three completely unrelated transactions.

4 See, CD Radio, Inc., 9 FCC Rcd 2569, 2571 (1994). In this case the Commission approved the sale of a majority interest in an applicant subject to a cut-off order. The facts in the present situation are dramatically different in that the equity investors have not obtained majority control.

5 Id.

urges that: (1) the cumulative effect of the three acquisitions is not "substantial," and a "major" amendment is not required; or, alternatively, (2) even if an amendment were deemed "substantial" or "major," the changes in ownership caused by the three transactions are "in the public interest" under §25.116(c)(2) and exempt from a "cut-off" date.

As Constellation demonstrates in this amendment, during the last three and one-half years it has pursued a course identical to the other Big LEO applicants. Each of the applicants has recognized that the implementation of a Big LEO system would require a great deal of capital and technical expertise. This resulted in a scramble by all the applicants to assemble a team of strategic, technical and financial partners. Constellation has certainly been successful in this endeavor as demonstrated by its relationships with Bell Atlantic, E-Systems, Telebras, Martin Marietta and Texas Instruments. Given this success, Constellation believes that the grant of its application at this time will serve the public interest.