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November 16, 1994

17-SAT-LA-[redacted]
18-SAT-AMEND-[redacted] 95

BY R&S COURIERS, INC.

Federal Communications Commission
Satellite and Radiocommunication Division
P.O. Box 358160
Pittsburgh, PA 15251-5160

Re: **Amendment to Application of TRW Inc. for Authority to Construct Mobile Satellite Service Above 1 GHz Satellite System, File Nos. 20-DSS-P-91(12) and CSS-91-015**

Dear Sir or Madam:

On behalf of TRW Inc., enclosed are the original and nine copies of an amendment to its pending application for authority to establish a system of space stations in the new Mobile Satellite Service Above 1 GHz.

Also enclosed is a completed fee processing form (FCC Form 159), along with a check in the amount of $3,445.00, made payable to the Federal Communications Commission, to cover the requisite filing fee. Finally, enclosed is a "Return Copy" of the amendment. Please date-stamp this "Return Copy" and return it to the courier delivering this package.

Please address any questions concerning this matter to the undersigned.

Respectfully yours,

Stephen D. Baruch

Enclosures

(RESERVED)

(Read instructions carefully BEFORE proceeding.)

FEDERAL COMMUNICATIONS COMMISSION

FCC REMITTANCE ADVICE

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

PAGE NO. 1 OF 1

SPECIAL USE

FCC USE ONLY FCC/MELLON NOV 16 1994

PAYOR INFORMATION

(1) FCC ACCOUNT NUMBER 0 3 4 0 5 7 5 4 3 0	Did you have a number prior to this? Enter it.	(2) TOTAL AMOUNT PAID (dollars and cents) $ 3,445.00

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

(4) STREET ADDRESS LINE NO. 1
c/o Leventhal, Senter & Lerman

(5) STREET ADDRESS LINE NO. 2
2000 K Street, N.W., Suite 600

(6) CITY Washington	(7) STATE DC	(8) ZIP CODE 20006-1809
(9) DAYTIME TELEPHONE NUMBER (Include area code) 202-429-8970	(10) COUNTRY CODE (if not U.S.A.)	

ITEM #1 INFORMATION

(11A) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR TRW Inc.	FCC USE ONLY

(12A) FCC CALL SIGN/OTHER ID	(13A) ZIP CODE	(14A) PAYMENT TYPE CODE	(15A) QUANTITY	(16A) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14
File Nos. 20-DSS-P-91(12) and CSS-91-015	90278	C A W	1	$ 3,445.00

(17A) FCC CODE 1	(18A) FCC CODE 2

(19A) ADDRESS LINE NO. 1	(20A) ADDRESS LINE NO. 2)	(21A) CITY/STATE OR COUNTRY CODE
One Space Park		Redondo Beach, CA

ITEM #2 INFORMATION

(11B) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR	FCC USE ONLY

(12B) FCC CALL SIGN/OTHER ID	(13B) ZIP CODE	(14B) PAYMENT TYPE CODE	(15B) QUANTITY	(16B) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14
				$

(17B) FCC CODE 1	(18B) FCC CODE 2

(19B) ADDRESS LINE NO. 1	(20B) ADDRESS LINE NO. 2	(21B) CITY/STATE OR COUNTRY CODE

CREDIT CARD PAYMENT INFORMATION

(22) MASTERCARD/VISA ACCOUNT NUMBER:

☐ Mastercard EXPIRATION DATE: Month Year

☐ Visa

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

AUTHORIZED SIGNATURE DATE

See public burden estimate on reverse.

FCC FORM 159
April 1994

CERTIFICATE OF SERVICE

I, Katharine B. Squalls, hereby certify that a true and correct copy of the attached "Amendment to Application" was mailed, first-class postage prepaid, this 16th day of November, 1994 to the following:

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Room 658
Washington, DC 20554

*Kathleen Wallman
Chief
Common Carrier Bureau
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Katharine B. Squalls

TRW

AMENDMENT TO APPLICATION OF TRW INC. TO THE FEDERAL COMMUNICATIONS COMMISSION FOR AUTHORITY TO CONSTRUCT A NON-GEOSTATIONARY SATELLITE SYSTEM IN THE MOBILE SATELLITE SERVICE ABOVE 1 GHZ

ODYSSEY™

NOVEMBER 16, 1994

17-SAT-L-A-95
18-SAT-AMEND-95

November 15, 1994

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

Re: Amendment to Application of TRW Inc.
File Nos. 20-DSS-P-91(12) and CSS-91-015

Dear Mr. Caton:

TRW Inc. ("TRW") hereby amends its above-referenced application for authority to construct a non-geostationary satellite system in the new Mobile-Satellite Service Above 1 GHz ("MSS Above 1 GHz" or "Big LEO" service). TRW's Amendment is both contemplated and necessitated by the Commission's Report and Order in CC Docket No. 92-166 which promulgated final rules for the MSS Above 1 GHz.[1/] With this Amendment, TRW completes its demonstration that it is legally, technically, and financially qualified to be granted an MSS Above 1 GHz system license. Accordingly, TRW urges the Commission, by the January 31, 1995 target date established in the MSS Above 1 GHz Report and Order, to issue TRW an MSS Above 1 GHz construction authorization that is conditioned only upon the final assignment of spectrum for the system's feeder links.[2/]

1/ See Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile-Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Bands, FCC 94-261 (released October 14, 1994) ("MSS Above 1 GHz Report and Order"). In the MSS Above 1 GHz Report and Order, the Commission afforded the six first-round Big LEO applicants until November 16, 1994 to amend their applications to conform to the rules and policies it adopted therein. Id., FCC 84-261, slip op. at 3.

2/ See id., FCC 94-261, slip op. at 62.

Attachment A to this Amendment contains a revised technical portion of TRW's application. Certain elements of TRW's technical proposal for "Odyssey™"[3/] have been modified or added specifically to bring the proposal into conformance with the rules and policies adopted in the MSS Above 1 GHz Report and Order. Other portions of the original technical proposal have been modified in minor respects that reflect the more than three years of refinement and continuing development efforts that have taken place since the original application was filed in May 1991. TRW emphasizes that the revisions in this second class, to the extent they are not also included within the first category, were made to reduce frequency conflicts and facilitate the implementation of inter-system sharing by Big LEO applicants. In the interest of clarity, TRW has produced an integrated technical showing that includes in a unitary format the aspects of the original technical proposal for Odyssey™ that have been carried forward, as well as those that have been modified for this Amendment.[4/]

Attachment B to this Amendment contains TRW's demonstration -- pursuant to new Section 25.143(b)(3) of the Commission's rules -- that it is financially qualified to meet its estimated costs of the construction, launch, and first year's operation of the twelve operational satellites that will comprise Odyssey™, plus two ground spare satellites. TRW has sufficient current assets, based on its most recent audited financial statements, to cover the entire $1.8+ billion estimated costs of Odyssey™ through the first year of operation. Moreover, TRW has made the requisite showing that the management of TRW Inc., absent a material change in circumstances, is committed to expending the funds necessary to establish Odyssey™.[5/]

3/ "Odyssey" is a trademark of TRW Inc. Odyssey™ is a satellite telecommunications system which is to be comprised of a constellation of twelve satellites in medium Earth orbit.

4/ As a result, Attachment A and its figures and appendices replace Section IV (pp. 33-51) of the original application and its associated appendices, as modified by TRW's July 1991 Erratum and Technical Clarification.

5/ Pursuant to Section 25.114(c)(17) of the Commission's rules, as imposed upon Big LEO applicants by new Section 25.143(b)(1), TRW also includes as part of Attachment B a detailed schedule of the estimated investment and operating costs for Odyssey™ by year during the pre-operational and design lifetime phases of Odyssey™'s satellites. See 47 C.F.R. §§ 25.114(c)(17) and 25.143(b)(1).

TRW has also updated its legal qualifications showing. As was the case in the original application, only TRW Inc.'s employee stock ownership plan owns or votes ten percent or more of the common voting stock of TRW Inc. There have, however, been a number of changes in the composition of the officer and director corps of TRW. These changes are reflected in the revised FCC Form 430 (with appropriate exhibits) that is included in Attachment C to this Amendment.

As required by new Section 25.143(b)(1) and Section 25.114(c)(21) of the Commission's rules, TRW has updated its schedule of the dates by which it currently anticipates that construction of the satellites of Odyssey™ will be commenced and completed, the dates on which the satellites will be launched, and when the system will be placed into service. This updated schedule is included as Attachment D to this Amendment.

Finally, and as required by the Commission's MSS Above 1 GHz Report and Order, TRW is requesting authority to launch and operate its proposed Big LEO system. Attachment E to this Amendment contains a copy of TRW's application for authority to launch and operate the Odyssey™ system, and this application is hereby incorporated by reference into the instant application, as amended.

TRW emphasizes that it has made a concerted, good faith effort to comply in full with the technical and other requirements of Sections 25.114 and 25.143 of the Commission's rules. To the extent that any particular information-gathering requirement of either of these rules does not apply to the Odyssey™ system concept, or that TRW's endeavors to comply with a provision may not have been perfected herein, TRW respectfully requests a waiver of the affected provisions to the extent necessary.

OVERVIEW OF ODYSSEY™'S TECHNICAL AND OPERATIONAL FEATURES

TRW is continuing today its pursuit of the forward-looking service concept, marketplace objectives, and public interest benefits it identified for Odyssey™ when the original application was filed in 1991. TRW, now as then, is placing its vast high technology manufacturing experience, its leadership in the satellite industry, and time-tested reputation as one of the world's preeminent space technology companies fully behind Odyssey™. TRW expects nothing less than that Odyssey™ will remake the marketplace for global mobile telecommunications services.

With this Amendment, TRW does not alter its proposal to establish a twelve-satellite constellation of medium-Earth orbit spacecraft that would operate in three separate orbital planes.[6/] Nor does TRW alter its commitment to employ spectrum efficient and pro-competitive code division multiple access ("CDMA") modulation techniques on its user links in the 1610-1626.5 MHz and 2483.5-2500 MHz bands. Both of these cornerstones of TRW's application are carried forward in the instant Amendment. Other unique features of TRW's initial approach -- e.g., the fact that the longer orbit periods attendant to Odyssey™'s medium Earth orbit operation reduce the need for complicated intracall handoffs, the generally high elevation angles (20 degrees or more) that minimize blockage by trees and buildings, and the reality that Odyssey™'s smaller number of satellites (as compared to other Big LEO concepts) means lower susceptibility to launch failures and on-station mishaps -- all remain intact under this Amendment.

What TRW has proposed to do is to make a number of design enhancements that will enable it to make efficient use of the limited amount of spectrum at 1610-1626.5 MHz that will be available for systems employing CDMA modulation techniques, and to do so in a way that will maximize the system capacity and interference tolerance of the CDMA systems that will be required to share spectrum both at 1610-1621.35 (and initially at 1610-1622.60 MHz) and at 2483.5-2500 MHz. For example, where TRW's original application proposed to operate with three 5.5 MHz channel bandwidths and a 19-beam configuration across the 1610-1626.5 MHz band, TRW has reduced the bandwidths to 2.5 MHz and each satellite in Odyssey™ will now be able to project 37 contiguous "cells" onto the surface of the Earth. TRW has also included a CDMA call alerting signal as an optional premium service that may be used to notify mobile users of an incoming call if the normal paging process is not effective due to signal attenuation within large structures.

TRW's use of CDMA techniques will allow for full frequency spectrum reuse over each satellite's 37 beams -- a significant improvement over the original application, and one that results from the obligation to share with multiple CDMA

6/ As a constellation of non-geostationary satellites, Odyssey™ is in compliance with new Section 25.143(b)(2)(i) of the Commission's rules. The selection of orbital planes and altitudes made by TRW means that Odyssey™ readily satisfies the coverage capability requirements of new Sections 25.143(b)(2)(ii) and (iii) of the Commission's rules. See Attachment A at Figures 2b and 2c.

systems -- and the decision to channelize the spectrum into 2.5 MHz subbands affords TRW tremendous flexibility in terms of traffic management; individual cells or frequency subbands can be turned off or avoided in situations where interference to or from users of other services would ensue. Indeed, the 2.5 MHz subband/37 beam configuration was designed specifically to enable TRW to comply with the obligations that are imposed on MSS Above 1 GHz systems operating in the lower portion of the 1610-1626.5 MHz band by new Section 25.213(a) of the Commission's rules (dealing with protection of the radioastronomy service during periods of observation) and by the continuing need to protect certain aeronautical radionavigation services from harmful interference so long as spectrum is shared by Big LEO and aeronautical radionavigation users. This configuration also enables TRW efficiently to comply in full with the Commission's new global coverage requirement.[7/]

As a result of the minor modifications TRW has made to the design of Odyssey™, each satellite will now have a capacity of 3000 users. Because two satellites will provide simultaneous coverage at any given point, 6000 users may be simultaneously

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7/ As will be noted below, TRW's move to smaller subbands and more beams per satellite has an impact on its feeder link spectrum requirements. Where feeder links for 19 beams could be accommodated in just over 100 MHz of Ka-band spectrum in each direction, the current 37-beam proposal, coupled with full frequency reuse capability in each beam, will require approximately 300 megahertz of Ka-band spectrum in each direction once adequate guardbands and TT&C capabilities are factored in. Because this increase in feeder link spectrum requirements for TRW is the inevitable byproduct of the change TRW has made in Odyssey™'s beam pattern to bring its system into conformance with both the rules and policies adopted in the MSS Above 1 GHz Report and Order, the feeder link issues must be deemed not to affect TRW's status as a member of the first-round processing group. See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 25. See also id. at 61 (Commission recognizes that four of the Big LEO applicants -- including TRW -- have indicated that their feeder link spectrum requirements have "increased significantly" since the original applications were filed). In any event, TRW notes that its proposal to increase from 100 to 300 MHz of feeder link spectrum in each direction will not create any conflict with any other current Big LEO applicant's proposal, or with any other applicant that has secured cut-off protection for proposals to use the frequencies requested by TRW for its feeder links.

served in any single region. These figures have been increased substantially from the original Odyssey™ application, as system capacity is maximized through full frequency reuse in the 37-cell system. Moreover, because TRW has the ability to manipulate the bandwidth and RF transmit power of each beam and to direct coverage to selected areas, circuits can be concentrated from areas of low traffic density to areas of high traffic density. Odyssey™ will thus be able dynamically to maximize the number of users that can access the system at any one time. This is a unique feature among the Big LEO systems, and one that further enhances the efficiency of TRW's approach.

TRW will establish earth station and TT&C facilities on the U.S. west coast and U.S. east coast. Initially, the west coast facility will be used to manage and control the satellite constellation; both stations will serve as gateways for providing Odyssey™ capacity to customers and/or users. One substantial benefit of TRW's medium Earth orbit approach is that with just two gateway earth stations -- one located on the U.S. west coast and one on the U.S. east coast -- Odyssey™ can provide service to all of the United States region (i.e., the 50 states, Puerto Rico, and the U.S. Virgin Islands). Global service can be provided with a few strategically located earth stations (the two U.S. earth stations plus additional stations on the other continents). Additional users can be accommodated with the establishment of more gateway earth stations, with the possible future deployment of additional satellites in each of Odyssey™'s orbital planes, or with some combination of the two.

Each type of user transceiver to be associated with Odyssey™ will have a dual mode configuration that will support communications through Odyssey™ and through one of the multiple terrestrial cellular system standards. All of the functions to be performed by the handsets are now commercially available, and the typical unit itself will be similar in size, weight, and power to state-of-the-art cellular handsets.

REVISED FREQUENCY PLAN

In order to comply with the interim and permanent band sharing plans adopted in the Commission's MSS Above 1 GHz Report and Order, TRW has made a number of minor modifications to its frequency plan for Odyssey™. Whereas the original application contemplated that Odyssey™ would operate across the entire 1610-1626.5 MHz band for the user-to-satellite link, Odyssey™'s current plan for the United States region would initially allow use only of spectrum in the 1610-1622.6 MHz band, with ultimate transition to full-time use of the 1610-1621.35 MHz band segment.[8/]

As noted above, TRW is also revising its feeder link spectrum requirements. Whereas TRW initially applied for just over 100 MHz of spectrum in the 29.5-30.0 GHz band for its uplinks and 100 MHz at 19.7-20.2 GHz for its feeder link downlinks, TRW is now seeking 300 MHz within the same bands. Specifically, TRW is seeking to employ the 29.7-30.0 GHz band for its Earth-to-space feeder link transmissions and the 19.8-20.1 GHz band for its space-to-Earth feeder link transmissions.[9/] In the 20/30 GHz bands, Odyssey™'s 37 beams will share 108 2.5 MHz, frequency division multiplexed channels, and will employ CDMA modulation techniques within each channel.[10/]

8/ As the Commission permitted, TRW will construct its satellites to include the capability of operating across the entire 1610-1626.5 MHz band (i.e., with six 2.5 megahertz bands). See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 22. Moreover, while TRW has adopted a frequency plan that conforms to the band sharing scheme the Commission has now adopted for the United States, it intends to pursue alternative frequency plans for its "bent-pipe" system outside of the United States. Id. at 83. TRW would also expect to have an opportunity to conform to any further modifications that may be adopted on reconsideration.

9/ Details of TRW's feeder link transmissions are provided in Attachment A to this Amendment.

10/ In its MSS Above 1 GHz Report and Order, the Commission stated that it would not make any final feeder link assignments when it issues the first Big LEO license(s) in January 1995. Instead, it stated that it would grant construction permits that are conditioned only upon the ultimate issuance of feeder link assignments, and allow permittees to commence construction at their own risk pursuant to waivers of Section 319(d) of the Communications Act. MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 63. The Commission also stated that it would continue to pursue the allocation of frequency bands at and below 15 GHz for Big LEO feeder links, and vowed to "allow licensees to modify their licenses to request operational authority in any new bands if, and when, they become available." Id., slip op. at 63-64. TRW hereby states that it is prepared to proceed with the construction of 20/30 GHz band feeder link capacity if its

(continued...)

Finally, as was the case in TRW's original application for Odyssey™, there is a limited amount of C-band spectrum that would be used by Odyssey™ satellites for telemetry, tracking, and command ("TT&C") purposes during the launch, deployment, "safe haven," and depositioning phases of the satellites' lifecycles. Once a component spacecraft of Odyssey™ is established on-orbit, the TT&C subsystem would switch to the 20/30 GHz band frequencies that are used for feeder links.[11/]

INTERFERENCE ANALYSES

TRW's proposal to use CDMA spread spectrum modulation techniques for Odyssey™ substantially minimizes both interference between MSS Above 1 GHz systems that are operating on a co-frequency basis, and interference between Odyssey™ and other co-primary radio services with which the MSS Above 1 GHz service is to share specific frequency band segments. The design and operational considerations that TRW will employ in order to comply with the applicable interference-mitigation requirements that the Commission adopted in its MSS Above 1 GHz Report and Order are described in detail in Attachment A to this Amendment (and its associated appendices).

Sharing with Other MSS Above 1 GHz Systems

TRW has modified its satellite design from the original application in several ways to enhance its ability to share spectrum on a co-frequency basis with other Big LEO systems that will employ CDMA modulation techniques. First, TRW reduced the bandwidth of its beams from 5.5 MHz to 2.5 MHz, which allows greater flexibility

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10/ (...continued)
application is granted, and no other appropriate feeder link spectrum is made available on a timely basis. However, in the event that sufficient feeder link spectrum is made available at or below 15 GHz for Big LEO permittees, either on a co-directional or reverse-band working basis with respect to bands now heavily used or available for use by geostationary fixed-satellite service systems, TRW would expect to be provided with an opportunity to modify its system authorization to specify feeder links in the lower frequency range(s).

11/ A complete description of the C-band TT&C frequencies TRW would use for Odyssey™ is included in Attachment A to this Amendment.

in frequency band assignment and traffic management both on an intrasystem and an intersystem basis. TRW also increased the number of beam "cells" per satellite coverage area from 19 to 37, and enhanced frequency reuse capabilities. Because TRW has the ability to shut down certain 2.5 MHz subbands within any of the 37 cells (each with a diameter of 600 nautical miles) in order to mitigate or avoid an interference situation, the design modification should enhance the ability of Odyssey™ to operate on a non-interfering basis with other Big LEO systems.[12/]

TRW recognizes that mutual interference between Odyssey™ users and the users of other CDMA Big LEO systems has the potential to limit total Big LEO system capacity in the portion of the 1610-1626.5 MHz band that is available to them. Nevertheless, analyses conducted by TRW -- both alone and in conjunction with other Big LEO system applicants -- reveal that the total number of users that can be accommodated within the spectrum available for CDMA systems is much greater than the number that the Odyssey™ system, operating alone as a twelve-satellite constellation, is designed to serve. This means that there is room for future growth for Odyssey™ as user demand increases, and for multiple CDMA systems.

Sharing with the Radioastronomy Service

In new Section 25.213 of the Commission's rules, there are a number of provisions designed to ensure that MSS Above 1 GHz systems operating at or near the 1610.6-1613.8 MHz band that is shared on a co-primary basis with the radioastronomy service do so compatibly. TRW recognizes its obligations with respect to the radioastronomy service, and commits to taking whatever steps are required to ensure that Odyssey™'s operations will comply with the new rules. Specifically, and as permitted by Section 25.213(a)(1)(iii), Odyssey™ will not serve user transceivers in the appropriate frequency bands of whichever of the 37 beam(s) are covering the exclusion zones surrounding the radioastronomy sites listed in Sections 25.213(a)(2)(i) and (a)(2)(ii)

12/ With respect to the ability of Odyssey™ to share with other systems the 300 MHz of spectrum TRW is requesting in each direction for 20/30 GHz band feeder links, TRW notes that sharing between Odyssey™'s 20/30 GHz-band feeder links and a limited number of geostationary fixed-satellite service satellites may be feasible. As to Odyssey™'s ability to share feeder link spectrum at 20/30 GHz with other Big LEO systems, TRW has serious concerns about the feasibility of co-frequency sharing on any basis other than, possibly, opposite-sense polarization.

during periods of actual observation. Moreover, and despite the fact that it is TRW's preference and intention to enter into a coordination agreement with the Electromagnetic Spectrum Management Unit ("ESMU") of the National Science Foundation that sets forth the terms pursuant to which Odyssey™ may employ a beacon-actuated protection zone concept to meet its obligations,[13/] TRW is prepared to implement precision position determination techniques or completely shut down service in the relevant frequency bands on the satellite antenna beam(s) that cover a radioastronomy site during any periods of actual observation of which it receives notice pursuant to Paragraph 107 of the MSS Above 1 GHz Report and Order.[14/]

As TRW identified in its July 1991 Erratum and Technical Clarification, it will use harmonic rejection filters in the S-band transmitters of Odyssey™ spacecraft in order to ensure that any spurious emissions in the 4990-5000 MHz band are reduced to acceptable levels.[15/] The harmonic filters TRW will employ will limit spurious emissions in the 4990-5000 MHz band to no more than -241 dB(W/m^2/Hz), thereby bringing TRW into compliance with the provisions of new Section 25.213(a)(3).

Sharing with Aeronautical Radionavigation Systems

The modifications TRW has made to the design of Odyssey™ will in no way compromise the ability of mobile earth stations that will operate with Odyssey™ in the 1610-1626.5 MHz band to comply with the various requirements that have been imposed upon such stations by the Commission. For example, all mobile earth stations operating

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13/ The Commission expressly stated that such a protection zone system could be employed in lieu of fixed-radius protection zones and position determination capability if the respective MSS Above 1 GHz system operator and the ESMU could agree to the terms and conditions of such a system. See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 41-42.

14/ See id. at 43.

15/ See TRW Application, Erratum and Technical Clarification at p. C-6.

with Odyssey™ will not radiate an equivalent isotropically radiated power ("e.i.r.p.") density greater than -15 dB(W/4kHz), irrespective of the frequencies to be used.[16/]

Sharing with the Radionavigation-Satellite Service

Mobile earth stations that comply with the e.i.r.p. density levels stated in new Section 25.213(b) of the Commission's rules with respect to out-of-band emissions in the 1574.397-1576.443 MHz band will be able successfully to operate with the Odyssey™ system. Accordingly, sharing between Odyssey™ and the Global Positioning System ("GPS") should occur without difficulty.[17/]

16/ TRW is of the view that by limiting its associated mobile earth stations in the 1610-1626.5 MHz band to e.i.r.p. levels of no greater than -15 dB(W/4kHz), it will be in full compliance with the requirements of International Radio Regulation No. 731E (which is imposed on MSS Above 1 GHz systems by new Section 25.213(c) of the Commission's rules). Nevertheless, it recognizes that the Commission has interpreted RR 731E/Section 25.213(c) in a manner that imposes on mobile-earth stations in the 1610-1626.5 MHz band the additional obligation of not causing harmful interference to or claiming protection from stations in the aeronautical radionavigation service and stations operating pursuant to RR 732. See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 48. TRW intends to seek reconsideration of this aspect of the MSS Above 1 GHz Report and Order. However, until such time as the Commission's interpretation of RR 731E/Section 25.213(c) may be conformed with TRW's prior understanding, TRW will ensure that its associated mobile earth stations will both radiate an e.i.r.p. density of no greater than -15 dB(W/4kHz) and not cause harmful interference to or claim protection from stations operating pursuant to RR 732.

17/ Indeed, it is to be expected that makers of "high-end" handsets that will operate with Odyssey™ will incorporate GPS chips and capability into the devices.

Sharing with Fixed Services

In its MSS Above 1 GHz Report and Order, the Commission adopted as a power flux density ("pfd") "threshold" for Big LEO space-to-Earth transmissions at 2483.5-2500 MHz the values that are specified in RR 2566.[18/] If those values are exceeded, the offending system must coordinate with affected terrestrial systems.

TRW's use of the 2483.5-2500 MHz band will comply with the Commission's power flux density determinations. As a general proposition, the angles of arrival for Odyssey™ are sufficiently high as to allow the use of the highest pfd value from RR 2566. In those cases where Odyssey™'s use of the 2483.5-2500 MHz band may place it above the pfd "threshold," TRW will undertake to coordinate its use of those beams to the extent necessary. TRW remains mindful, however, of the ongoing efforts to pursue an international relaxation of the pfd limits that apply to the Big LEO S-band downlinks, and is hopeful that changes will be made at either the 1995 or the 1997 World Radiocommunication Conference that will obviate any potential need for TRW to coordinate its downlink for Odyssey™ with any terrestrial users.[19/]

TRW also recognizes that an additional potential coordination obligation relating to the fixed service is imposed by new Section 25.213(d) of the Commission's rules. Mobile earth stations operating in the 1610-1626.5 MHz band are obliged not to cause harmful interference to or complain of interference received from stations in certain foreign countries that have the right (pursuant to RR 730) to use the 1610-1626.5 MHz band for fixed service stations on a primary basis. With respect to operators of mobile earth stations associated with Odyssey™ that wish to use spectrum in the countries (or their successors) named in RR 730, TRW is prepared to assist in the necessary coordination pursuant to International Telecommunication Union Resolution 46.

18/ See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 57. Under RR 2566, the pfd limits vary from -142 dB($W/m^2/4kHz$) to -152 dB($W/m^2/4kHz$) depending upon the angle of arrival of the incoming signal.

19/ See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 57.

REGULATORY CONSIDERATIONS

Non-Common Carrier Status

TRW does not intend to provide space segment capacity on Odyssey™ directly to end users. Instead, TRW will sell or lease space segment capacity in bulk to resellers and others that will, in turn, offer commercial mobile radio services ("CMRS") to end users. As a result, TRW is entitled to be regulated as a non-common carrier, and requests such a designation.[20/]

Nature of System Modifications

TRW believes that the system modifications identified in this Amendment, either by themselves or cumulatively, do not constitute a "major" amendment under Section 25.116 of the Commission's Rules.[21/] The "minor" nature of the Amendment is not altered by the fact that TRW now proposes to increase the number of beams its satellites lay down on the Earth's surface or by the corresponding alteration to TRW's feeder link spectrum requirements. Both of these changes came about as a result of TRW's efforts to conform to the Commission's spectrum assignment scheme and coverage requirements in a way that maximizes both the efficiency of operation and the sharing opportunities for all first-round systems.[22/]

20/ See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 68. See also 47 C.F.R. § 25.114(c)(20).

21/ See 47 C.F.R. § 25.116. See also MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 25 (Commission implies that changes that are not necessary to bring application into conformance with new rules but that do not create increased frequency conflicts would be acceptable).

22/ In this regard, TRW notes that following the Commission's call for conforming amendments in the wake of its issuance of a report and order establishing the new Non-Voice, Non-Geostationary ("NVNG") MSS late last year, one applicant filed a "conforming" amendment that increased by 50 percent the number of non-geostationary satellites in its proposed constellation, increased the number of orbital planes, and lowered the planned altitude of its spacecraft -- all without (continued...)

TRW notes further that an exception to the treatment of an amendment as "major" will be made in cases where "[t]he amendment resolves frequency conflicts with authorized stations or other pending applications but does not create new or increased frequency conflicts."[23/] Here, TRW's frequency plan for Odyssey™ will facilitate sharing among the Big LEO applicants, and does not create new or increased frequency conflicts with any of them.[24/]

Construction/Deployment Schedule

TRW expects to commence construction of Odyssey™ in the immediate future. On November 7, 1994, TRW was granted a waiver of the construction permit requirements of Section 319(d) of the Communications Act of 1934, as amended, 47 U.S.C. § 319(d), pursuant to which it is now permitted to expend up to $10 million to commence construction of Odyssey™ and procurement of long lead items at its own risk.[25/] Upon the conditional grant of its application for Odyssey™, which is expected in January 1995, TRW will continue its construction program (seeking any additional waivers that may be necessary), even though the multi-level milestone schedule to be applied to Odyssey™ will not formally commence until after the condition imposed as a result of the feeder link assignment situation has been removed.

22/ (...continued)
being charged with filing a "major" amendment. The Commission determined that because the cumulative effect of the applicant's system changes did not increase the potential interference to the system to be implemented by another NVNG MSS applicant, the modifications were acceptable. See Orbital Communications Corporation, FCC 94-268, slip op. at 9 (released October 27, 1994).

23/ 47 C.F.R. § 25.116(c)(1).

24/ See also 47 C.F.R. § 25.116(c)(4).

25/ See Letter dated November 7, 1994, from Chief, International Bureau to Counsel for TRW, File No. 8-DSS-MISC-95.

At this time, and because of the Commission's decision not to make "final" feeder link assignments at the time initial system license(s) are awarded in January 1995,[26/] TRW is unable to state with certainty what its schedule for completion of the construction of the satellites of Odyssey™ will be, nor can it state when the satellites will be launched and placed into service. TRW can state unequivocally that it will not exceed the periods for commencement/completion of satellite construction and for launch and placement of satellites into operation that will be accorded by the milestone schedule that will be established with the grant of TRW's final authorization. If, however, feeder link assignments are finalized in a manner that does not delay TRW's current program projections for Odyssey™, TRW will operate pursuant to the schedule projections that are included in the Construction and Launch Schedule for Odyssey™ that is included as Attachment D to this Amendment.

Launch Considerations

On this date, TRW is applying for Commission authority to launch and operate its MSS Above 1 GHz service system. Although TRW has not finalized arrangements for the dual satellite launches that it is planning for the twelve operational spacecraft that will comprise Odyssey™ (replacement launches will be made on a single-satellite basis as needed), TRW reports that there are a number of domestic and international commercial launch services operators that are capable of accommodating TRW's needs.[27/] TRW will procure launch services for Odyssey™ in due course, and in a manner consistent both with its budgetary projections and program schedule constraints.

Section 304 Waiver

TRW waives any claim to the use of any particular frequency or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise, and requests authority in accordance with its Application, as Amended.

26/ See MSS Above 1 GHz Report and Order, FCC 94-261, slip op. at 62.

27/ The manner in which the component spacecraft of Odyssey™ will be deployed and established in their proper orbits is described in Attachment A to this Amendment.

* * *

On the basis of this Amendment, TRW urges the Commission to find that it is legally, technically, and financially qualified to construct, launch, and operate its proposed MSS Above 1 GHz satellite system. TRW has complied in all ways with the rules the Commission recently adopted for the MSS Above 1 GHz service, and implementation of Odyssey will clearly advance the public interest, convenience, and necessity.

Respectfully submitted,

Timothy W. Hannemann

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ATTACHMENT A

Odyssey™ System Technical Description

The Odyssey™ personal communication satellite system illustrated in Figure 1 will provide high quality personal and mobile communication services globally between 70° North latitude and 55° South latitude. These services include voice and data (including messaging) and will be provided by a constellation of medium-altitude Earth orbiting satellites. Communication can be established either between mobile and fixed users or between pairs of mobile users. A fixed user is one who is connected to the terrestrial networks. The mobile customers will use inexpensive hand-held or vehicle mounted communication transceivers. These transceivers will be self-powered and generally require less than 0.5 watt of average transmitted power to provide quality communications.

The satellite constellation for which authorization to construct is sought will be comprised of twelve satellites in three orbital planes. The satellite orbits will be circular, with an altitude of approximately 5600 nautical miles. At this altitude, the user-to-earth station propagation time delay will range from 68 to 104 milliseconds for mobile to fixed users, thus virtually eliminating the adverse effect of delay on interactive voice communications. In addition, the altitude is high enough so that the effects of the Van Allen radiation belt, which are known to cause degradation to satellites and interfere with service, are minimal. Only nine satellites (three per plane) are required to provide at least one satellite in view of any user

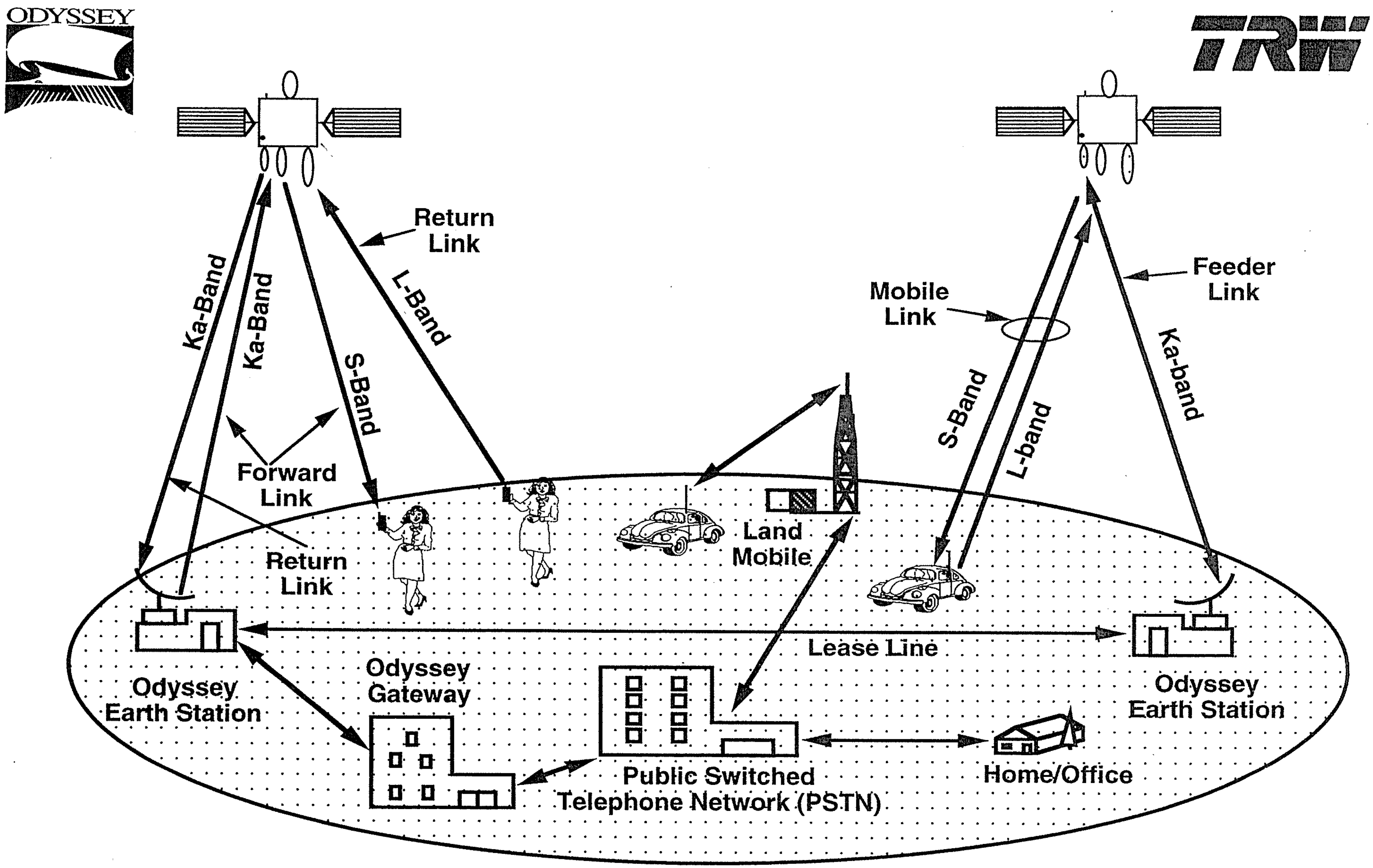

Figure 1: Odyssey System Overview

anywhere in the world. Twelve satellites will ensure that at least two satellites are visible to any user anywhere in the world.

In order to satisfy the coverage requirements of new Section 25.143 of the FCC's rules, each satellite will have a multibeam antenna pattern that divides its coverage area into 37 contiguous cells (i.e., beams), each providing an approximately 600 nautical mile diameter spot on the Earth. Each cell will be fully capable of using frequencies within the entire allocated bandwidth of 16.5 MHz. This design improvement is a direct result of the US service region and global coverage requirements adopted in the Report and Order. In the US region, the system will use only those frequencies allocated for CDMA. Specifically, up to 12.60 MHz (at 1610-1622.60 MHz) will be used during the duration of the FCC's interim plan. Thereafter, 11.35 MHz in the frequency band from 1610 to 1621.35 MHz will be used as required by the baseline allocation for the US service region in the Report and Order. At all times, Odyssey™ will use the full 16.5 MHz assignment at 2483.5-2500 MHz for its space-to-Earth user-link transmissions.

Odyssey™ will use spread spectrum code division multiple access (CDMA) signaling methods. As such, Odyssey™ can share frequency spectrum with other proposed systems employing CDMA techniques. At a minimum, Odyssey™ can share with the three other current CDMA applicants identified in the Report and Order, and may be able to share with one more CDMA non-geostationary system (depending on design characteristics, etc.).

User services setup and protocol procedures and formats for Odyssey™ will be similar to those developed for terrestrial cellular telephony systems. At call setup, a mobile user will be assigned, according to his cell location, a pair of uplink (L-band)/downlink (S-band) frequency subbands and a spread spectrum code. After the caller's account is validated, the ground station will connect to the public telephone network. If the second user is also mobile, the ground station will page the called number over the system signaling system. When the second mobile user responds, frequency subbands and codes will be assigned and the link will be established by the ground station. If necessitated by user movement or movement of the cell pattern, the user will be transferred between satellites or beams of a satellite during the course of a call. These assignments are to be handled automatically and will be transparent to the user.

The satellites are planned to be launched in pairs and placed in an elliptical parking orbit . Operation of the satellites will then be transferred to a ground station which will control satellite propulsive burns for the final orbit adjustment, deployment of the solar arrays and satellite antennas, orientation of the satellites, and operation of communication services.

Two earth stations -- one each located on the U. S. west coast and east coast -- will be used to provide service to North America . The west coast station will manage and control the satellite constellation and the communications assets on the satellites to ensure service to the subscribers. Worldwide service will be provided by additional earth stations placed at strategic locations. When a mobile user transmission is received at the satellite, it will be transmitted at Ka-band to a ground station in view of the satellite. It will then be routed to its destination by connection to the terrestrial network or to the called mobile user.

Eventually, additional system capacity may be provided by adding satellites to the system and/or by enhancing the corresponding earth station and network capability.

A. Orbit Selection and System Deployment

1. Orbit Selection

The Odyssey™ twelve-satellite constellation was selected to provide global communication services at low cost. TRW's selection of a medium-altitude Earth orbit represents a careful accommodation of several factors:

- minimizes the number of spacecraft and ground stations required to provide the desired degree of primary and redundant Earth coverage;
- optimizes satellite and subscriber unit terminal power requirements;
- ensures reliable service by providing two satellites in view of a user;

- allows reduced satellite antenna sizes (as compared to GEO satellites);
- minimizes beam to beam user transfer (as compared to LEO satellites);
- reduces the expected effects of the Van Allen radiation belt;
- limits propagation delay; and
- provides high view angles to the satellites to avoid blockage by trees and buildings, and terrain shadowing.

The selected altitude for the satellites, 5600 nautical miles, provides a satellite constellation which satisfies these objectives. The orbital period of the satellites is six hours. Figure 2a gives the characteristic parameters of the orbit. Figure 2b demonstrates that the coverage is continuous -- that is at least one Odyssey™ satellite is visible above 5° elevation angle at all times -- for the 50 US states, Puerto Rico, and the US Virgin Islands (henceforth called the US service region) with only nine satellites (3 per orbit plane) populating the Odyssey™ constellation. Inasmuch as the full Odyssey™ system will operate with 12 satellites (4 per orbit plane), the US service region requirement is clearly satisfied since 12 satellites provides additional coverage over and above that provided by nine satellites. In fact, the global coverage requirement of visibility above 5° elevation angle 75% of the time between 70° North and 55° South latitudes is satisfied with a six satellite (2 per orbit plane) constellation. This is shown in Figure 2c. Incidentally, Figure 2c also shows that the US service region coverage requirement, with the exception of Alaska, would be satisfied with a six satellite (2 per orbit plane) constellation. The robustness of the Odyssey™ constellation in

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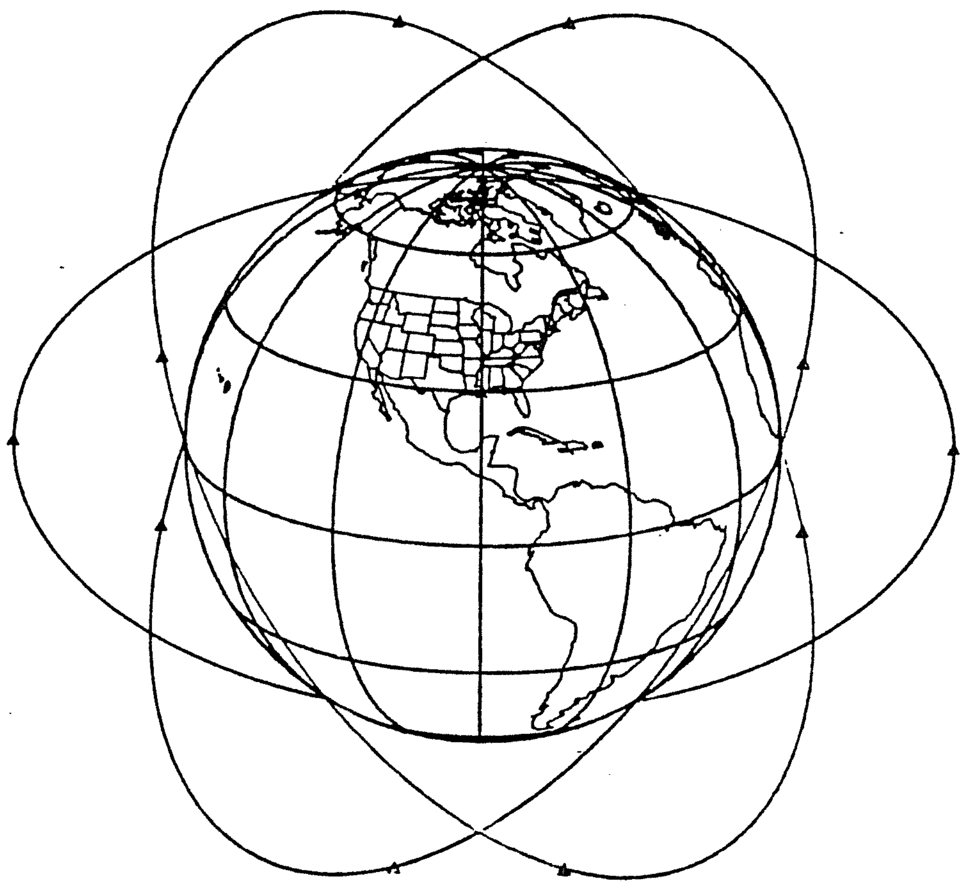

* Number of satellites: 12
* Number of planes: 3
* Altitude (circular): 5600 nm (or 10355 Km)
* Inclination: 50°
* Apogee: 5600 nm
* Perigee: 5600 nm
* Argument of Perigee: 0°
* Active Service Arcs: N/A
* Right Ascension of ascending node(s)
    - Reference: 0°, 120°, 240°
    - Varies during life time 0.1° per day

Figure 2a: Odyssey Satellite Constellation exceeding all coverage requirements of Section 25.143 is therefore manifest.

The 5600-nautical-mile satellite altitude places the satellites above the main region of the Van Allen radiation belt, yet handset to earth station propagation delay time is only between 68 to 104 milliseconds. The radiation environment impact on electronic systems at this altitude is easily managed. An additional benefit for system operation is the long time interval (up to an hour and a half) during which the satellite is visible to a user and the associated earth station. This minimizes the number of intra-call handoffs.

2. Launch, Deployment and Replenishment

The Odyssey™ constellation of twelve satellites will be deployed by launching two satellites at a time into one of three orbit planes. Each satellite will insert itself into the proper circular orbit using its on-board propulsion system. Replacement satellites will be launched as needed.

For initial deployment, each launch vehicle will place its payload of two satellites into a 100 x 5600 nm parking orbit, inclined 50 degrees to the equator. Once separated, each satellite will deploy its solar arrays, and maintain attitude reference using Earth and sun sensors. During this phase, an Odyssey™ ground station will assume control of both satellites using the facilities of a C-band ground network and the Odyssey™ TT&C system. The ground station will command firing of the orbit transfer engine to circularize the satellite orbit, after which the satellite will be oriented toward nadir and the communication system antennas deployed. Once the Ka-band gateway link is established, the C-band ground network support will be discontinued and satellite checkout will be completed, including maneuvering the satellite to its proper operational station via the Ka-band link. C-band TT&C will be available for contingency operation.

In the event of a satellite failure, the remaining satellites may be rephased to maximize coverage (single coverage at a minimum) until one of the ground spare satellites can be readied for launch. The profile for the launch of a single replenishment satellite will be similar to that for initial deployment . Once in the proper circular orbit, the satellite will be maneuvered to the station vacated by the satellite being replaced.

B. Space Segment

1. Frequency Plan

a. L/S-Band Links

The forward link includes a Ka-band link from the earth station to the satellite and an S-band link down to the user. The return link from the user to the earth station includes an L-band link to the Odyssey™ satellite and a Ka-band link down to the earth station. The satellite payload will function as a bent pipe, simple frequency translating transponder receiving and transmitting CDMA signals with no on-board signal processing.

Efficient spectrum utilization and mutual sharing requirements among the applicant CDMA systems, as imposed by the Commission's spectrum sharing plan, have led to design enhancements in the Odyssey™ system frequency plan. Flexibility in addressing the various frequency sharing requirements developed since filing the original application, has led to redefinition of channelization designs. Additionally, the enhanced design improves system flexibility with regard to interservice sharing constraints, out-of-band emission limitations, interference protection, and other requirements that were imposed in the Report and Order.

The Odyssey™ system design divides the 16.5 MHz L-band and S-band spectrum into six 2.5 MHz sub-bands. The Odyssey™ system is designed to be fully capable of utilizing the entire 16.5 MHz bandwidth in both the forward and return user/spacecraft link for CDMA signals in each of the 37 beams. The bandwidth of the subbands and the number of beams have been changed from the original applications in order to maximize the efficiency of Odyssey™'s spectrum usage and to conform flexibly to the spectrum plan adopted in the Report and Order. Originally, each Odyssey™ satellite was to have three 5.5 MHz subbands and 19 beams.

The entire S-band allocation of 2483.5 to 2500 MHz will be used by the Odyssey™ system for global coverage. Figure 3 shows the S-band spectrum utilization.

However, since there are varying restrictions on use of the L-band spectrum (1610 to 1626.5 MHz), each configuration will be discussed separately. Figure 4a shows the Odyssey™ design for use of the full 16.5 MHz L-band spectrum. In this situation all six 2.5 MHz sub-bands would be used.

Until Odyssey™ is no longer required to protect GLONASS operations in the 1610-1626.5 MHz frequency band (i.e., during the period within which the FCC's interim spectrum assignment plan is in effect), Odyssey™ will operate in the US service region across as much of the 1610 to 1622.6 MHz band as it can. This is shown in Figure 4b. Odyssey™'s proprietary signal design (patent pending) is being studied for modification to allow the option of half-band spreading so that the available L-band spectrum can be optimally utilized. Additionally, as shown in Appendix A, the L-band EIRP density requirements of RR 731E are easily satisfied by the Odyssey™ system. In the event and to the extent that the 1610 to 1612 MHz portion of the spectrum is not initially available for operation, Odyssey™ will shut down the lowest frequency 2.5 MHz sub-band (sub-band A) and operate as shown in Figure 4c.

S-Band (2483.5 - 2500.0 MHz) Spectrum Utilization

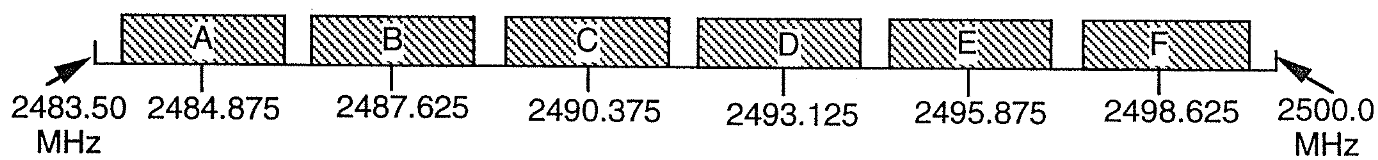

Figure 3

L-Band (1610 - 1626.5 MHz) Spectrum Utilization

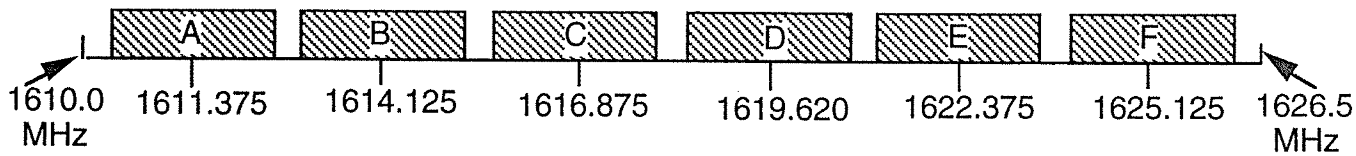

Figure 4a: Full L-Band Operation

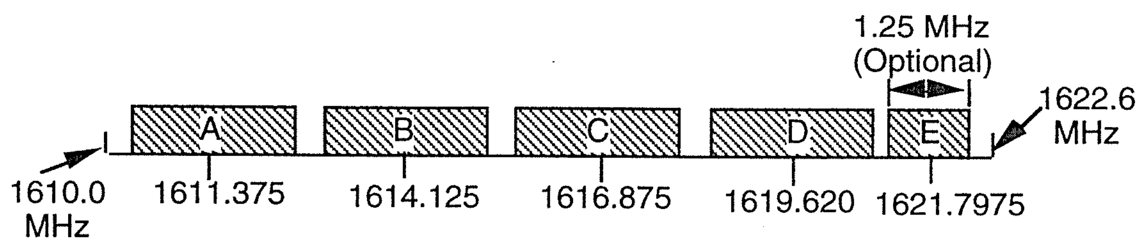

Figure 4b: Interim Sharing Plan Operation

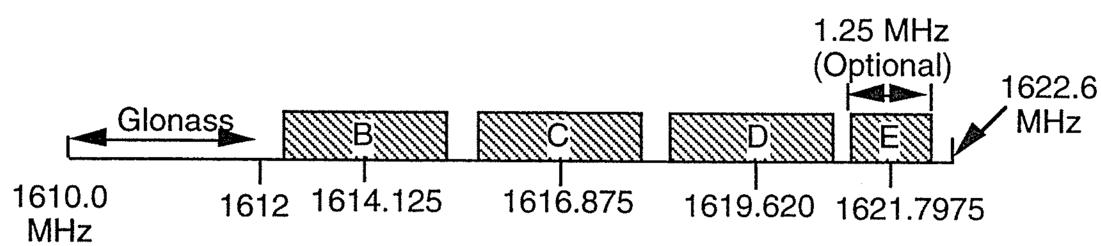

Figure 4c: Interim Sharing Plan Operation

When the entire 1610 - 1626.5 MHz band becomes available for operation, and the interim plan adopted in the Report and Order is terminated, Odyssey™ will revert to the basic frequency sharing plan and operate in the 1610 to 1621.35 frequency range utilizing the 11.35 MHz of allocated bandwidth (sub-bands A,B,C, and D) as shown in Figure 4d. This reversion from the interim sharing plan to the basic sharing plan will be achieved by not using, in the US service region, the half-band (sub-band E) of the interim sharing configuration shown in Figure 4b. This allows a technically attractive system design solution for accommodation of the interim and final spectrum sharing plan. Because Odyssey™ is a bent-pipe system, all frequency shifts can be accomplished with relative ease from the ground stations.

Odyssey™ will protect the Radio Astronomy Service (RAS) during actual radio astronomy observation periods by not serving user transceivers within the RAS exclusion zones in the appropriate frequency bands of the satellite antenna beams covering the RAS sites listed in Section 25.213. The Odyssey™ baseline design contemplates using beacon actuated protection zones in lieu of fixed radius protection zones. Odyssey™ intends to coordinate this approach with the Electromagnetic Spectrum Management Unit (ESMU) of the National Science Foundation. In the absence of coordination agreements with the ESMU, Odyssey™ will implement precision position determination techniques or completely shut down service in the

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L-Band (1610 - 1626.5 MHz) Spectrum Utilization

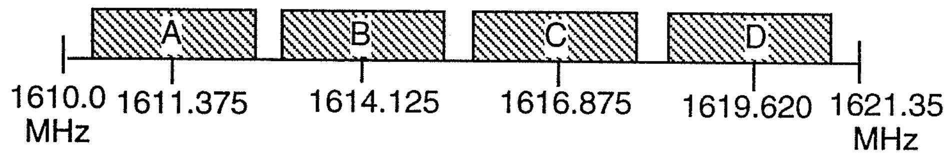

Figure 4d: Basic Sharing Plan Operation

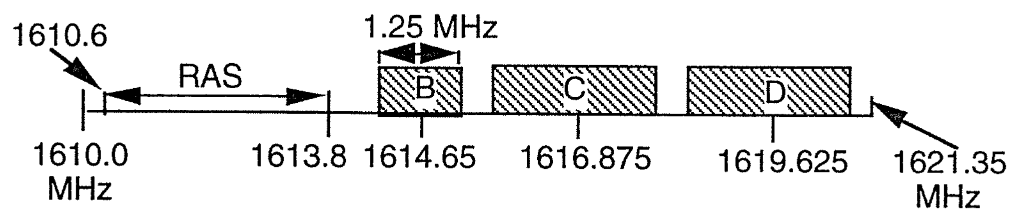

Figure 4e: RAS Optional Operation

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Feeder Link Frequency Plan

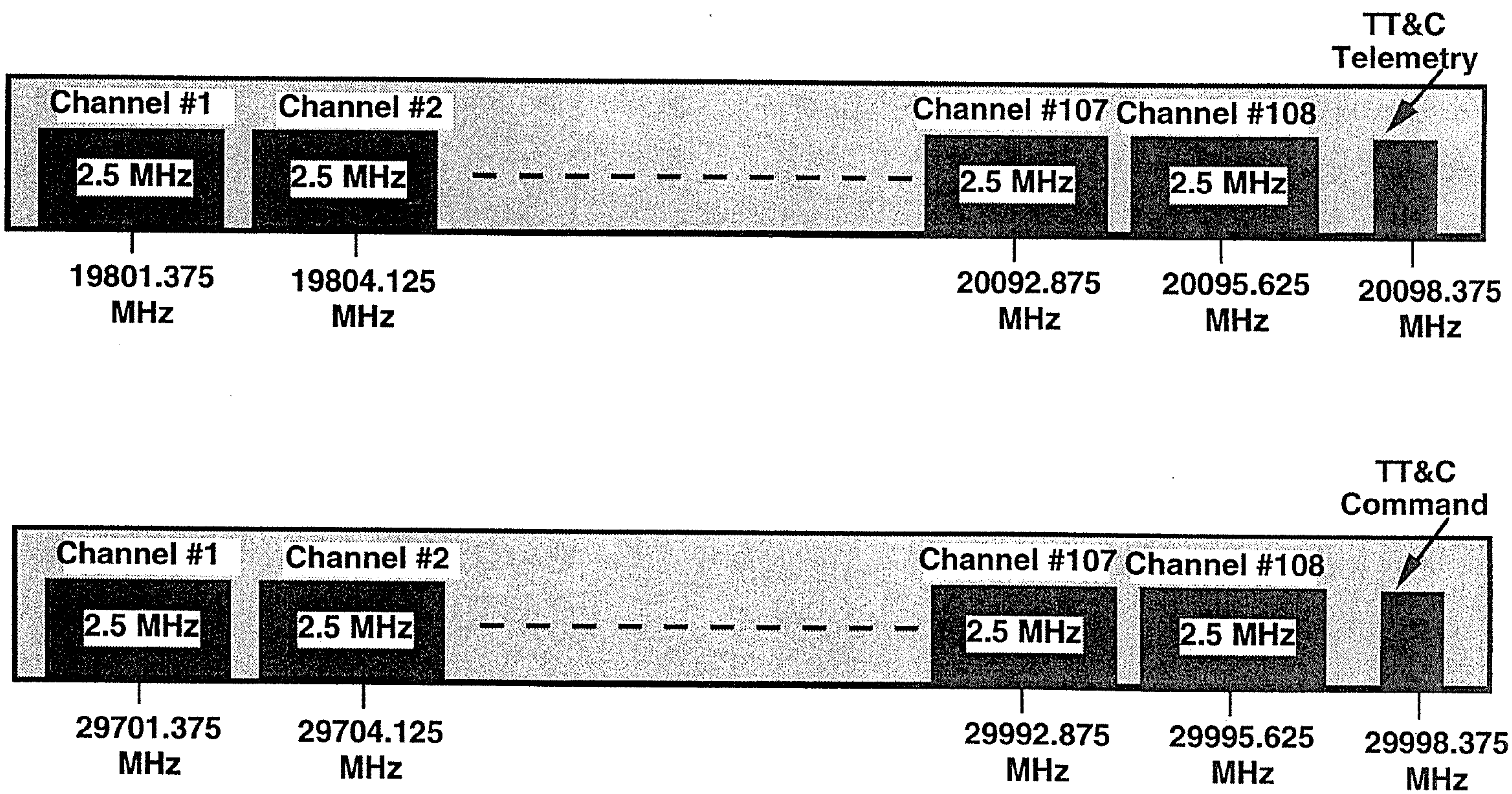

Figure 5

relevant frequency bands on the satellite antenna beam(s) covering an RAS site during periods of observation that have been duly notified to TRW. In this situation the L-band spectrum utilization would be as shown in Figure 4e with one-half of sub-band B, and sub-bands C and D utilized. It must be emphasized that this is the least desirable of solutions.

Odyssey™ will thus have full capability to comply with all interservice sharing and protection requirements. The 2.5 MHz sub-bands allow system flexibility for operational constraints, user traffic distribution variability, and regulatory compliance.

b. Ka-band Links

Provision of the above spectrum utilization flexibility induces increased feeder link bandwidth requirements. Additionally, the US service region and global coverage requirements, which drive the antenna design increase in the number of beams to 37, force an increase in the required feeder link bandwidth. Accordingly, Odyssey™ now requires a feeder link bandwidth allocation of 300 MHz.

The mobile link frequency bands are assembled into a frequency division multiplex (FDM) format of 300 MHz bandwidth for transmission on the Ka-band feeder links as shown in Figure 5. Circular polarization is used on all links. Single circular polarization is used due to the degradation of polarization isolation induced by such phenomena as rain. This frequency plan is proposed for worldwide operation. Odyssey™ feeder link operations will be coordinated with licensees authorized to operate fixed-satellite service and terrestrial service systems sharing the same frequency band to determine the geographic protection areas around each non-geostationary MSS/RDSS feeder link earth station in accordance with Section 25.203(j). The gain characteristics of the spacecraft antennas towards each of the US earth stations are given in Appendix D. Also, the Odyssey™ space stations will conform to established coordination agreements, to the extent required by Section 25.203(k).

System signaling will be accomplished using similar CDMA schemes as for voice and data traffic. This will be accomplished through a combination of the reservation of a number of (traffic level dependent) voice channels, and the injection of low bit rate signaling messages into normal traffic channels. Forward link signaling will include paging, access, and control messages. Return link signaling will include access and control messages. An optional, premium service for call alerting may use a CDMA signal on the forward link to alert users of an incoming call if the normal paging process is ineffective due to paging signal degradation inside structures.

2. Frequency Reuse/Cell Management

The satellite antennas for the mobile receive and transmit links between the satellite and the users are designed to produce identical patterns in the two bands . The composite antenna footprint, including all beams at the narrowest dimension, will cover the broadest angle subtended by the fifty US states, Puerto Rico and the US Virgin Islands (the US service region) as seen from orbit. The satellite will be oriented by program track to position the composite pattern on the US service region to insure that all the region is covered. The beam pattern is circular so that coverage can be achieved without the additional complexity required to rotate an asymmetrical antenna pattern to fit the US region boundary.

CDMA technology allows for full frequency spectrum reuse over the 37 beams. This essential feature of CDMA, along with the sub-band channelization plan used by Odyssey™, permits powerful and dynamic flexibility for traffic management. The sub-band filtering to be used along with CDMA modulation will allow a relatively modest demand on antenna beam spatial isolation requirements since demodulation will spread the interfering spectra and filtering will provide additional interference suppression.

The Odyssey™ constellation is designed to permit dual coverage of the US service region. The 37 beam patterns of two satellites will be overlaid on the region. Thus RF power requirements on individual satellites will be reduced by dividing the required power for peak traffic periods between a pair of satellites. Frequency assignments will be made so as to maximize satellite and system capacity.

3. System Capacity

Cellular communication systems are evolving to digital modulation formats, with CDMA and TDMA techniques supplanting other multiple access schemes (e.g. FDMA). The Odyssey™ system is designed in keeping with the evolving CDMA technology, particularly with respect to terrestrial cellular telephony.

Odyssey™ system capacity is maximized through full frequency reuse in the 37 cell system. Factors involved in capacity calculations include:

- User voice quality
- Bit error rate (BER)
- CDMA spectrum spreading technique
- Voice activity factor
- User traffic load distribution
- Thermal noise
- Multiple access interference.
- Intersystem interference

Each Odyssey™ satellite will have a capacity of 3000 circuits. This capacity results in economical satellite primary power requirements. Distribution of the 3000 circuits among the 37 cells will not be uniform. The satellite transmitter complement is designed using matrix amplifier techniques so that each satellite has the capability to support 600 circuits in a "hot spot" beam. This arrangement allows the system controller the flexibility to match beam transmit power to user geographic distribution.

Most regions will be able to take advantage of dual satellite coverage. Dual satellite coverage improves the overall availability of the communication system to a user. Additionally, dual coverage of a region allows 6000 circuits to serve the region.

Basic digital data service will be accommodated in the Odyssey™ system by using a data rate of 2400 bits/sec. Digital data service quality will be assured by maintaining a system BER of 10^{-5} through the use of sophisticated error correction encoding schemes. The digital data rate of 2400 bps is a factor of 2 less than the voice data rate (4800 bps). This will result in a digital data system capacity comparable to the voice user system capacity. Other data rates through and including 19200 bits/sec may be accommodated in the Odyssey™ system. Of course, a mixture of voice and data formats is compatible with the Odyssey™ system design.

4. Communication Subsystem

a. User Links

The user links consist of the L-band and S-band user-to-spacecraft and spacecraft-to-user transmission paths. At one end of the link is the Odyssey™ handset which provides the voice and low data rate interface to the user. At the other is the Odyssey™ spacecraft. The Odyssey™ handset and spacecraft communication payload are both described later.

The link budgets (Appendix B) cover the end-to-end forward and return links. The user-satellite and satellite-base station link segments are combined to show the cumulative effect of each segment on link performance. Since at least one satellite will be 20 degrees or more above the horizon, all link budgets are done with elevation angles of 20° or higher.

b. Earth Station Links

The key earth station requirements are summarized in Table 1. Each earth station will include four antenna sites supporting concurrent operation with two satellites, plus handover operations with a third satellite. A spare antenna will be provided for extremely high availability and for maintenance. The four antenna sites are to be geographically mutually diverse to protect against sun intrusions and atmospheric conditions (primarily heavy rain) which degrade user service. The earth station will provide modulation/demodulation, multiplexing/demultiplexing, system signaling, and

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Table 1: Odyssey Earth Station Terminal Summary

Parameter	Uplink (transmit)	Downlink (receive)
Frequency	29.7 --> 30.0 GHz	19.8 --> 20.1 GHz
Bandwidth	300 MHz	300 MHz
Polarization	LHCP	RHCP
Ground Tracking Antenna		
* Diameter	7.0 meters	7.0 meters
* Gain	64.8 dBi (peak)	60.8 dBi (peak)
* 3 dB beamwidth	0.11 degree	0.17 degree
* Pointing angle range	10° --> 90° E.L	10 --> 90° E.L
Transmit EIRP per User	54.25 dBW	N/A
Receive G/T	N/A	32.5 dB/K

interfacing to the Public Switched Telephone Network (PSTN) for all satellites being serviced from the station.

An active ground station antenna must follow the track of a satellite it is servicing since Odyssey™ satellites will be in motion relative to the ground station. Up to two "active" satellites may be operating out of a single earth station. A third "rising" satellite may also be serviced from the same earth station. As an active satellite begins to "set" relative to a ground station, either the communications traffic must be handed off to a rising satellite or the active satellite must be handed off to another ground station. This transition will be transparent to Odyssey™ and PSTN users involved in active calls.

Each antenna site will provide frequency downconversion of the 37 antenna beams contained in each Odyssey™ return link. This signal will be routed to the baseband electronic equipment for processing. On the forward links the antenna site will upconvert the 37 antenna beam signals for transmission to the Odyssey™ spacecraft.

In the baseband electronic equipment, each received baseband spectrum will be passed through a group of spread spectrum de-spreaders. The de-spread signal will be demodulated and error correction decoded. The resulting user bit stream will then be available for connection to PSTN or for forward link transmission to another Odyssey™ user. Forward link processing involves encoding, spreading, modulation, and combining of the PSTN or Odyssey™ user bit streams in each beam for routing to the RF front end and ultimate transmission to an Odyssey™ spacecraft. Also included in the baseband electronics will be the common signaling channel processing required for establishing, maintaining, and terminating calls. Signaling information will be inserted into the bit stream.

c. Connection to PSTN

Bulk purchasers/lessees of Odyssey™ capacity will be able to utilize the Odyssey™ ground station to provide connection of voice or data users of the Odyssey™ system to either another Odyssey™ user or to a PSTN user. PSTN interconnection will be provided through a Gateway. The Gateway will perform all the conversions between the Odyssey™ formats for voice, data, and signaling to the format of the interconnecting PSTN. Gateways will be located at strategic sites throughout the world to allow users of Odyssey™ capacity to establish a circuit to any destination worldwide. Connections between two Odyssey™ users or between an Odyssey™ user and a PSTN user will be accomplished through a digital matrix switch. The Common Carrier Interface, to be located on the PSTN side of the matrix switch, will provide the final multiplexing and protocol interface to the PSTN.

d. **Communications Payload Equipment Description**

1. **L/S Band User Links**

The return link will be capable of being received in 2.5 MHz sub-bands by the 37 beam return link antenna over the frequency range of 1610 to 1626.5 MHz. The antenna outputs will be filtered, low-noise amplified and downconverted to IF using redundant active components. The downconversion will use a variable local oscillator (LO) to enable fixed IF filtering. Redundancy and frequency switching will be via stored or real-time ground commands through the spacecraft command and data handling subsystem.

2. **Feeder Links**

The payload can transpond up to 108 individual 2.5 MHz bands spaced 2.75 MHz from band center to band center. This allocation supports the 300 MHz feeder link and allows for telemetry and command signals and guard bands to prevent adjacent channel interference. A fixed quantity of frequency bands will be permanently assigned to beams. The remaining bands will be switched among the 37 beams to provide extra communication capability to specific geographic locations, as traffic requires. The filtering will be accomplished by narrowband surface acoustic wave (SAW) filters. The filter outputs will be combined into a single 300 MHz frequency division multiplexed (FDM) signal. The FDM signal will be identically divided three ways, upconverted to the 20 GHz Ka-band downlink frequency and amplified using a traveling wave tube amplifier (TWTA). The three redundant TWTAs will each output to a dual band (20 and 30 GHz, Ka-band), circularly polarized narrow beam antenna. Each of the three Ka-band antennas will be independently gimbaled and pointed toward earth stations. Since the same signals are to be transmitted by the three Ka-band antennas, up to three downlink footprints will be created, enabling three or more earth stations to simultaneously receive the Odyssey™ return link traffic and telemetry.

The 30 GHz band uplink signals will be collected by one or more Ka-band spacecraft receive antennas. The uplink signal has a 300 MHz bandwidth consisting of 108 2.5 MHz FDM bands and the spacecraft command signal, analogous to the Ka-band downlink signal. Each antenna's output will be amplified and downconverted to IF. The IF signals from the three receivers will be combined into a single 300 MHz IF signal. The combined IF will be separated into 2.5 MHz bands using SAW filters. The assignment of 2.5 MHz bands to the 37 transmitted mobile link beams follows the same implementation of fixed and switched bands as in the return link, above. By combining the IF signals of all three antennas and selecting the bandwidth for each mobile link beam, the traffic for a particular beam can originate from any earth station without the need for instantaneous reconfiguration of the payload.

The 37 IF signals will each be upconverted from IF to S-band. The S-band signals will be routed to five 8-way multi-port amplifiers (MPAs) which provide the final, high-power amplification. The MPAs have the capability of providing RF powers for each output port that are in proportion to the RF power at the input ports of that MPA without switching or internal reconfiguration. Thus, up to 20% of the RF output power of the payload can be assigned to any specific transmit beam. The amplified S-band signals will be propagated to the user terminals using a 37 beam antenna. The beams of the transmit and receive antennas are co-aligned to facilitate traffic management and power control. Table 2 gives basic payload parameters. A block diagram of the Odyssey™ payload is shown in the Figure 6.

5. Satellite Description

The Odyssey™ satellite depicted in Figure 7 will consist of a three-axis stabilized bus and a communication payload. The basic spacecraft is 1.9 meters long, 2.2 meters wide (28 meters wide with solar arrays deployed), and 2.4 meters high. The bus will provide electrical power for the payload transponders and pointing of two body-fixed user antennas (L-and S-band) and three independently gimbaled gateway antennas (Ka- band). The L- and S-band satellite antennas will both be offset antennas driven by feed element arrays that form the 37 beam pattern. Antenna pointing will be effected by orienting the satellite. The independently gimbaled Ka-band antennas duplex the transmit and receive links to the base station.

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Table 2: Payload Parameters

Payload	Mobile Link		Feeder Link	
Parameters	User-to-Satellite	Satellite-to-User	E/S- to-Satellite	Satellite-to-E/S
Frequency (MHz)	1610 -->1626.5	2483.5 --> 2500.0	29700 -->30000	19800 -->20100
Bandwidth (MHz)	16.5	16.5	300.0	300.0
Polarization	LHCP	LHCP	LHCP	RHCP
Antenna Coverage	38° Field-of-view	38° Field-of-view	1.73° @ 3 dB	2.58° @ 3 dB
Number of Beams	37 beams	37 beams	3 steerable ant.	3 steerable ant.
Active Unit	40 LNAs	40 SSPAs	3 LNAs	3 TWTAs
G/T	$\geq$ -1.1 dB/K	N/A	6.1 dB/K	N/A
Output Amplifier	N/A	24.8 W	N/A	10.0 W
AEIRP	N/A	54.9 dBW	N/A	44.8 dBW
Design life	15 years			

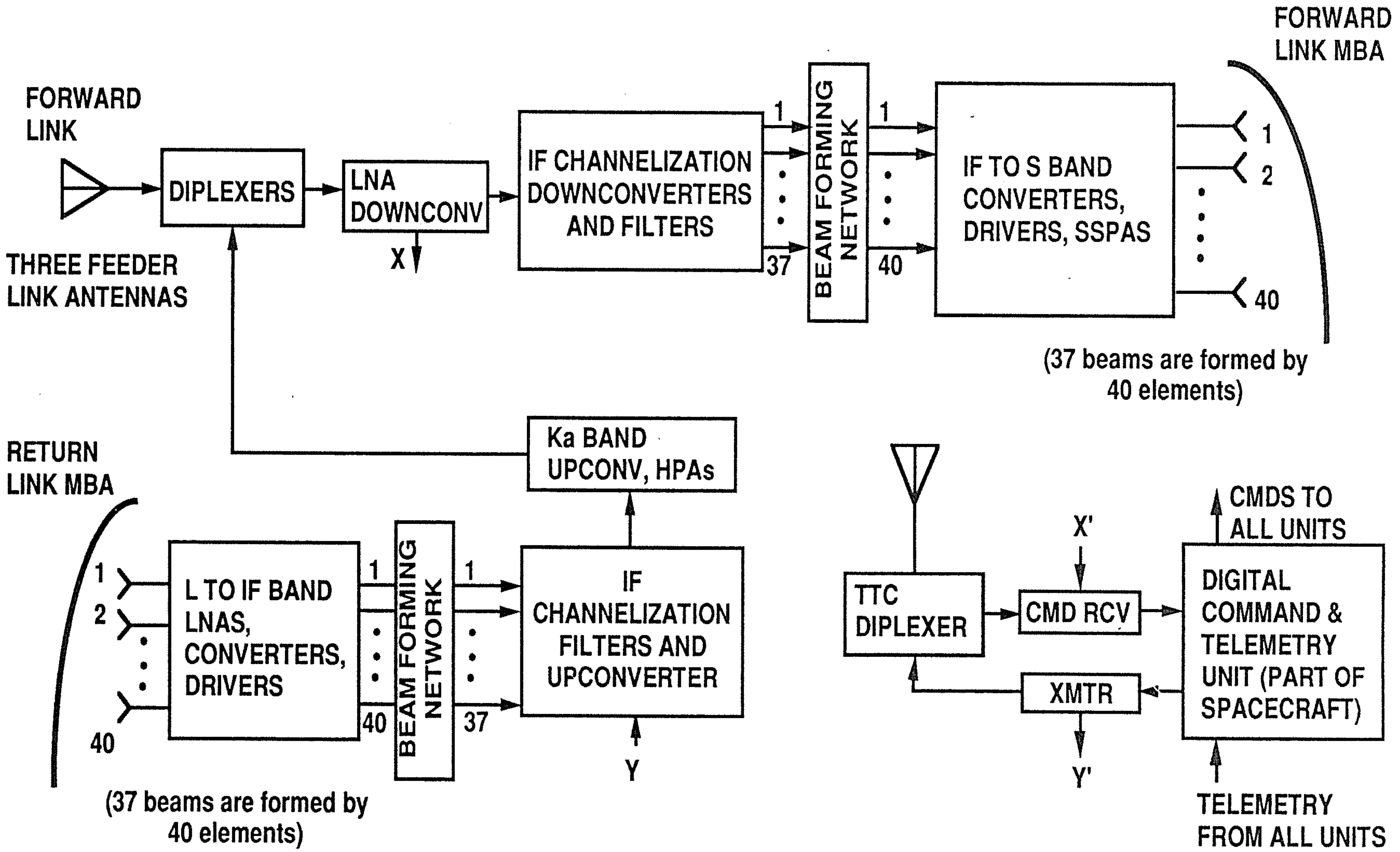

Figure 6: Odyssey Payload Block Diagram

Component	Weight	Power
Payload	749 lbs	2660 W
Spacecraft Bus	2015 lbs	390 W
Propellent	1546 lbs	-
Total S/C	4310 lbs	3050 W

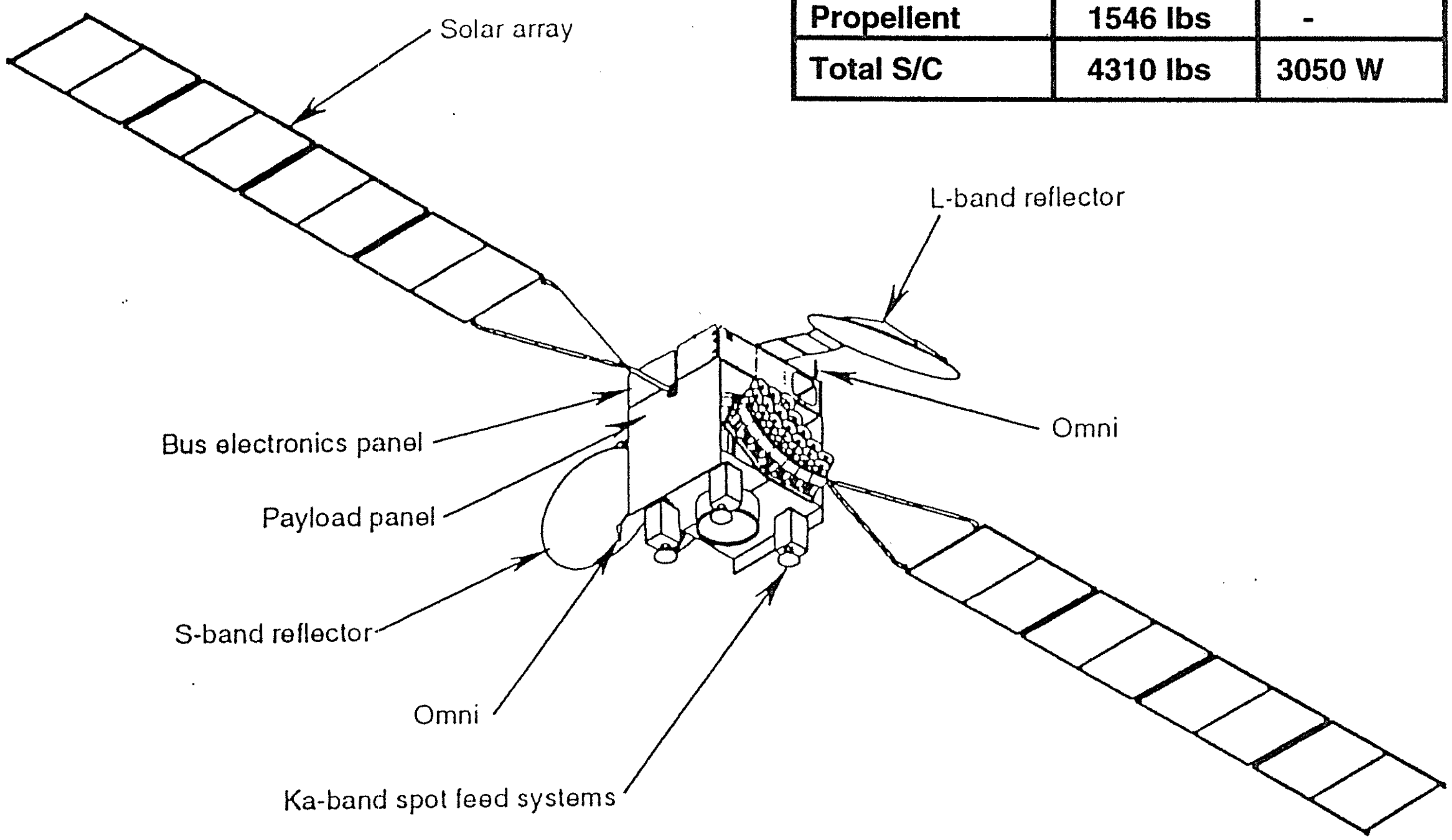

Figure 7: Odyssey Satellite Configuration

The satellite structure will house the payload transponders; a battery for full eclipse operation; the propellant tanks and antenna feed elements; and subsystem electronics and components such as reaction wheels, which will be used for satellite pointing control. The structure will support two solar array wings for electrical power; C-band omni antennas for ground communication during launch and deployment; attitude sensors for orientation and pointing; high level thruster for orbit insertion; low-level thrusters for station keeping and rephasing; and the payload antennas. Temperature control will be accomplished by rejecting heat to space from two sides of the satellite which are to be maintained parallel to the sun line and by insulating the other sides from space with multi-layer insulation.

The 37 element mobile link antennas will be pointed to a service area (e.g. US region) on the Earth by executing satellite attitude commands as the satellite passes over the service area. These commands will be generated on the ground and stored onboard the satellite to provide at least 24 hours of pointing sequence information. At the same time a pre-stored attitude profile for pointing the feeder link antennas will be executed. In order to assure dual-coverage over the US region, a satellite will have to switch from a ground station leaving view to the earth station coming into view. To preclude a break in the link, one Ka-band antenna is to be assigned to each ground station and make-before-break switching will be accomplished electronically. Pointing the solar arrays at the sun will be achieved by yaw turn control and single axis array pointing. This will also assure that two equipment bearing sides of the satellite are oriented parallel to the sun for heat rejection.

6. Space Segment Reliability/Life

The Odyssey™ space segment will provide system availability exceeding 99.5% for 10 years. To achieve this performance, the entire system will feature highly reliable components and subsystems with redundancy implemented throughout, achieving a satellite mean mission duration of 12 years. Expendables, such as station keeping fuel, and wear-out items, such as reaction wheels, are sized for 15 years. The solar array and electronic components are to be selected and shielded to accommodate the space radiation environment of the Odyssey™ orbits.

7. Transmission Characteristics

a. Provision of Services

The Odyssey™ system will provide voice and data services . Voice service at 4800 bps is to be provided by transmission of digitally encoded voice and in-band signaling. Several such voice encoders (vocoders) exist and can be implemented within the processing used at the earth station and handset. Processing by these vocoders produces discrete blocks or packets of data at the coder framing rate. Each information packet is protected from errors with a combination of a forward error correcting code and interleaving.

Basic data service will be provided by the handset with transmission at the rate of 2400 bps. Forward error correction and interleaving will be used to protect against transmission errors. Higher transmission rate data services may be provided through more sophisticated user terminals dedicated to this function.

b. Modulation Characteristics

Modulation and multiple access techniques for the Odyssey™ system have been chosen to complement the expected evolution of terrestrial cellular systems. Digital modulation using CDMA techniques is employed for both voice and data information.

Spread spectrum CDMA has been chosen for multiple access because it minimizes intersystem interference and allows frequency spectrum sharing. The spread spectrum functions can easily be implemented with microelectronic technology. While mutual interference between Odyssey™ users (and from other systems) is a limit to total system capacity, the number of users that can be accommodated within the spectrum allocation is greater than Odyssey™ is designed to serve. Consequently there is room for future growth for Odyssey™ as user demand increases, and for joint use of the spectrum for other applicants. See Appendix C for multiple access interference analysis.

Quadrature phase shift keying (QPSK) is the basic signal structure used for waveform modulation. For the voice user, a speech detector within the voice encoder determines when the user is not actively speaking. In this case, the bit rate at handset output will be reduced to the minimum required to maintain the link. This feature increases the channel capacity by nearly a factor of two by taking advantage of the fact that a user will actively be speaking only about one-half of the time.

c. Performance Objectives

Voice service will be the high quality typified by a mean opinion score (MOS) of 3.5 or better. To achieve this, the end-to-end bit error rate has been designed to be 0.001 for voice transmissions. Data transmission will operate at a bit error rate of 10^{-5} or better.

8. Telemetry, Tracking & Command (TT&C) Subsystem

The TT&C subsystem will monitor and control the satellite through all phases including prelaunch, launch, transfer, on-station, orbit maintenance, rephasing, and depositioning. The command functions provide control of the satellite's configuration, position and attitude by receiving, decoding, storing, and executing ground-generated commands. The telemetry functions transmit to the ground data necessary to monitor and evaluate satellite performance.

The subsystem consists of an RF transponder, a master interface unit, and a satellite data bus. The master interface unit, which contains a processor and memory, stores and distributes commands to and collects data from the other subsystems and payload via the data bus. The transponder will operate at C band through two omni antennas during the launch, deployment, "safe haven", orbit maintenance and depositioning phases, and link the satellite to the Odyssey™ ground station via the commercial ground network. During normal on-orbit operations the TT&C subsystem will switch to the Ka-band feeder link frequency to receive commands and transmit data to the ground. Key parameters of the C-band TT&C subsystem are provided in Table 3. Exact C band frequencies used are to be coordinated with other C band TTOC users to minimize interference.

9. Propulsion Subsystem (PS)

The PS will provide impulse for final orbit injection, orbit maintenance, rephasing, and end-of-life orbit disposal. Apogee burns to circularize the orbit will be accomplished with a bipropellant thruster. During the apogee burn the spacecraft will be stabilized using small monopropellant thrusters. The small thrusters will also be used for orbit maintenance, including rephasing of the satellites when required during deployment and replenishment, and end- of-life depositioning. Propellant loading will support mission operations for at least 15 years.

10. Electrical Power and Distribution Subsystem (EPDS)

The EPDS will generate and distribute the electrical power for the spacecraft and store energy for eclipse operation. A photovoltaic solar array will generate power during sunlight to support the electrical loads and to recharge the battery, which stores energy for full operation during eclipses, power transients and momentary overloads, and fault clearing. The EPDS provides sufficient power to operate all payload functions and all housekeeping loads for the entire mission including eclipse periods.

The solar array will consist of two, rigid-panel, fold-out array wings sized to include the effects of degradation due to the space radiation environment. The arrays will be pointed at the sun by the spacecraft and a redundant single-axis drive mechanism. A single NiH2 battery with cell redundancy will provide 160 ampere hours of energy storage. A battery-regulated bus will provide stable uninterrupted power and bus voltage control, regardless of overloads or eclipse conditions. A processor will monitor and controls EPDS function, provide telemetry data and accept ground override commands.

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Table 3: Telemetry, Tracking & Command Subsystem

TT&C	Transfer Orbit (C-Band)		On Orbit (Ka-Band)	
Parameters	Uplink (Command)	Downlink (Telemetry)	Uplink (Command)	Downlink (Telemetry)
Frequency (MHz)	6170 --> 6180.0	3900.0 --> 4000.0	29998.375 ± 1.0	20098.375 ± 1.0
Polarization	LHCP	RHCP	LHCP	RHCP
Carrier Modulation	FM	Phase	FM	Phase
FMData Modulation	FSK	BPSK	FSK	BPSK
Ranging Format		Tone Ranging		Tone Ranging
Data Rate	1.0 Kbps	4.8 Kbps	1.0 Kbps	4.8 Kbps
TX EIRP (Peak)	N/A	-4.2 dBW	N/A	10.76 dBW
G/T(Peak)	-33.1 dB/K	N/A	6.1 dB/K	N/A

NINE S/C SINGLE VISIBILITY COVERAGE

9/3/3/50 Constellation

Coverage MGEA = 5 Deg

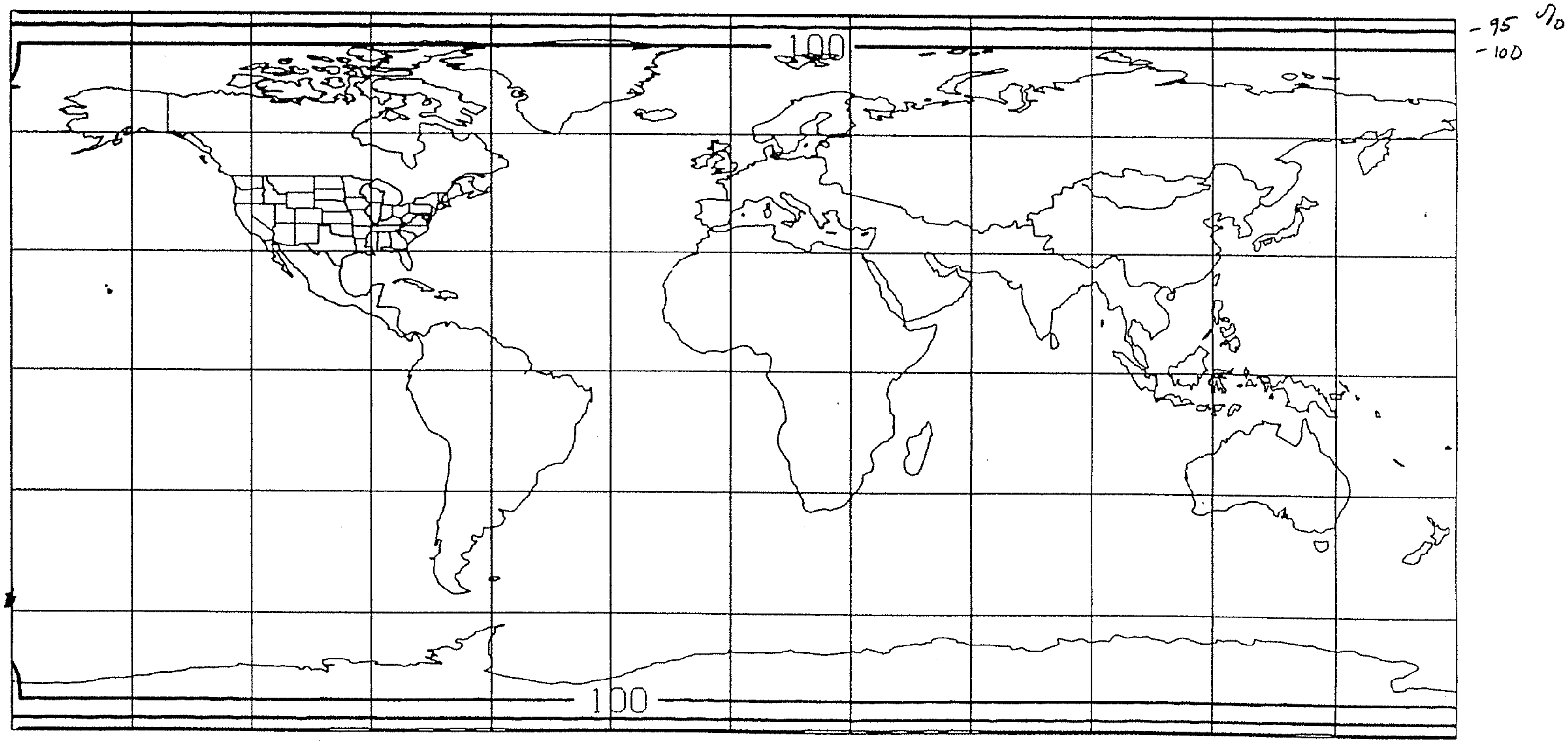

Figure 2b:

SIX S/C SINGLE VISIBILITY COVERAGE
6/3/3/50 Constellation
Coverage MGEA = 5 Deg

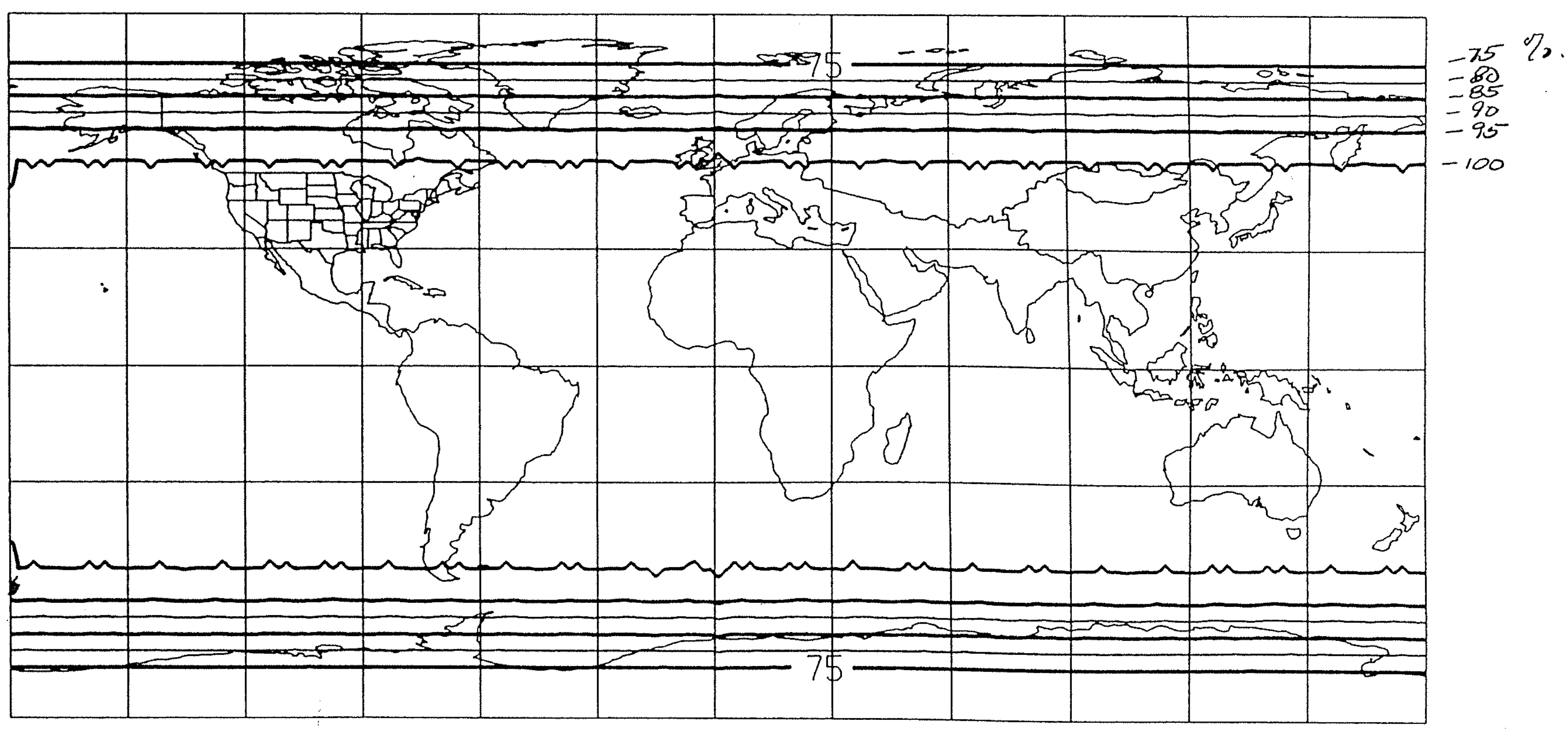

Figure 2c:

11. Attitude Control Subsystem (ACS)

The ACS will provide for attitude control and pointing of the body fixed and gimbaled antennas through the 12 year life of the spacecraft. Off-nadir pointing of the spacecraft will be accomplished using four reaction wheels (one redundant) and conical scan Earth sensors to an accuracy of $\pm 0.5°$. Yaw control during sunlit portions of the orbit will be accomplished using fine sun sensors mounted on the solar array drive axes, which will maintain these axes normal to the sun line. This will provide full shading of two spacecraft side panels throughout the year. Offset pointing will be obtained by changing the reaction wheel speeds and momentum dumping will be provided by three magnetic torque rods with three-axis magnetometers for magnetic field sensing. The ACS will control the angular position of the solar arrays to maximize solar energy collection and drive the antenna gimbals to point them at the earth station terminals to within $\pm 0.5°$.

The ACS is to be fully redundant, with no single point failure points, and include a proven safe haven mode. This mode would be entered when large attitude errors and/or angular rates are computed in the ACS processor. The spacecraft would automatically reorient to the sun pointing position, initiate a rotation about the sun line, and await interrogation and commanding via the TT&C link.

12. Thermal Control Subsystem (TCS)

The TCS will maintain all equipment within allowable temperature ranges over the seasons of the year. Heat rejection and thus temperature control will be facilitated by two surfaces of the spacecraft being maintained parallel to the sun line during orbital operations. Electrical heaters on propulsion units and equipment panels will be controlled by the master interface unit to prevent excessive cold conditions.

The heat from high powered electronic equipment is to be spread away from the equipment by fixed conductance heat pipes. The heat from the electronic equipment will be radiated to space by second surface mirrors that are to be bonded on the external surfaces of the equipment mounting panels which will be maintained parallel to the sun line. All other surfaces of the spacecraft compartment will be covered with multilayer insulated blankets to thermally isolate the spacecraft from deep space and the sun. Multilayer insulation and paint will be used to control the temperature of the antennas and other external components and minimize specular focusing of solar energy onto the antenna feeds.

C. Ground Segment

The Ground Segment which will provide user service to the US region and adjacent areas is to be comprised of two earth stations (ES) -- one each on the east coast and the west coast. Each US region earth station will have the equipment and software to monitor and control the satellite constellation, route user traffic and manage the communication network . Either the east coast or the west coast station is to be designated the master station for normal operations. However, the other can assume that role in the event of problems. Redundant antennas and processing equipment will assure high segment availability.

Each US region ES is to be comprised of seven equipment groups as illustrated in Figure 8. The antenna and RF equipment will be located at the four Ka-band steerable antenna sites which will be geographically mutually dispersed by 10 to 30 km to improve rain availability characteristics. The baseband equipment will include the CDMA modems and beam switching units. Command and telemetry processing, as well as range tone generation and extraction, are performed with the TT&C equipment group. The satellite control equipment contains the software and operator consoles required to control and monitor the satellites (orbit, attitude, configuration, communications performance and state of health). The system management group performs the overall planning, scheduling, and communications switching control for the ES and all in-view satellites.

Each ES will always be in contact with two satellites and preparing to transfer operations to a third. Satellite commands will be generated by the US region ES central control group and interleaved with user traffic to the

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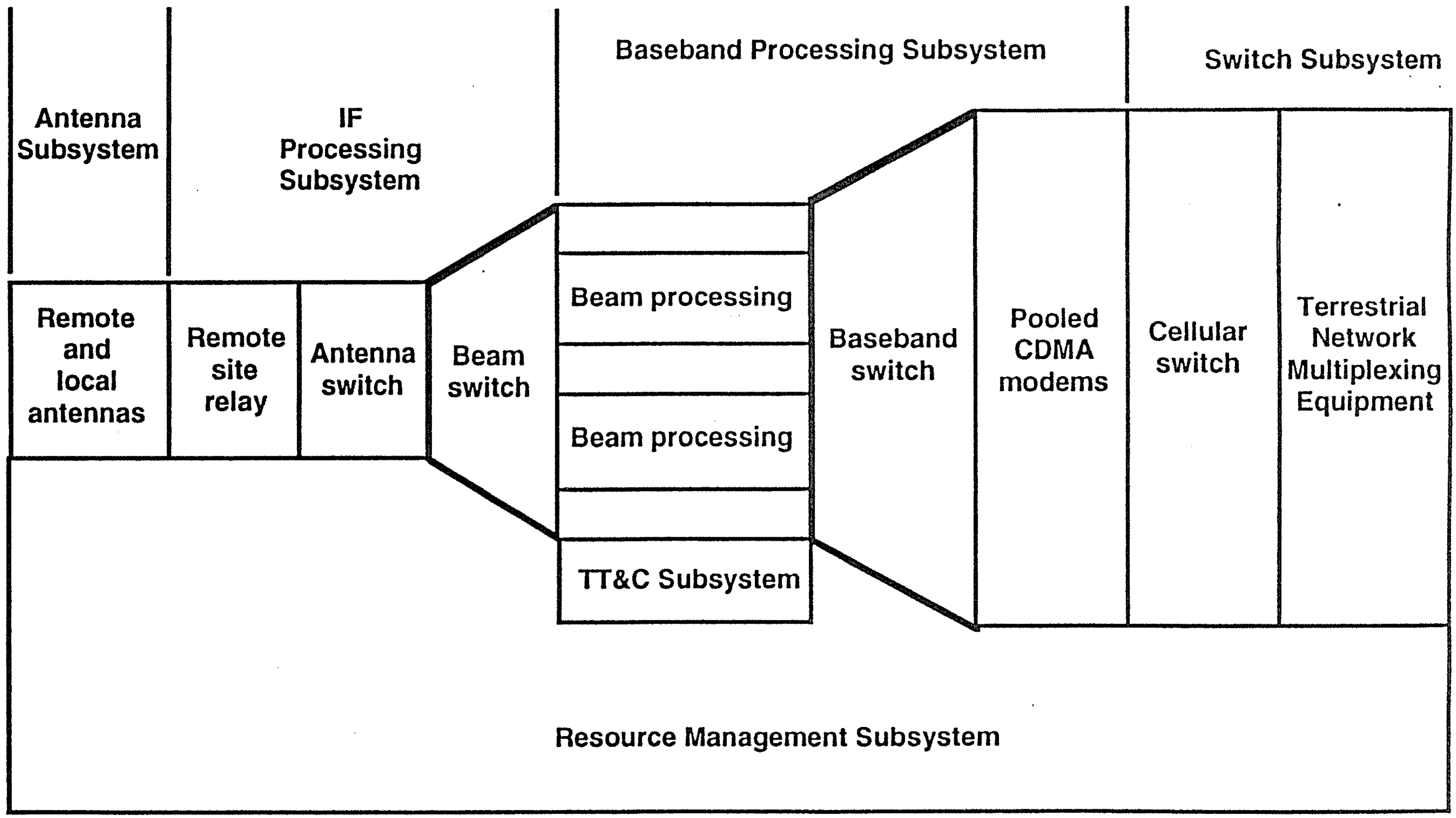

Figure 8: Odyssey Ground Station

satellite. Status telemetry, also interleaved on the downlink with user traffic, is processed and displayed in the centralized control facility . The US satellite control facility will provide each satellite with antenna pointing data and monitor the pointing process via telemetry and signal strength measurements. The US satellite control facility will also determine satellite orbital parameters and perform station keeping rephasing and disposal maneuvers.

Each ES is to act as a switchboard to establish and maintain user communications. These operations, occurring almost concurrently, involve identifying a user request for service, linking the parties to the call, and switching one or more parties to another beam or even to another satellite to maintain signal quality during the call. The operational sequences in initiating a call and then establishing the best communications links, including routing traffic through communication terrestrial lines to users, will occur within a few milliseconds and be completely transparent to the users. Similar sequences relate to switching a user to another beam on a satellite or to a different satellite. In addition to establishing user-to-user connectivity, the ES will continually monitor the quality of the user channels and switch links to alternate beams or satellites as appropriate.

D. Handset Segment

The Odyssey™ handset is a dual mode design that will support user communication through the Odyssey™ system and a terrestrial cellular system. Several versions of the handset will be available to support dual mode service with the various terrestrial cellular standards.

Full duplex communication between the Odyssey™ handset and the satellite will be provided by modulated digital data using spread spectrum CDMA techniques. Subscriber voice is to be digitized, compressed, formatted, and error correction encoded in the handset and routed to the transmitter section. Basic 2400 bps data service may be input to the handset through a compatible data port in the place of voiced data. This data will be formatted and encoded into a data stream. The data stream will then be used to modulate the L-band uplink carrier. The user received S-band signal is to undergo the reverse processing to deliver either voice or digital data to the subscriber. Table 4 provides a summary of typical handset performance.

The protocol between the handset and the ground station is similar to that used for a typical cellular system to the greatest extent possible. The protocols for placing a call, call setup, handover, termination, and other administrative functions have been modeled after the terrestrial cellular systems.

Table 4: Odyssey Handset Summary

	Transmit (Uplink)	Receive (Downlink)
Frequency	1610.0 - 1626.5 MHz2483.5 - 2500.0	MHz
Signal Polarization	LHCP	LHCP
Output Power Amplifier (Input To Antenna)	1.4 W - Peak Max less than 0.5 W average (typical)	N/A
Antenna * Type * Gain * Area of Coverage	 Quadrifliar helix or equivalent 0.5 --> 3.0 dBi 20 --> 90° elevation angel	 Same as transmit ant. 0.5 --> 3.0 dBi 20° --> 90° elevation angle
EIRP	1.9 --> 4.5 dBW	N/A
G/T	N/A	- 24.5 --> -21.7 dB/°K
Modulation	CDMA/ QPSK	CDMA/ QPSK

The Odyssey™ handset functional block diagram is shown in Figure 9. The functions depicted in the block diagram are supported by commercially available hardware. The complexity of the handset is similar to cellular handsets and will conform to their size, weight, and power.

Appendix A shows the uplink EIRP density. Appendix B contains link budget analyses for the Odyssey™ system. Interference analyses are shown in Appendix C, and antenna patterns in Appendix D. Appendix E lists the emission designators for Odyssey™.

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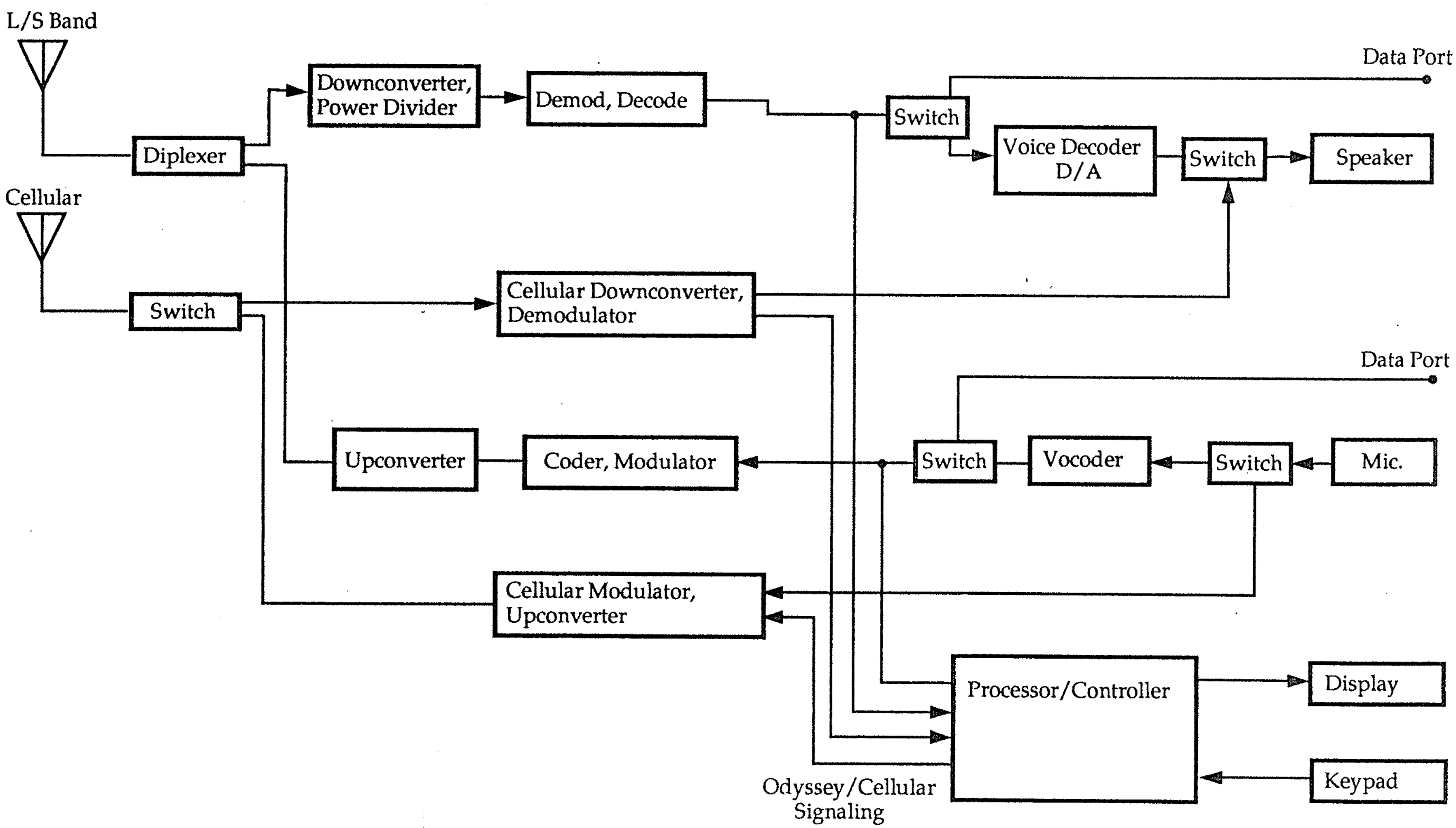


Figure 9: Odyssey Subscriber Unit Block Diagram

Appendix A

EIRP Power Density

Appendix A

L-Band Uplink EIRP Power Density

According to WARC-92 No. 731E, the mobile user operating in the 1610-1626.5 MHz frequency band shall not produce an EIRP density in excess of -15 dB(W/4 kHz) on frequencies being used by systems operating in accordance with international Radio Regulation RR 732, and shall not produce an EIRP density in excess of -3 dB(W/4 kHz) on frequencies not being so used.

Odyssey uplink EIRP power density can be calculated as:

$$EIRP\ power\ density = EIRP + 10Log\left(\frac{4\ kHz}{Spread\ Bandwidth}\right)$$

$$= 3.0\ dBW + 10Log\left(\frac{4\ kHz}{2.5\ MHz}\right)$$

$$= -25\ dBW/4\ kHz$$

Thus, the Odyssey uplink EIRP power density meets the ITU requirements.

Appendix B

Link Budgets

The link budgets presented here show instances of Odyssey™ system operation. Three sets of link budgets are presented. The first is for voice communication at elevation angles of 26, 38, 47, 63, 75, and 86 degrees. Forward and return link budgets are presented for the case of users uniformly distributed across the field-of-view. Additionally, an example of link performance with a hot spot of 1800 users in three adjacent beams is presented. In each link budget, the EIRP of the user link is varied using power control to an amount that closes the link with sufficient margin, but does not unnecessarily use excessive transmit power.

A second set of link budgets is presented to show typical links with mixture of voice and digital data users. In all cases presented, 25% of the users are transmitting digital data and the rest are voice users.

The third set of link budgets shows TT&C link performance for both C-band and Ka-band operation.

TABLE B-1: FORWARD LINK - VOICE - USER AT 26° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 26 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	10.0	10.0
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	1.5	1.5
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	24.0	24.0
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	24.3	24.3
RANGE	Km	12916.4	12916.4
PATH LOSS	dB	182.6	182.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-159.1	-159.1
HANDSET RECEIVE ANTENNA GAIN	dBi	0.7	0.7
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-24.0	-24.0
USER RX SIGNAL POWER, C	dBW	-158.4	-158.4
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.1	-226.1
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.5**	**45.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.5	45.4
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.4**	**4.3**

TABLE B-2: FORWARD LINK - VOICE - USER AT 38° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 38 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	5.0	5.0
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	0.8	0.8
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.7	25.7
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	22.9	22.9
RANGE	Km	12035.3	12035.3
PATH LOSS	dB	182.0	182.0
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-159.8	-159.9
HANDSET RECEIVE ANTENNA GAIN	dBi	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.2	-23.2
USER RX SIGNAL POWER, C	dBW	-158.3	-158.4
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.0	-226.0
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.6**	**45.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.6	45.5
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	dB	4.5	4.4

TABLE B-3: FORWARD LINK - VOICE - USER AT 47° ELEVATION ANGLE

Users are uniformly distributed over the field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	4.8	4.8
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	0.7	0.7
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	22.4	22.4
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-159.9	-160.0
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-158.3	-158.4
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.0	-226.1
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.6**	**45.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.6	45.5
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.5**	**4.4**

TABLE B-4: FORWARD LINK - VOICE - USER AT 63° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 63 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	3.7	3.7
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	0.6	0.6
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.4	25.4
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	21.4	21.4
RANGE	Km	10798.7	10798.7
PATH LOSS	dB	181.0	181.0
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-160.4	-160.5
HANDSET RECEIVE ANTENNA GAIN	dBi	2.0	2.0
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-22.7	-22.7
USER RX SIGNAL POWER, C	dBW	-158.4	-158.5
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.1	-226.1
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.5**	**45.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.5	45.4
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.4**	**4.3**

TABLE B-5: FORWARD LINK - VOICE - USER AT 75° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 75 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS		
SATELLITE ALTITUDE	10355 KM		
TOTAL FEEDER LINK BANDWIDTH	300 MHZ		

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	63.4	63.4

SATELLITE-TO-USERS

NUMBER OF USER PER BEAM	81	USERS
NUMBER OF BEAMS	37	
#CHANNELS PER BEAM	6	CHANNELS
BANDWIDTH PER BEAM	16.50	MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	2.8	2.8
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	0.4	0.4
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	26.3	26.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	21.1	21.1
RANGE	Km	10491.3	10491.3
PATH LOSS	dB	180.8	180.8
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-160.5	-160.5
HANDSET RECEIVE ANTENNA GAIN	dBi	2.2	2.2
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-22.5	-22.5
USER RX SIGNAL POWER, C	dBW	-158.3	-158.3
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-225.9	-226.0
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.6**	**45.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.6	45.5
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.6**	**4.4**

TABLE B-6: FORWARD LINK - VOICE - USER AT 86° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 86 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USER PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	1.9	1.9
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
EFFECTIVE TX RF POWER PER USER	W	0.3	0.3
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	27.7	27.7
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	20.6	20.6
RANGE	Km	10364.8	10364.8
PATH LOSS	dB	180.7	180.7
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-160.8	-160.9
HANDSET RECEIVE ANTENNA GAIN	dBi	2.5	2.5
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-22.2	-22.2
USER RX SIGNAL POWER, C	dBW	-158.3	-158.4
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.0	-226.1
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.6**	**45.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.6	45.5
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.5**	**4.4**

TABLE B-7: RETURN LINK - VOICE - USER AT 26° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 26 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.23	0.23
USER TRANSMIT ANTENNA GAIN	dBi	0.7	0.7
EFFECTIVE EIRP PER USER	dBW	-5.8	-5.8
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	12916.4	12916.4
PATH LOSS	dB	178.8	178.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-185.3	-185.4
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.0	25.0
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.4	-1.4
RX SIGNAL POWER, C	dBW	-160.6	-160.7
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-212.6	-212.6
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.4**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.4	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.2**	**40.9**
RECEIVED Eb/No	**dB**	**4.4**	**4.0**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**8.3**	**8.0**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-8: RETURN LINK - VOICE - USER AT 38° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 38 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.16	0.16
USER TRANSMIT ANTENNA GAIN	dBi	1.5	1.5
EFFECTIVE EIRP PER USER	dBW	-6.6	-6.6
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	12035.3	12035.3
PATH LOSS	dB	178.2	178.2
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-185.6	-185.6
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.2	25.2
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.2	-1.2
RX SIGNAL POWER, C	dBW	-160.6	-160.6
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-212.5	-212.5
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.5**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.5	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.2**	**40.9**
RECEIVED Eb/No	**dB**	**4.4**	**4.1**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**9.9**	**9.6**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-9: RETURN LINK - VOICE - USER AT 47° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 47 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.13	0.13
USER TRANSMIT ANTENNA GAIN	dBi	1.6	1.6
EFFECTIVE EIRP PER USER	dBW	-7.3	-7.3
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	177.8	177.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-185.8	-185.8
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.5	25.5
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.0	-1.0
RX SIGNAL POWER, C	dBW	-160.7	-160.7
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-212.6	-212.6
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.4**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.4	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.2**	**40.8**
RECEIVED Eb/No	**dB**	**4.3**	**4.0**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**10.7**	**10.4**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-10: RETURN LINK - VOICE - USER AT 63° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 63 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.15	0.15
USER TRANSMIT ANTENNA GAIN	dBi	2.0	2.0
EFFECTIVE EIRP PER USER	dBW	-6.2	-6.2
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	10798.7	10798.7
PATH LOSS	dB	177.3	177.3
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-184.3	-184.3
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.8	25.8
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-0.7	-0.7
RX SIGNAL POWER, C	dBW	-158.8	-158.8
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-210.7	-210.7
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**43.1**	**43.0**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	43.1	43.0
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**42.7**	**42.3**
RECEIVED Eb/No	**dB**	**5.9**	**5.5**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**11.6**	**11.2**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-11: RETURN LINK - VOICE - USER AT 75° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 75 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.10	0.10
USER TRANSMIT ANTENNA GAIN	dBi	2.2	2.2
EFFECTIVE EIRP PER USER	dBW	-8.0	-8.0
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	10491.3	10491.3
PATH LOSS	dB	177.0	177.0
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-185.8	-185.8
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.5	25.5
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.0	-1.0
RX SIGNAL POWER, C	dBW	-160.6	-160.7
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-212.5	-212.6
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.4**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.4	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.2**	**40.9**
RECEIVED Eb/No	**dB**	**4.4**	**4.1**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**12.0**	**11.7**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-12: RETURN LINK - VOICE - USER AT 87° ELEVATION ANGLE

Users are uniformly distributed over field-of-view

User elevation angle = 87 Deg.
Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
TX RF POWER TO ANTENNA	W	0.05	0.05
USER TRANSMIT ANTENNA GAIN	dBi	2.5	2.5
EFFECTIVE EIRP PER USER	dBW	-11.0	-11.0
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	10360.5	10360.5
PATH LOSS	dB	176.9	176.9
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-188.6	-188.6
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	28.3	28.3
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	1.8	1.8
RX SIGNAL POWER, C	dBW	-160.7	-160.7
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-212.6	-212.6
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.4**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.4	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.1**	**40.8**
RECEIVED Eb/No	**dB**	**4.3**	**4.0**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**15.3**	**15.0**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-13: FORWARD LINK - VOICE - USER AT 47° ELEVATION ANGLE

HOT SPOT - 600 USERS PER BEAM

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER	W	0.0013	0.0853
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER	dBW	35.6	53.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-171.4	-171.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-132.6	-132.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**63.4**	**63.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	600 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	36.0	36.0
NUMBER OF USERS PER 2.5 MHz	Users	100.0	100.0
EFFECTIVE TX RF POWER PER USER	W	0.7	0.7
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EFFECTIVE EIRP PER USER	dBW	22.3	22.3
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-160.0	-160.1
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-158.4	-158.5
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-222.1	-222.2
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**45.4**	**45.3**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	63.4	63.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	45.4	45.3
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE (4800 bps)	dB	36.8	36.8
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**41.1**	**41.1**
AVERAGE DOWN LINK MARGIN	**dB**	**4.4**	**4.2**

TABLE B-14: RETURN LINK - VOICE - USER AT 47° ELEVATION ANGLE

HOT SPOT - 600 USERS PER BEAM

User elevation angle = 47 Deg.
Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	**600 USERS**
NUMBER OF BEAMS	**37**
SATELLITE ALTITUDE	**10355 KM**
# CHANNELS PER BEAM	**4 CHANNELS**

PARAMETERS	**UNIT**	**CLEAR**	**RAIN**
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	150.0	150.0
TX RF POWER TO ANTENNA	W	0.25	0.25
USER TRANSMIT ANTENNA GAIN	dBi	1.6	1.6
EFFECTIVE EIRP PER USER	dBW	-4.4	-4.4
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	177.8	177.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-183.0	-183.0
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.5	25.5
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.0	-1.0
RX SIGNAL POWER, C	dBW	-157.8	-157.8
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-202.0	-202.1
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.4**	**41.4**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.4	41.4
SATELLITE-TO-EARTH STATION C/No	dB Hz	64.9	52.5
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE (4.8 KBPS)	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**41.2**	**40.9**
RECEIVED Eb/No	**dB**	**4.4**	**4.1**
REQUIRED Eb/No	**dB**	**4.0**	**4.0**
EXCESS UP LINK MARGIN	**dB**	**7.8**	**7.5**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	**3000 USERS**
TOTAL FEEDER LINK BANDWDITH	**300 MHZ**

PARAMETERS	**UNIT**	**CLEAR**	**RAIN**
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
EFFECTIVE TX RF POWER PER USER	**W**	**0.0009**	**0.0009**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EFFECTIVE EIRP PER USER	dBW	**5.31**	**5.31**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-198.32**	**-208.67**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-137.52**	**-147.87**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**64.90**	**52.50**

TABLE B-15: FORWARD LINK - DATA - DATA RATE = 2.4 KBPS

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER / DATA	W	0.0021	0.1352
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER /DATA	dBW	37.6	55.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-169.4	-169.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-130.6	-130.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**65.4**	**65.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	4.5	4.5
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
% USER USES FOR DATA TRANSMISSION	%	25.0	25.0
TX RF POWER PER USER/DATA	W	0.6	0.6
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EIRP PER USER/DATA	dBW	21.5	21.5
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-160.8	-160.9
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-159.2	-159.3
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-226.9	-227.0
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**44.7**	**44.6**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	65.4	65.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	44.7	44.6
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE	dB	33.8	33.8
REQUIRED Eb/No (1E-5 = BER)	**dB**	**6.0**	**6.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**40.2**	**40.2**
AVERAGE DOWN LINK MARGIN	**dB**	**4.5**	**4.4**

TABLE B-16: FORWARD LINK - DATA - DATA RATE = 4.8 KBPS

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER / DATA	W	0.0042	0.2705
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER /DATA	dBW	40.6	58.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-166.3	-166.4
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-127.6	-127.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**68.4**	**68.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	12.0	12.0
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
% USER USES FOR DATA TRANSMISSION	%	25.0	25.0
TX RF POWER PER USER/DATA	W	1.2	1.2
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EIRP PER USER/DATA	dBW	24.5	24.5
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-157.8	-157.9
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-156.2	-156.3
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-223.9	-224.0
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**47.6**	**47.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	68.4	68.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	47.6	47.5
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE	dB	36.8	36.8
REQUIRED Eb/No (1E-5 = BER)	**dB**	**6.0**	**6.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**43.2**	**43.2**
AVERAGE DOWN LINK MARGIN	**dB**	**4.4**	**4.3**

TABLE B-17: FORWARD LINK - DATA - DATA RATE = 9.6 KBPS

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER / DATA	W	0.0085	0.5410
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER /DATA	dBW	43.6	61.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-163.3	-163.3
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-124.6	-124.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**71.4**	**71.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	34.0	34.0
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
% USER USES FOR DATA TRANSMISSION	%	25.0	25.0
TX RF POWER PER USER/DATA	W	2.2	2.2
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EIRP PER USER/DATA	dBW	27.2	27.2
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-155.1	-155.2
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-153.5	-153.6
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-221.2	-221.3
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**50.3**	**50.2**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	71.4	71.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	50.3	50.2
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE	dB	39.8	39.8
REQUIRED Eb/No (1E-5 = BER)	**dB**	**6.0**	**6.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**46.2**	**46.2**
AVERAGE DOWN LINK MARGIN	**dB**	**4.1**	**4.0**

TABLE B-18: FORWARD LINK - DATA - DATA RATE = 19.2 KBPS

Users are uniformly distributed over field-of-view

Earth station alevation angle= 10 Deg.
User elevation angle = 47 Deg.

EARTH STATION-TO-SATELLITE

SATELLITE CAPACITY	3000 USERS
SATELLITE ALTITUDE	10355 KM
TOTAL FEEDER LINK BANDWIDTH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	29.85	29.85
TX RF POWER TO ANTENNA	W	2.0	128.0
TX RF POWER PER USER / DATA	W	0.0169	1.0820
Tx ANTENNA GAIN	dBi	64.4	64.4
EIRP PER USER /DATA	dBW	46.6	64.7
RANGE	Km	14403.8	14403.8
PATH LOSS	dB	205.1	205.1
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	1.8	1.9
LINK AVAILABILITY	%	N/A	99.9
RAIN LOSS	dB	0.0	18.0
USER RX SIGNAL	dBW	-160.3	-160.3
RECEIVE ANTENNA GAIN	dBi	38.8	38.8
SYSTEM NOISE FIGURE	dB	8.0	8.0
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	1829.8	1829.8
	dBK	32.6	32.6
G/T	dB/°K	6.1	6.1
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.6	-228.6
THERMAL NOISE DENSITY	dBW/Hz	-196.0	-196.0
USER RX SIGNAL POWER, C	dBW	-121.6	-121.6
THERMAL NOISE DENSITY, No	dBW/Hz	-196.0	-196.0
EARTH STATION-TO-SATELLITE C/No	**dB-Hz**	**74.4**	**74.4**

SATELLITE-TO-USERS

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
#CHANNELS PER BEAM	6 CHANNELS
BANDWIDTH PER BEAM	16.50 MHz

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	2.49	2.49
TX SIGNAL RF POWER	W	118.0	118.0
NUMBER OF USERS PER 2.5 MHz	Users	13.0	13.0
% USER USES FOR DATA TRANSMISSION	%	25.0	25.0
TX RF POWER PER USER/DATA	W	4.6	4.6
CIRCUIT LOSS BETWEEN HPA & ANTENNA	dB	1.3	1.3
TRANSMIT ANTENNA GAIN	dBi	25.3	25.3
ANTENNA CIRCUIT LOSS	dB	0.3	0.3
EIRP PER USER/DATA	dBW	30.4	30.4
RANGE	Km	11494.6	11494.6
PATH LOSS	dB	181.6	181.6
ATMOSPHERIC/POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.1
RX SIGNAL	dBW	-152.0	-152.0
HANDSET RECEIVE ANTENNA GAIN	dBi	1.6	1.6
ANTENNA NOISE TEMPERATURE	°K	125.0	125.0
HANDSET RECEIVE NOISE FIGURE	dB	2.0	2.0
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	3.8
TOTAL SYSTEM NOISE TEMPERATURE	°K	294.6	298.5
G/T	dB/°K	-23.1	-23.1
USER RX SIGNAL POWER, C	dBW	-150.4	-150.4
THERMAL NOISE DENSITY, No	dBW/Hz	-203.9	-203.9
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-218.1	-218.1
SATELLITE-TO-USER C/(No+I0)	**dB-Hz**	**53.4**	**53.3**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
EARTH STATION-TO-SATELLITE C/No	dB HZ	74.4	74.4
SATELLITE-TO-USER C/(No+I0)	dB Hz	53.4	53.3
PAYLOAD C/IM3	dB	17.0	17.0
DATA RATE	dB	42.8	42.8
REQUIRED Eb/No (1E-5 = BER)	**dB**	**6.0**	**6.0**
REQUIRED SATELLITE-TO-USER C/(No+Io)	**dB Hz**	**49.2**	**49.2**
AVERAGE DOWN LINK MARGIN	**dB**	**4.2**	**4.1**

TABLE B-19: RETURN LINK - DATA - DATA RATE= 2.4 KBPS

Users are uniformly distributed over field-of-view

User elevation angle = 26 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER TO ANTENNA	W	0.20	0.20
USER TRANSMIT ANTENNA GAIN	dBi	0.7	0.7
EIRP PER USER/ DATA	dBW	-6.3	-6.3
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	12926.3	12926.3
PATH LOSS	dB	178.8	178.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-185.9	-185.9
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.0	25.0
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.4	-1.4
RX SIGNAL POWER, C	dBW	-161.2	-161.2
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-213.7	-213.7
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**41.0**	**41.0**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	41.0	41.0
SATELLITE-TO-EARTH STATION C/No	dB Hz	61.5	49.1
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE	dB Hz	33.8	33.8
COMBINED C/(No+Io)	**dB Hz**	**40.5**	**40.0**
RECEIVED Eb/No	**dB**	**6.7**	**6.2**
REQUIRED Eb/No (1E-5= BER)	**dB**	**6.0**	**6.0**
EXCESS UP LINK MARGIN	**dB**	**9.2**	**8.6**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER PER USER/ DATA	**W**	**0.0004**	**0.0004**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EIRP PER USER/ DATA	dBW	**1.88**	**1.88**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-201.75**	**-212.09**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-140.95**	**-151.29**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**61.48**	**49.07**

TABLE B-20: RETURN LINK - DATA - DATA RATE= 4.8 KBPS

Users are uniformly distributed over field-of-view

User elevation angle = 26 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER TO ANTENNA	W	0.35	0.35
USER TRANSMIT ANTENNA GAIN	dBi	1.2	1.2
EIRP PER USER/ DATA	dBW	-3.4	-3.4
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	1.4	1.4
RANGE	Km	12926.3	12926.3
PATH LOSS	dB	178.8	178.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-182.9	-183.0
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.0	25.0
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.4	-1.4
RX SIGNAL POWER, C	dBW	-158.2	-158.3
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-211.2	-211.2
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**43.7**	**43.7**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	43.7	43.7
SATELLITE-TO-EARTH STATION C/No	dB Hz	65.8	53.4
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE	dB Hz	36.8	36.8
COMBINED C/(No+Io)	**dB Hz**	**43.3**	**42.9**
RECEIVED Eb/No	**dB**	**6.5**	**6.1**
REQUIRED Eb/No (1E-5= BER)	**dB**	**6.0**	**6.0**
EXCESS UP LINK MARGIN	**dB**	**6.5**	**6.1**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER PER USER/ DATA	**W**	**0.0011**	**0.0011**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EIRP PER USER/ DATA	dBW	**6.18**	**6.18**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-197.45**	**-207.79**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-136.65**	**-146.99**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**65.78**	**53.37**

TABLE B-21: RETURN LINK - DATA - DATA RATE= 9.6 KBPS

Users are uniformly distributed over field-of-view

User elevation angle = 26 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER TO ANTENNA	W	0.75	0.75
USER TRANSMIT ANTENNA GAIN	dBi	1.2	1.2
EIRP PER USER/ DATA	dBW	0.0	0.0
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	3.0	3.0
RANGE	Km	12926.3	12926.3
PATH LOSS	dB	178.8	178.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-179.6	-179.6
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.0	25.0
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.4	-1.4
RX SIGNAL POWER, C	dBW	-154.9	-154.9
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-208.3	-208.3
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**46.5**	**46.5**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	46.5	46.5
SATELLITE-TO-EARTH STATION C/No	dB Hz	70.6	58.2
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE	dB Hz	39.8	39.8
COMBINED C/(No+Io)	**dB Hz**	**46.1**	**45.9**
RECEIVED Eb/No	**dB**	**6.3**	**6.1**
REQUIRED Eb/No (1E-5= BER)	**dB**	**6.0**	**6.0**
EXCESS UP LINK MARGIN	**dB**	**6.3**	**6.1**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER PER USER/ DATA	**W**	**0.0033**	**0.0033**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EIRP PER USER/ DATA	dBW	**11.00**	**11.00**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-192.64**	**-202.98**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-131.84**	**-142.18**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**70.59**	**58.18**

TABLE B-22: RETURN LINK - DATA - DATA RATE= 19.2 KBPS

Users are uniformly distributed over field-of-view

User elevation angle = 26 Deg.

Satellite-to-Earth station = 10 Deg.

USER-TO-SATELLITE

NUMBER OF USERS PER BEAM	81 USERS
NUMBER OF BEAMS	37
SATELLITE ALTITUDE	10355 KM
# CHANNELS PER BEAM	4 CHANNELS

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	1.62	1.62
NUMBER OF USERS PER 2.5 MHZ CHANNEL	Users	20.0	20.0
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER TO ANTENNA	W	1.75	1.75
USER TRANSMIT ANTENNA GAIN	dBi	1.2	1.2
EIRP PER USER/ DATA	dBW	3.6	3.6
MAXIMUM TX RF POWER INPUT TO ANTENNA	W	7.0	7.0
RANGE	Km	12926.3	12926.3
PATH LOSS	dB	178.8	178.8
ATMOSPHERIC / POLARIZATION LOSS	dB	0.7	0.7
RAIN LOSS	dB	0.0	0.0
USER RX SIGNAL	dBW	-175.9	-176.0
RECEIVE ANTENNA GAIN (95% COVERAGE AREA)	dBi	25.0	25.0
RECEIVE ANTENNA CIRCUIT LOSS	dB	0.3	0.3
SYSTEM NOISE FIGURE	dB	1.5	1.5
ANTENNA NOISE TEMPERATURE	°K	290.0	290.0
TOTAL SYSTEM NOISE TEMPERATURE	°K	409.6	409.6
G/T	dB/°K	-1.4	-1.4
RX SIGNAL POWER, C	dBW	-151.2	-151.3
THERMAL NOISE DENSITY, No	dB/Hz	-202.5	-202.5
INTERFERENCE NOISE DENSITY, Io	dB/Hz	-205.1	-205.1
USER-TO-SATELLITE C/(No+Io)	**dB Hz**	**49.3**	**49.3**

COMBINED UPLINK & DOWNLINK	UNIT	CLEAR	RAIN
USER-TO-SATELLITE C/(No+Io)	dB Hz	49.3	49.3
SATELLITE-TO-EARTH STATION C/No	dB Hz	75.8	63.4
SATELLITE C/IM3	dB	17.0	17.0
DATA RATE	dB Hz	42.8	42.8
COMBINED C/(No+Io)	**dB Hz**	**49.0**	**48.8**
RECEIVED Eb/No	**dB**	**6.1**	**6.0**
REQUIRED Eb/No (1E-5= BER)	**dB**	**6.0**	**6.0**
EXCESS UP LINK MARGIN	**dB**	**6.2**	**6.0**

SATELLITE-TO-EARTH STATION

SATELLITE CAPACITY	3000 USERS
TOTAL FEEDER LINK BANDWDITH	300 MHZ

PARAMETERS	UNIT	CLEAR	RAIN
FREQUENCY	GHZ	19.950	19.950
TX SIGNAL RF POWER	W	1.35	1.35
% USER USES FOR DATA TRANSMISSION	%	25.00	25.00
TX RF POWER PER USER/ DATA	**W**	**0.0112**	**0.0112**
TRANSMIT ANTENNA GAIN	dBi	35.77	35.77
EIRP PER USER/ DATA	dBW	**16.26**	**16.26**
RANGE	Km	14403.78	14403.78
PATH LOSS	dB	201.62	201.62
ATMOSPHERIC/SCINTILLATION/POLARIZATION LOSS	dB	2.02	2.36
AVAILABILITY	%	N/A	99.90
RAIN LOSS	dB	0.00	10.00
RX SIGNAL	dBW	**-187.38**	**-197.72**
RECEIVE ANTENNA GAIN	dBi	60.80	60.80
SYSTEM NOISE FIGURE	dB	3.40	3.40
ANTENNA NOISE TEMPERATURE	°K	70.00	70.00
NOISE TEMP. INCREASE DUE TO RAIN	°K	N/A	252.04
TOTAL SYSTEM NOISE TEMPERATURE	°K	414.45	666.49
	dB	26.17	28.24
G/T	dB/°K	**34.63**	**32.56**
BOLTZMANN'S CONSTANT	dB/Hz-K	-228.60	-228.60
THERMAL NOISE DENSITY, No	dBW/Hz	-202.43	-200.36
SIGNAL POWER, C	dBW	**-126.58**	**-136.92**
SATELLITE-TO-EARTH STATION C/No	dB Hz	**75.85**	**63.44**

TABLE 23: C-Band TT&C Link Budgets

Transfer Orbit

Elevation Angle (Deg.) = 3 Satellite Altitude (Km) = 10355	UPLINK (Command)	DOWNLINK (Telemetry)	(UNITS)
FREQUENCY	6.17	3.95	GHz
TRANSMIT RF TO ANTENNA	200.00	1.00	Watts
FEED/CABLE LOSSES	-	-2.00	dB
AVAILABLE RF POWER	23.01	-2.00	dBW
TRANSMIT ANTENNA PEAK DIR GAIN	-	0.00	dBi
ANTENNA CIRCUIT LOSS	-	-1.00	dB
TRANSMIT ANTENNA PEAK GAIN	55.20	-1.00	dBi
POINTING ERROR	-0.60	-0.20	dB
TRANSMIT ANTENNA GAIN	54.60	-1.20	dBi
PAYLOAD MARGIN	-	1.00	dB
EIRP	77.61	-4.20	dBW
RANGE	15141.50	15141.50	Km
PATH LOSS	191.86	187.98	dB
ATMOSPHERIC LOSS	-1.00	-0.50	dB
POLARIZATION LOSS	-0.40	-0.40	dB
RECEIVE ANTENNA PEAK DIR GAIN	0.00	-	dBi
ANTENNA CIRCUIT LOSS	-1.00	-	dB
RECEIVE ANTENNA GAIN	-1.00	51.30	dBi
EDGE OF BEAM (OR ROLL OFF)	-0.50	-0.50	dB
RCV ANTENNA GAIN	-1.50	50.80	dBi
RECEIVED POWER	-117.15	-142.28	dBW
RECEIVE NOISE TEMPERATURE	864.51	159.16	°K
SYSTEM NOISE FIGURE	6.00	1.90	dB
ANTENNA NOISE TEMPERATURE	290.00	80.00	°K
TOTAL SYSTEM NOISE TEMPERATURE	1154.51	239.16	°K
	30.62	23.79	dBK
MARGIN	1.00	-	dB
G/T	-33.12	27.01	dB-K
BOLTZMANN CONSTANT (k)	-228.60	-228.60	dBW/K/Hz
THERMAL NOISE DENSITY, No	-197.98	-204.81	dBW/Hz
C/No	79.83	62.53	dBHz
CARRIER MODULATION	FM	PHASE	
DATA MODULATION	FSK	BPSK	
DATA RATE	1.00	4.80	kbps
RECEIVED Eb/No	49.83	25.72	dB
REQUIRED Eb/No +MODULATION LOSS	18.00	15.00	dB
TOTAL MARGIN, CLEAR SKY	31.83	10.72	dB
RAIN			
LINK AVAILABILITY	99.95	99.95	%
RAIN MARGIN (WORST CASE)	9.37	2.00	dB
NOISE TEMP INCREASE DUE TO RAIN	-	103.39	°K
RECEIVED Eb/No IN RAIN	40.46	22.16	dB
TOTAL MARGIN IN RAIN	**22.46**	**7.16**	**dB**

TABLE 24: K-Band TT&C Link Budgets

On Orbit

Elevation Angle (Deg.) = 10 Satellite Altitude (Km) = 10355	UPLINK (Command)	DOWNLINK (Telemetry)	(UNITS)
FREQUENCY	30.00	20.10	GHz
POWER AMPLIFIER (SAT)	0.05	0.01	Watts
FEED/CABLE LOSSES	-2.00	-1.00	dB
AVAILABLE RF POWER	-15.01	-24.01	dBW
POWER SPECTRAL DENSITY	-45.01	-60.82	dBW/Hz
TRANSMIT ANTENNA PEAK GAIN	64.85	36.00	dBi
POINTING ERROR	-0.50	-0.23	dB
TRANSMIT ANTENNA GAIN	64.35	35.77	dBi
PAYLOAD MARGIN	-	1.00	dB
EIRP	49.34	10.76	dBW
RANGE	14403.78	14403.78	Km
PATH LOSS	205.16	201.68	dB
ATMOSPHERIC LOSS	-1.30	-1.48	dB
POLARIZATION LOSS/ SCINTILLATION LOSS	-0.61	-0.88	dB
RECEIVE ANTENNA GAIN	39.50	60.80	dBi
EOC	-0.50	-	dB
BEAM POINTING LOSS	0.23	0.20	
RECEIVED POWER	-118.46	-132.68	dBW
RECEIVE NOISE TEMPERATURE	1539.78	344.45	°K
SYSTEM NOISE FIGURE	8.00	3.40	dB
ANTENNA NOISE TEMPERATURE	290.00	70.00	°K
TOTAL SYSTEM NOISE TEMPERATURE	1829.78	414.45	°K
	32.62	26.17	dBK
G/T	6.15	34.63	dB-K
BOLTZMANN CONSTANT (k)	-228.60	-228.60	dBW/K/Hz
THERMAL NOISE DENSITY, No	-195.98	-202.43	dBW/Hz
C/No	77.52	69.74	dBHz
CARRIER MODULATION	FM	PHASE	
DATA MODULATION	FSK	BPSK	
DATA RATE	1.00	4.80	kbps
RECEIVED Eb/No	47.52	32.93	dB
REQUIRED Eb/No +MODULATION LOSS	18.00	15.00	dB
TOTAL MARGIN, CLEAR SKY	29.52	17.93	dB
RAIN			
LINK AVAILABILITY	99.90	99.90	%
RAIN MARGIN (SITE DIVERSITY)	18.00	10.00	dB
NOISE TEMP INCREASE DUE TO RAIN	-	252.04	°K
RECEIVED Eb/No IN RAIN	29.52	20.87	dB
TOTAL MARGIN IN RAIN	11.52	5.87	dB

The cases presented show various sharing scenarios with both fully loaded systems as well as nominally loaded systems. Results are presented in terms of link margin. For CDMA systems, link margin can be traded for capacity so that in benign environments where link margin requirements are minimal, larger sharing capacity exists and conversely capacity in a service band may be reduced to achieve increased link margin when needed.

ATTACHMENT E

TABLE E-2: THE ODYSSEY SHARES WITH OTHER CDMA SYSTEM

Odyssey: 150 Users per 2.5 MHz,Other CDMA : 60 users per 1.2 MHz

RETURN LINK : USER-TO-SATELLITE

PARAMETERS	UNIT			
SYSTEM		**ODYSSEY**		**OTHER CDMA**
POLARIZATION		LHCP		RHCP
NUMBER OF USERS PER X SPREAD BW		**150.0**		**60.0**
SPREAD BANDWIDTH	MHz	2.5		1.2
CHIP RATE	Mcps	3.7		1.2
FREQUENCY	GHZ	1.6		1.6
VOICE DUTY CYCLE	%	50.0		50.0
AVERAGE SIGNAL POWER/USER	W	0.7		0.7
AVERAGE INTERFERENCE POWER/USER	W	0.4		0.4
USER'S TRANSMIT ANTENNA GAIN	dBi	1.2		1.2
SIGNAL EIRP	dBW	2.7		2.7
INTERFERENCE EIRP/USER	dBW	-3.4		-3.4
PATH LOSS	dB	177.5		159.5
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8
S/C ANTENNA GAIN	dBi	25.5		4.0
POLARIZATION ISOLATION	dB	3.0		3.0
RX SIGNAL POWER, C	dB	-150.1		-153.6
THERMAL NOISE DENSITY No	dB-Hz	-203.0		-203.0
SELF INTERFERENCE, Io self	dB-Hz	-200.1		-202.8
OTHER INTERFERENCE, Iother	dB-Hz	-201.0		-201.9
No+Ioself	dB Hz	-198.3		-199.9
No + Ioself + Iother	dB-Hz	-196.5		-197.8
RECEIVED Eb/No	dB	16.0		12.5
RECEIVED Eb/(No+Io self)	dB	11.4		9.5
RECEIVED Eb/(No+Io self+ Iother)	dB	9.5		7.3
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	1.9		2.1
UPLINK MARGIN	**dB**	**5.0**		**2.8**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

TABLE C- 3: ODYSSEY SHARES WITH OTHER TWO CDMA SYSTEMS

Odyssey: 150 Users per 2.5 MHz,Other CDMA SYSTEM : 60 users per 1.2 MHz

RETURN LINK : USER-TO-SATELLITE

PARAMETERS	UNIT	SYSTEM #1		SYSTEM #2	SYSTEM #3
SYSTEM		**ODYSSEY**		**OTHER CDMA**	**OTHER CDMA**
POLARIZATION		LHCP		RHCP	LHCP
NUMBER OF USERS PER X SPREAD BW		**150.0**		**60.0**	**30.0**
SPREAD BANDWIDTH	MHz	2.5		1.2	1.2
CHIP RATE	Mcps	3.7		1.2	1.2
FREQUENCY	GHZ	1.6		1.6	1.6
VOICE DUTY CYCLE	%	50.0		50.0	50.0
AVERAGE SIGNAL POWER/USER	W	0.7		0.7	0.7
AVERAGE INTERFERENCE POWER/USER	W	0.4		0.4	0.4
USER'S TRANSMIT ANTENNA GAIN	dBi	1.2		1.2	1.2
SIGNAL EIRP	dBW	2.7		2.7	2.7
INTERFERENCE EIRP/USER	dBW	-3.4		-3.4	-3.4
PATH LOSS	dB	177.5		159.5	159.5
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8	0.8
S/C ANTENNA GAIN	dBi	25.5		4.0	4.0
POLARIZATION ISOLATION	dB	3.0		3.0	3.0
RX SIGNAL POWER, C	dB	-150.1		-153.6	-153.6
THERMAL NOISE DENSITY No	dB-Hz	-203.0		-203.0	-203.0
SELF INTERFERENCE, Io self	dB-Hz	-200.1		-202.8	-205.9
OTHER INTERFERENCE, Iother	dB-Hz	-198.1		-200.4	-197.4
No+Ioself	dB Hz	-198.3		-199.9	-201.2
No + Ioself + Iother	dB-Hz	-195.2		-197.1	-195.9
RECEIVED Eb/No	dB	16.0		12.5	12.5
RECEIVED Eb/(No+Io self)	dB	11.4		9.5	10.8
RECEIVED Eb/(No+Io self+ Iother)	dB	8.2		6.7	5.4
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5	4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	3.1		2.8	5.3
UPLINK MARGIN	**dB**	**3.7**		**2.2**	**0.9**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

TABLE C-4: ODYSSEY SHARES WITH OTHER TWO CDMA SYSTEMS

Odyssey: 100 Users per 2.5 MHz,Other CDMA SYSTEM : 30 users per 1.2 MHz

RETURN LINK : USER-TO-SATELLITE

PARAMETERS	UNIT	SYSTEM #1		SYSTEM #2	SYSTEM #3
SYSTEM		**ODYSSEY**		**OTHER CDMA**	**OTHER CDMA**
POLARIZATION		LHCP		RHCP	LHCP
NUMBER OF USERS PER X SPREAD BW		**100.0**		**30.0**	**30.0**
SPREAD BANDWIDTH	MHz	2.5		1.2	1.2
CHIP RATE	Mcps	3.7		1.2	1.2
FREQUENCY	GHZ	1.6		1.6	1.6
VOICE DUTY CYCLE	%	50.0		50.0	50.0
AVERAGE SIGNAL POWER/USER	W	0.7		0.7	0.7
AVERAGE INTERFERENCE POWER/USER	W	0.4		0.4	0.4
USER'S TRANSMIT ANTENNA GAIN	dBi	1.2		1.2	1.2
SIGNAL EIRP	dBW	2.7		2.7	2.7
INTERFERENCE EIRP/USER	dBW	-3.4		-3.4	-3.4
PATH LOSS	dB	177.5		159.5	159.5
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8	0.8
S/C ANTENNA GAIN	dBi	25.5		4.0	4.0
POLARIZATION ISOLATION	dB	3.0		3.0	3.0
RX SIGNAL POWER, C	dB	-150.1		-153.6	-153.6
THERMAL NOISE DENSITY No	dB-Hz	-203.0		-203.0	-203.0
SELF INTERFERENCE, Io self	dB-Hz	-201.9		-205.9	-205.9
OTHER INTERFERENCE, Iother	dB-Hz	-199.4		-201.6	-199.5
No+Ioself	dB Hz	-199.4		-201.2	-201.2
No + Ioself + Iother	dB-Hz	-196.4		-198.4	-197.2
RECEIVED Eb/No	dB	16.0		12.5	12.5
RECEIVED Eb/(No+Io self)	dB	12.4		10.8	10.8
RECEIVED Eb/(No+Io self+ Iother)	dB	9.4		7.9	6.8
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5	4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	3.0		2.8	4.0
UPLINK MARGIN	**dB**	**4.9**		**3.4**	**2.3**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

TABLE C-5: ODYSSEY SHARES WITH OTHER CDMA SYSTEM

Odyssey: 150 Users per 2.5 MHz,Other CDMA : 60 users per 1.2 MHz

FORWARD LINK : SATELLITE-TO-USER

PARAMETERS	UNIT			
SYSTEM		ODYSSEY		OTHER CDMA
POLARIZATION		LHCP		RHCP
NUMBER OF USERS PER X SPREAD BW		**150.0**		**60.0**
SPREAD BANDWIDTH	MHz	2.5		1.2
CHIP RATE	Mcps	3.7		1.2
FREQUENCY	GHZ	2.5		2.5
VOICE DUTY CYCLE	%	50.0		50.0
AVERAGE SIGNAL POWER/USER	W	0.3		0.3
AVERAGE INTERFERENCE POWER/USER	W	0.2		0.1
TRANSMIT ANTENNA GAIN	dBi	25.3		7.5
SIGNAL EIRP	dBW	23.4		4.5
INTERFERENCE EIRP/USER	dBW	17.4		-1.5
PATH LOSS	dB	181.6		163.4
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8
HANDSET ANTENNA GAIN	dBi	1.6		1.6
POLARIZATION ISOLATION	dB	3.0		3.0
RX SIGNAL POWER, C	dB	-157.4		-158.1
THERMAL NOISE DENSITY No	dB-Hz	-203.9		-203.9
SELF INTERFERENCE, Io self	dB-Hz	-223.1		-221.6
OTHER INTERFERENCE, Iother	dB-Hz	-209.0		-205.6
No+Ioself	dB Hz	-203.8		-203.8
No + Ioself + Iother	dB-Hz	-202.7		-201.6
RECEIVED Eb/No	dB	9.7		9.0
RECEIVED Eb/(No+Io self)	dB	9.7		8.9
RECEIVED Eb/(No+Io self+ Iother)	dB	8.5		6.7
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	1.2		2.2
UPLINK MARGIN	**dB**	**4.0**		**2.2**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

TABLE C-6: ODYSSEY SHARES WITH OTHER TWO CDMA SYSTEM

Odyssey:150 Users per 2.5 MHz,Other CDMA : 60 users per 1.2 MHz

FORWARD LINK : SATELLITE-TO-USER

PARAMETERS	UNIT	SYSTEM #1		SYSTEM #2	SYSTEM #3
SYSTEM		ODYSSEY		OTHER CDMA	OTHER CDMA
POLARIZATION		LHCP		RHCP	LHCP
NUMBER OF USERS PER X SPREAD BW		**150.0**		**60.0**	**60.0**
SPREAD BANDWIDTH	MHz	2.5		1.2	1.2
CHIP RATE	Mcps	3.7		1.2	1.2
FREQUENCY	GHZ	2.5		2.5	0.0
VOICE DUTY CYCLE	%	50.0		50.0	50.0
AVERAGE SIGNAL POWER/USER	W	0.3		0.3	0.3
AVERAGE INTERFERENCE POWER/USER	W	0.2		0.1	0.1
TRANSMIT ANTENNA GAIN	dBi	25.3		7.5	7.5
SIGNAL EIRP	dBW	23.4		4.5	4.5
INTERFERENCE EIRP/USER	dBW	17.4		-1.5	-1.5
PATH LOSS	dB	181.6		163.4	163.4
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8	0.8
HANDSET ANTENNA GAIN	dBi	1.6		1.6	1.6
POLARIZATION ISOLATION	dB	3.0		3.0	3.0
RX SIGNAL POWER, C	dB	-157.4		-158.1	-158.1
THERMAL NOISE DENSITY No	dB-Hz	-203.9		-203.9	-203.9
SELF INTERFERENCE, Io self	dB-Hz	-223.1		-221.6	-221.6
OTHER INTERFERENCE, Iother	dB-Hz	-204.2		-203.3	-201.3
No+Ioself	dB Hz	-203.8		-203.8	-203.8
No + Ioself + Iother	dB-Hz	-201.0		-200.6	-199.4
RECEIVED Eb/No	dB	9.7		9.0	9.0
RECEIVED Eb/(No+Io self)	dB	9.7		8.9	8.9
RECEIVED Eb/(No+Io self+ Iother)	dB	6.8		5.7	4.5
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5	4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	2.8		3.3	4.4
UPLINK MARGIN	**dB**	**2.3**		**1.2**	**0.0**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

TABLE C-7: ODYSSEY SHARES WITH OTHER TWO CDMA SYSTEM

Odyssey:100 Users per 2.5 MHz,Other CDMA : 30 users per 1.2 MHz

FORWARD LINK : SATELLITE-TO-USER

PARAMETERS	UNIT	SYSTEM #1		SYSTEM #2	SYSTEM #3
SYSTEM		ODYSSEY		OTHER CDMA	OTHER CDMA
POLARIZATION		LHCP		RHCP	LHCP
NUMBER OF USERS PER X SPREAD BW		**100.0**		**30.0**	**30.0**
SPREAD BANDWIDTH	MHz	2.5		1.2	1.2
CHIP RATE	Mcps	3.7		1.2	1.2
FREQUENCY	GHZ	2.5		2.5	0.0
VOICE DUTY CYCLE	%	50.0		50.0	50.0
AVERAGE SIGNAL POWER/USER	W	0.3		0.3	0.3
AVERAGE INTERFERENCE POWER/USER	W	0.2		0.1	0.1
TRANSMIT ANTENNA GAIN	dBi	25.3		7.5	7.5
SIGNAL EIRP	dBW	23.4		4.5	4.5
INTERFERENCE EIRP/USER	dBW	17.4		-1.5	-1.5
PATH LOSS	dB	181.6		163.4	163.4
OTHER LOSSES (RAIN, ATMOSPHERIC,POLARIZATION)	dB	0.8		0.8	0.8
HANDSET ANTENNA GAIN	dBi	1.6		1.6	1.6
POLARIZATION ISOLATION	dB	3.0		3.0	3.0
RX SIGNAL POWER, C	dB	-157.4		-158.1	-158.1
THERMAL NOISE DENSITY No	dB-Hz	-203.9		-203.9	-203.9
SELF INTERFERENCE, Io self	dB-Hz	-223.1		-221.6	-221.6
OTHER INTERFERENCE, Iother	dB-Hz	-207.3		-205.5	-203.4
No+Ioself	dB Hz	-203.8		-203.8	-203.8
No + Ioself + Iother	dB-Hz	-202.2		-201.6	-200.6
RECEIVED Eb/No	dB	9.7		9.0	9.0
RECEIVED Eb/(No+Io self)	dB	9.7		8.9	8.9
RECEIVED Eb/(No+Io self+ Iother)	dB	8.0		6.7	5.7
REQUIRED Eb/(No + Itotal)*	dB	4.5		4.5	4.5
SYSTEM DEGRADATION DUE TO OTHER CDMA SYSTEM	dB	1.6		2.2	3.3
UPLINK MARGIN	**dB**	**3.5**		**2.2**	**1.2**

* ADDITIONAL 0.5 dB LOSS DUE TO OVERALL COMBINED (Eb/No)up, (Eb/No)down AND (C/IM3)

Appendix C

Interference Analyses

Interference Analyses

This appendix contains analyses of several interference related concerns. Additionally, for all operational situations Odyssey™ will coordinate all potential interference scenarios with the appropriate administrations in full accordance with ITU requirements.

A) Spurious Emission Analysis

The first analysis shows that Odyssey™ meet all requirements regarding spurious emissions into the 4990 - 5000 MHz frequency from primary downlink transmissions in the 2483.5 - 2500 MHz frequency band.

The out put of the spacecraft S-band HPAs are filtered by both bandpass and harmonic rejection filters. Then, harmonic rejection is at least 70 dB in the 4990 - 5000 MHz frequency region.

Since the Odyssey™ transmitted power flux density in the 2483.5 - 2500 MHz frequency band meets the ITU Radio Regulation Limitation of -142 $dBW/m^2/4kHz$, the filter rejection capability limits the level of the spurious emission to acceptable levels as shown below. The spurious spectral power flux density (Spfd) is:

$$Spfd \leq -142 - 10Log\,(4kHz) - 70 \text{ (Due to harmonic rejection filter)}$$

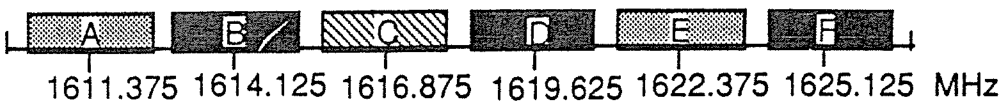
or

$$\mathbf{Spfd \leq -248\ dBW/m^2/Hz\ .}$$

Thus the requirement (-241 dBW/m2/Hz) of 25.213 is satisfied with more than 7 dB margin.

B) Protection of GPS from Out-of-band Emissions

The Odyssey™ user-to-satellite (L-band) link frequency utilization capability is shown in figure below



The QPSK signals used in the handset transceiver are digitally formed with fast roll off filtering. In addition the transmitter will employ filtering to assist the roll-off characteristics. The power spectral density of channel A is down at least 80 dB over the frequency range 1574.397 to 1576.443 MHz. The maximum e.i.r.p density (Med) at 1574.397 to 1576.443 MHz can then be shown as

$$Med = 10^{*}\log(.7) + 3.0 \text{ (antenna peak gain)} + 10\text{Log}(1/2.5) - 80$$

or

$$\mathbf{Med \leq -82.5\ dBW/1MHz}$$

Thus the isolation is achieved.

C) Power Flux Density

• Ka-band: the band segment 19.8 - 20.1 GHz will be used in the Odyssey™ satellite for the satellite-to-earth station.

The ITU Radio Regulations do not impose any limitation on the power flux density (pfd) of space stations in the fixed satellite service in the band 19.7 to 20.1 GHz. Therefore, the pfd level are not calculated for Ka-band satellite-to-earth station.

• S-band: According to No. 2566 (RR28-8) of the ITU Radio Regulations, the power flux density at the earth's surface produced by emissions from a space station, for all conditions and for all methods of modulation, shall not exceed the following values:

- 152 dB (W/m^2) in any 4 KHz band for $0° \leq \delta < 5°$
- 152 + $0.5(\delta - 5)$ dB (W/m^2) in any 4 KHz band for $5° \leq \delta < 25°$
- 142 dB (W/m^2) in any 4 KHz band for $\delta \geq 25°$

Where δ is the angle of any arrival in degrees above the horizontal plane.

The S-band power flux density is plotted in Figure C-1. The cases of uniformly distributed users as well as 600 users in a beam (the hot spot scenario) are both shown to satisfy the requirements.

D) Sharing with other systems

This section presents some sharing analysis with other hypothesized CDMA systems. Since the exact parameters of other CDMA systems are unknown at this time, some representative analysis cases are presented.

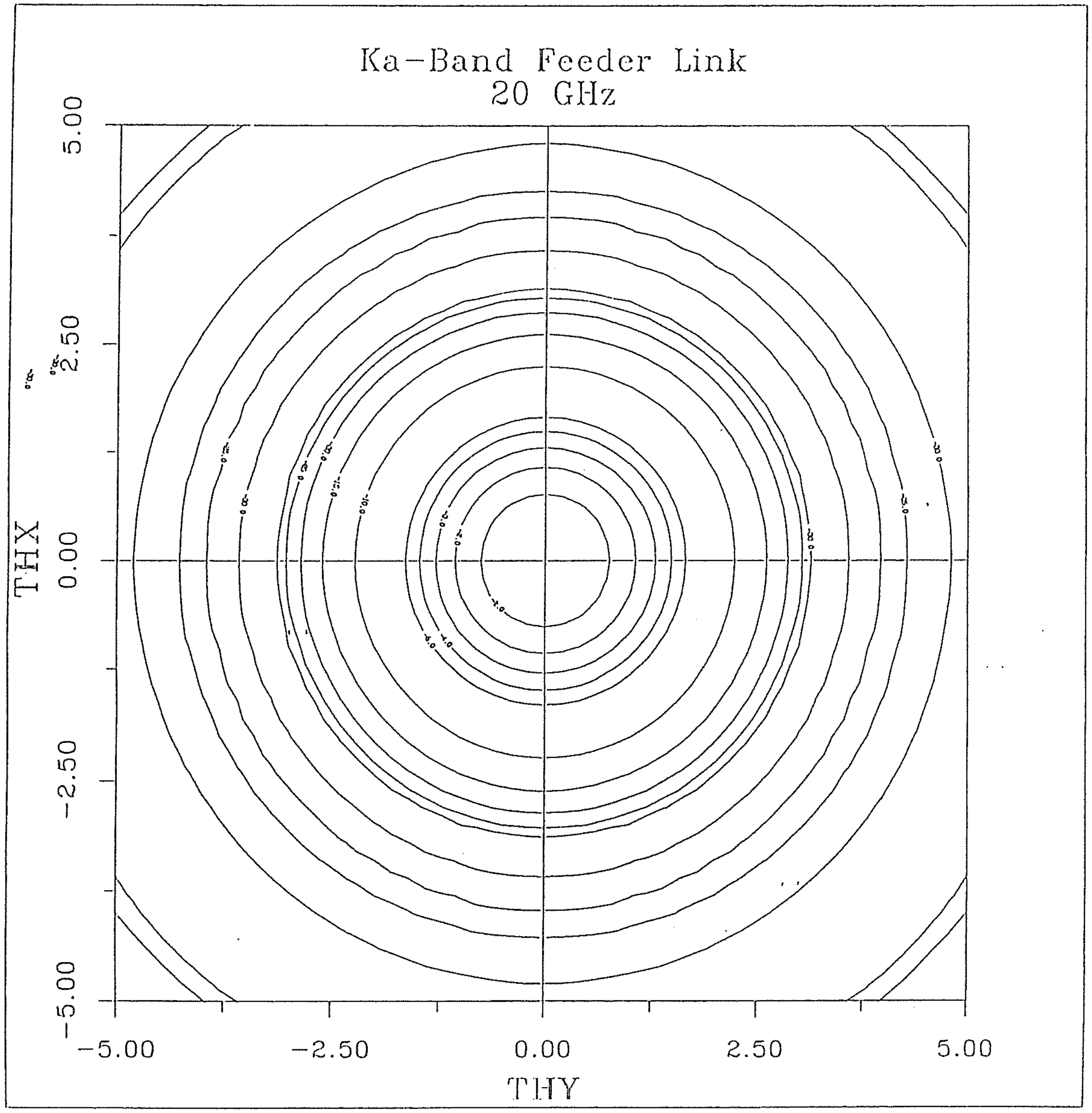


Figure D-2: Feeder Link Ka-Band Transmit Antenna Pattern

Contours: -1, -2, -3, -4, -6, -10, -15, -20, -25, -30 dB

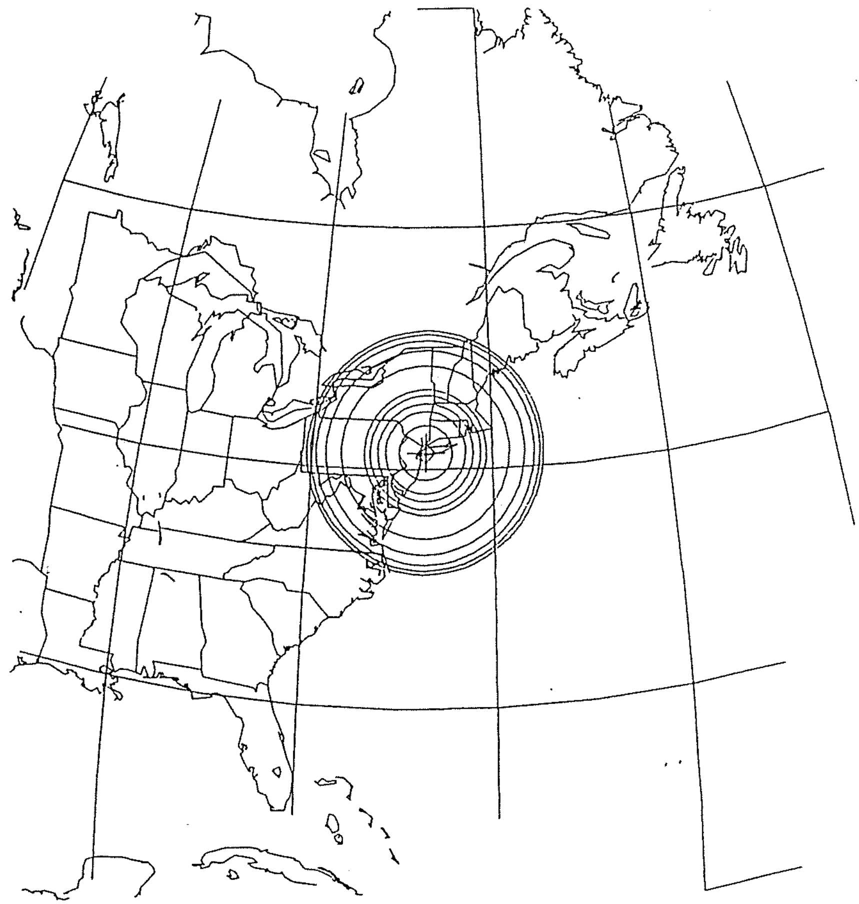


Figure D-3: East Coast Satellite-To-Ground Station Antenna Pattern

Contours: -1, -2, -3, -4, -6, -10, -15, -20, -25, -30 dB

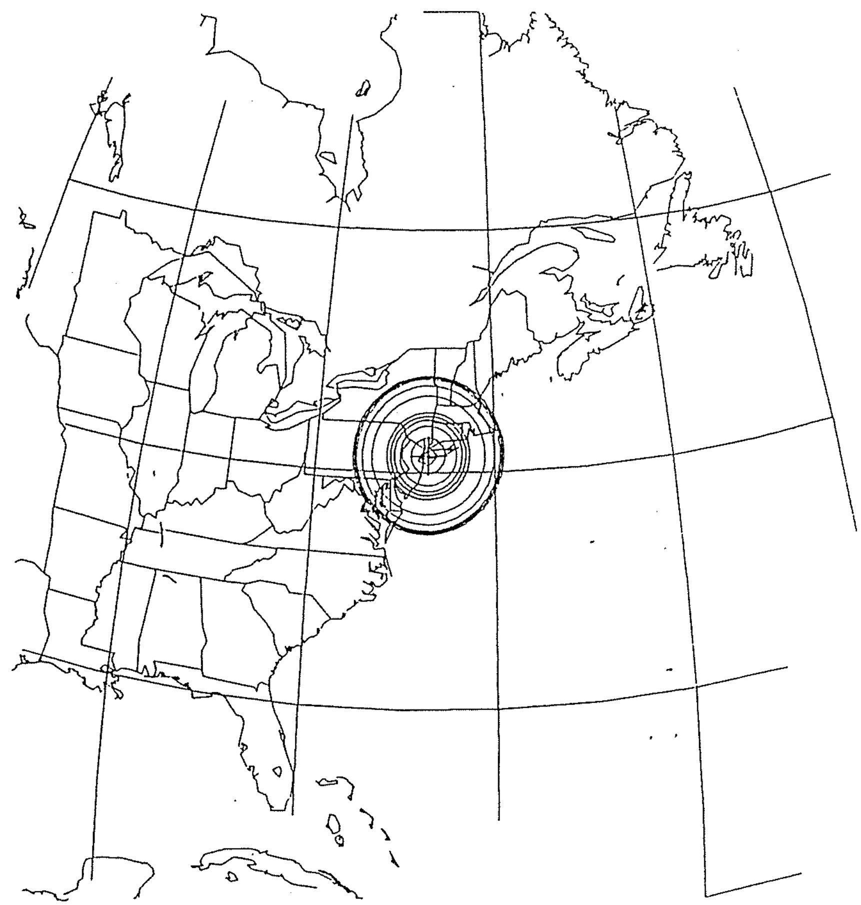
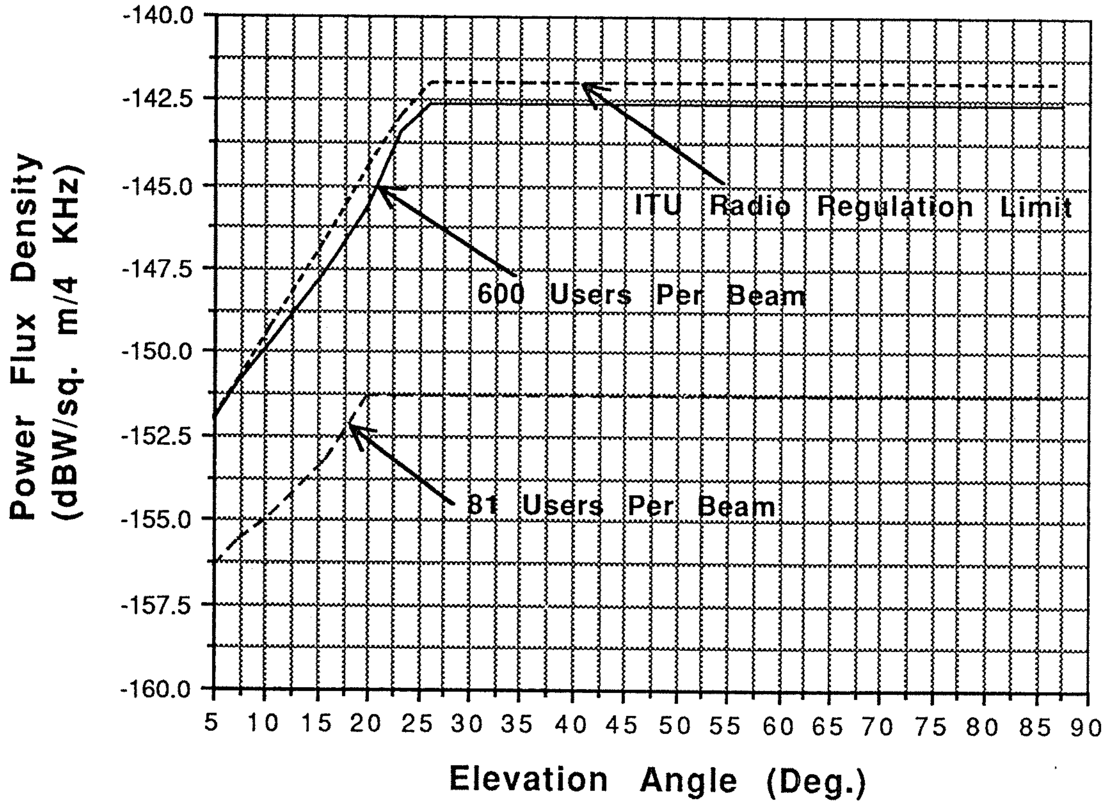


Figure D-4: East Coast Ground Station-to-Satellite Antenna Pattern

ODYSSEY

TRW

Figure C-1 Power Flux Density Vs Elevation Angle



Appendix D

Antenna Patterns

ODYSSEY

TRW

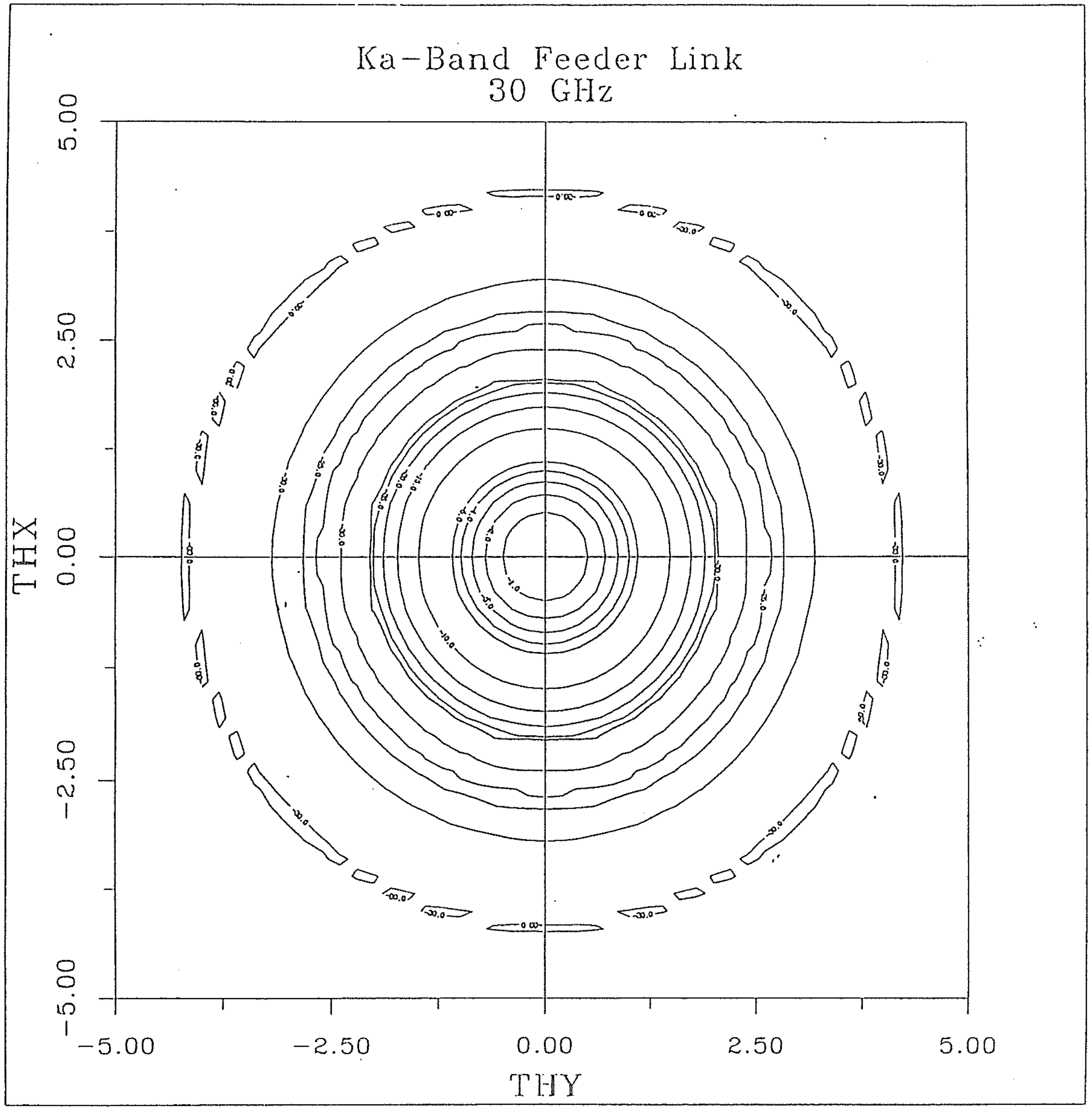


Figure D-1: Feeder Link Ka-Band Receive Antenna Pattern

Contours: -1, -2, -3, -4, -6, -10, -15, -20, -25, -30 dB

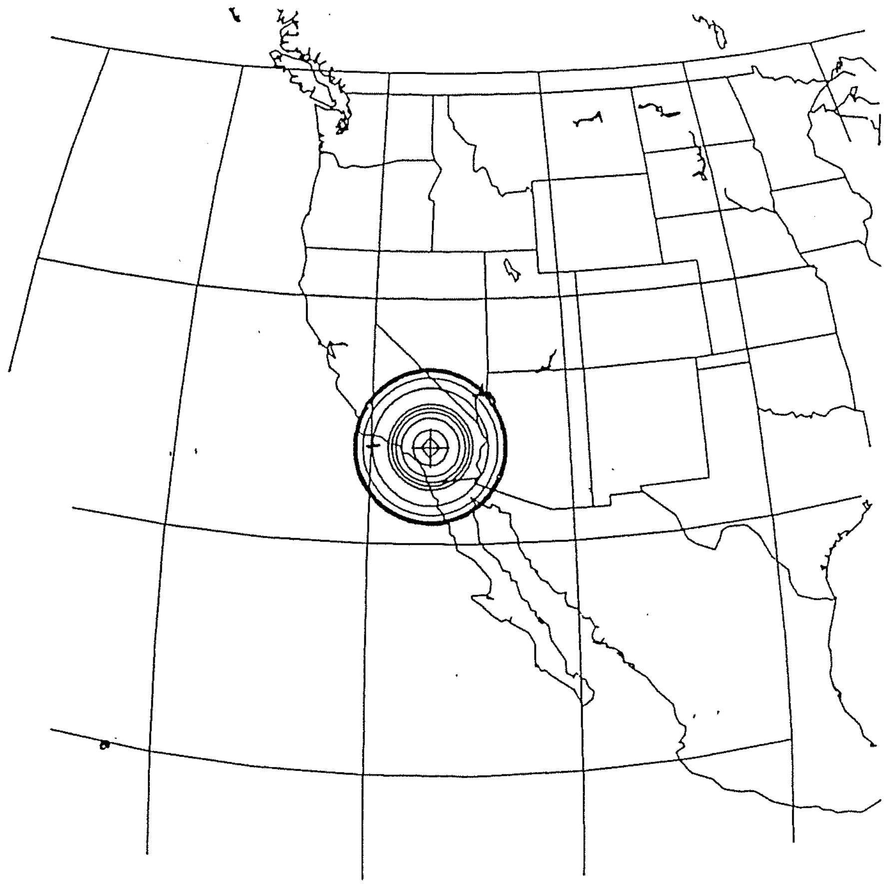


Figure D-5: West Coast Ground Station-to-Satellite Antenna Pattern

ODYSSEY

TRW

Contours: -1, -2, -3, -4, -6, -10, -15, -20, -25, -30 dB

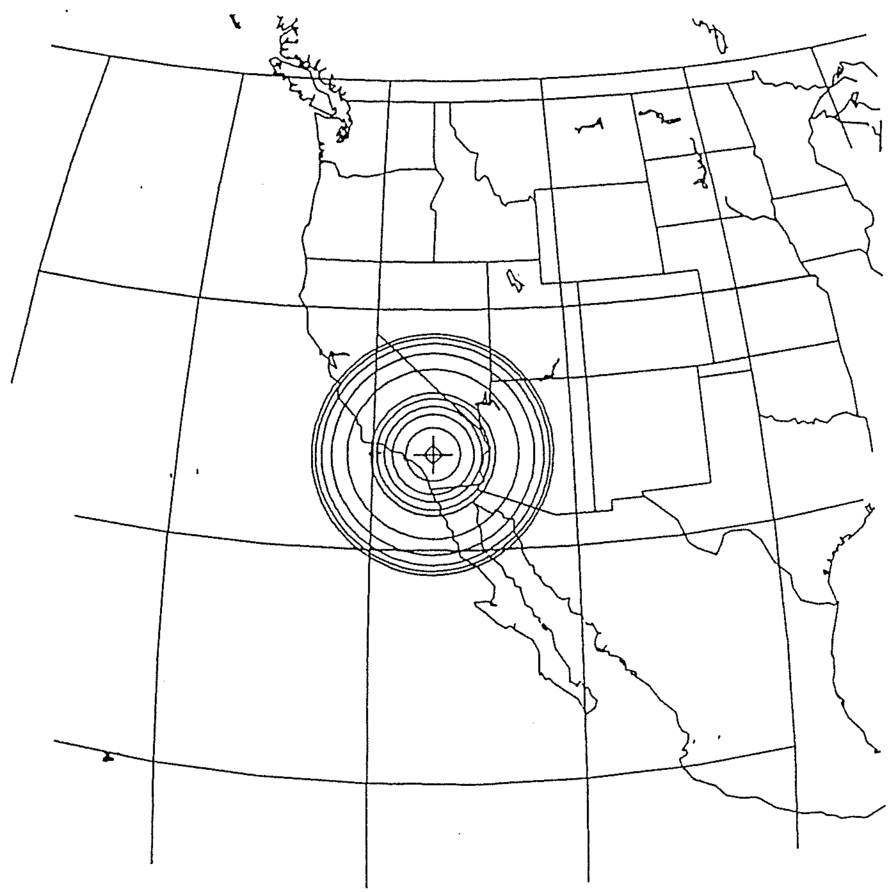


Figure D-6: West Coast Satellite-to-Ground Station Antenna Pattern

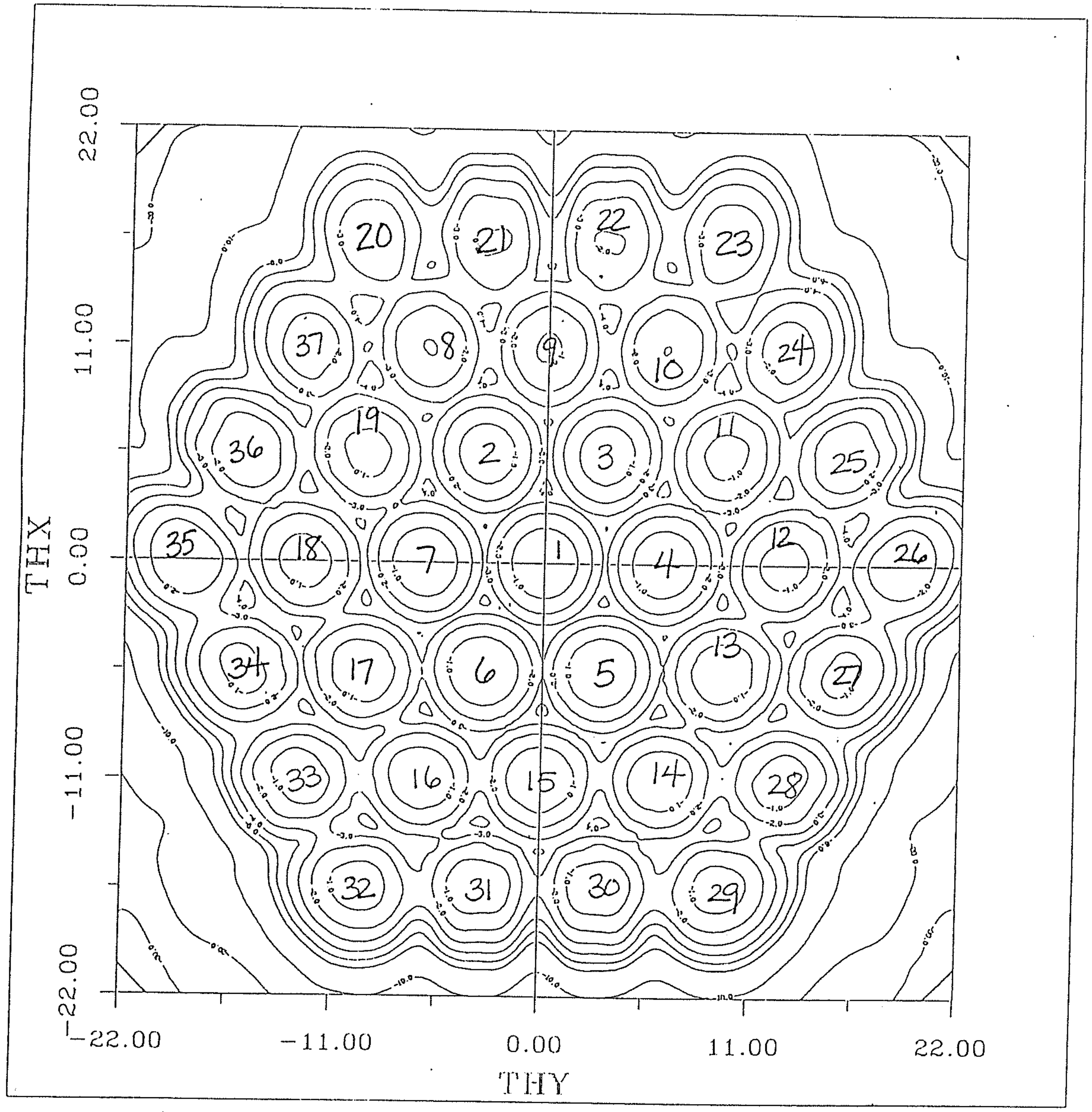


Figure D-7: Mobile Link Forward and Return Antenna Pattern

ODYSSEY

TRW

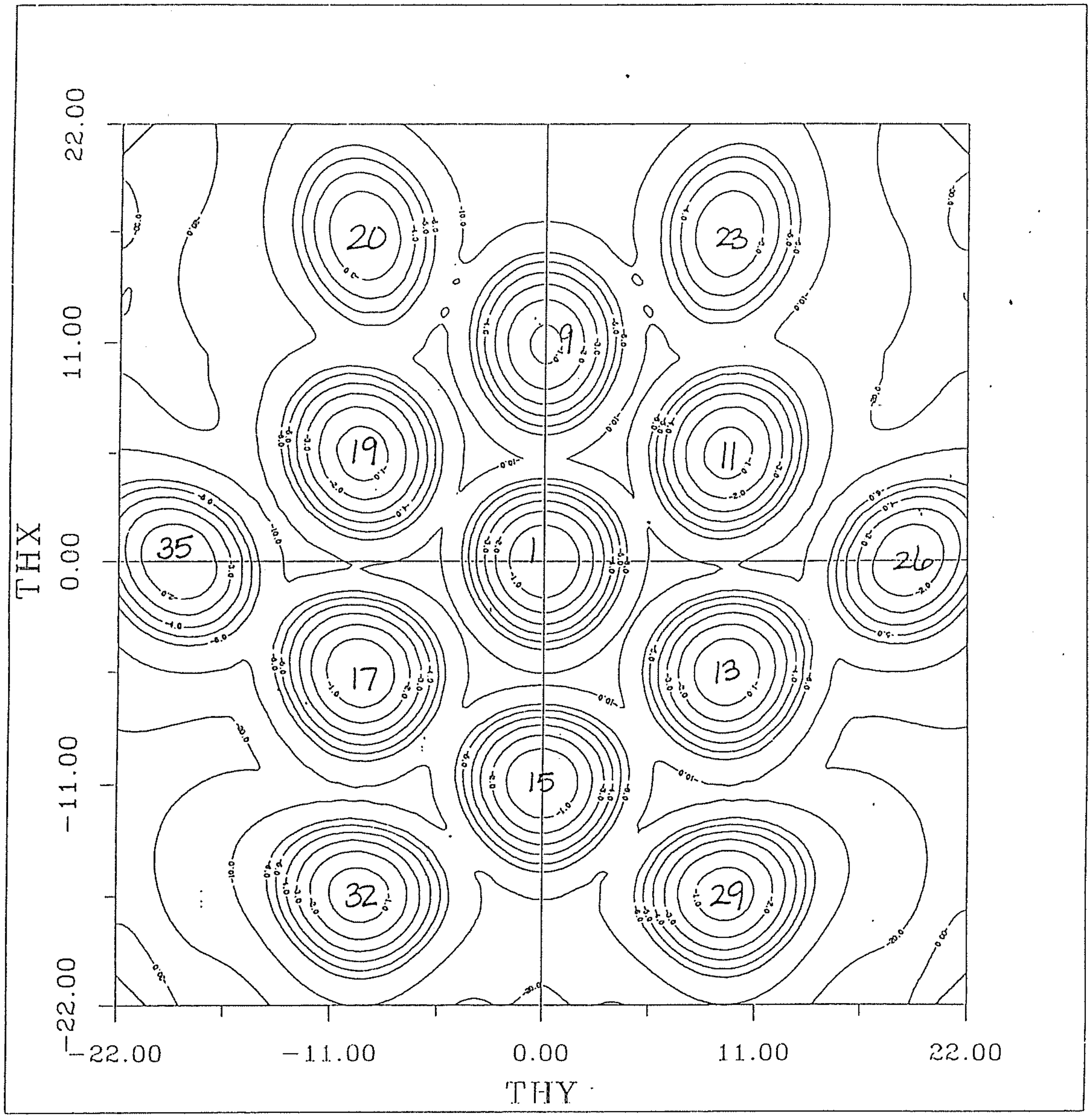


Figure D-8: Forward and Return Antenna Contour of Beams # 1, 9, 11, 13, 15, 17, 19, 20, 23, 26, 29 and 35

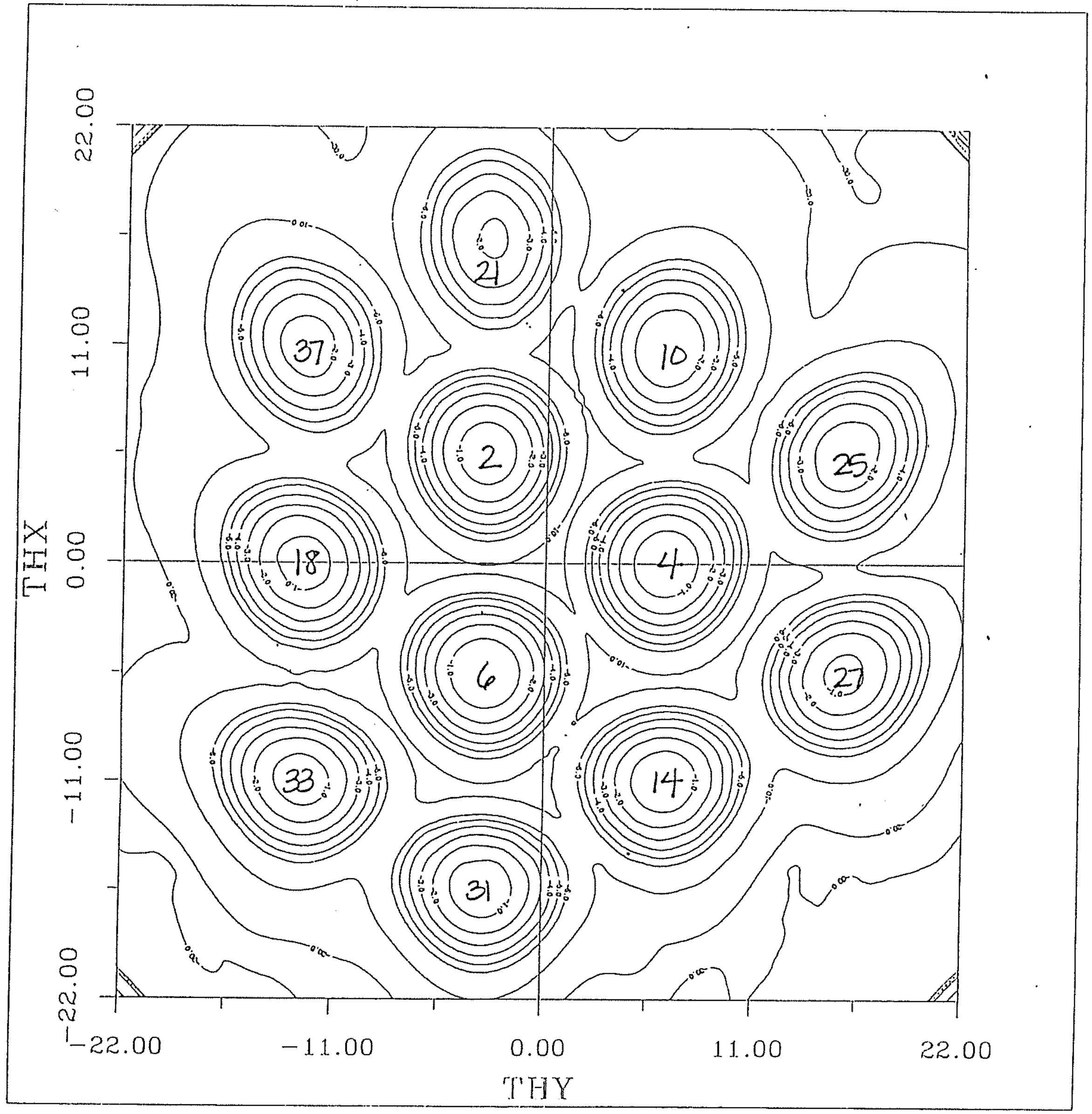


Figure D-9: Forward and Return Antenna Contour of Beams # 2, 4, 6, 10, 14, 18, 21, 25, 27, 31, 33, 33 and 37

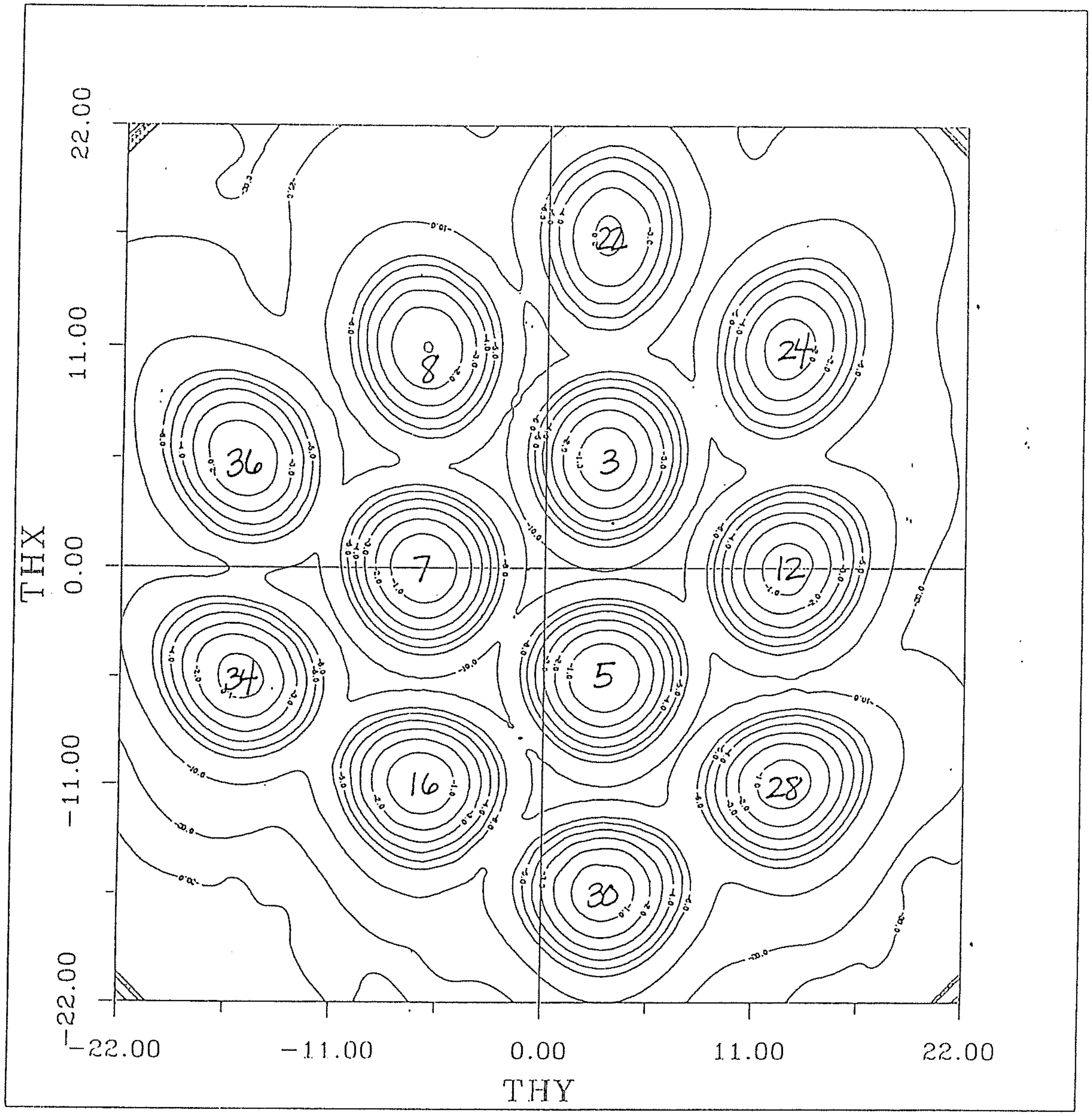


Figure D-10: Forward and Return Antenna Contour of Beams # 3, 5, 7, 8, 12, 16, 22, 24, 28, 30, 34 and 36

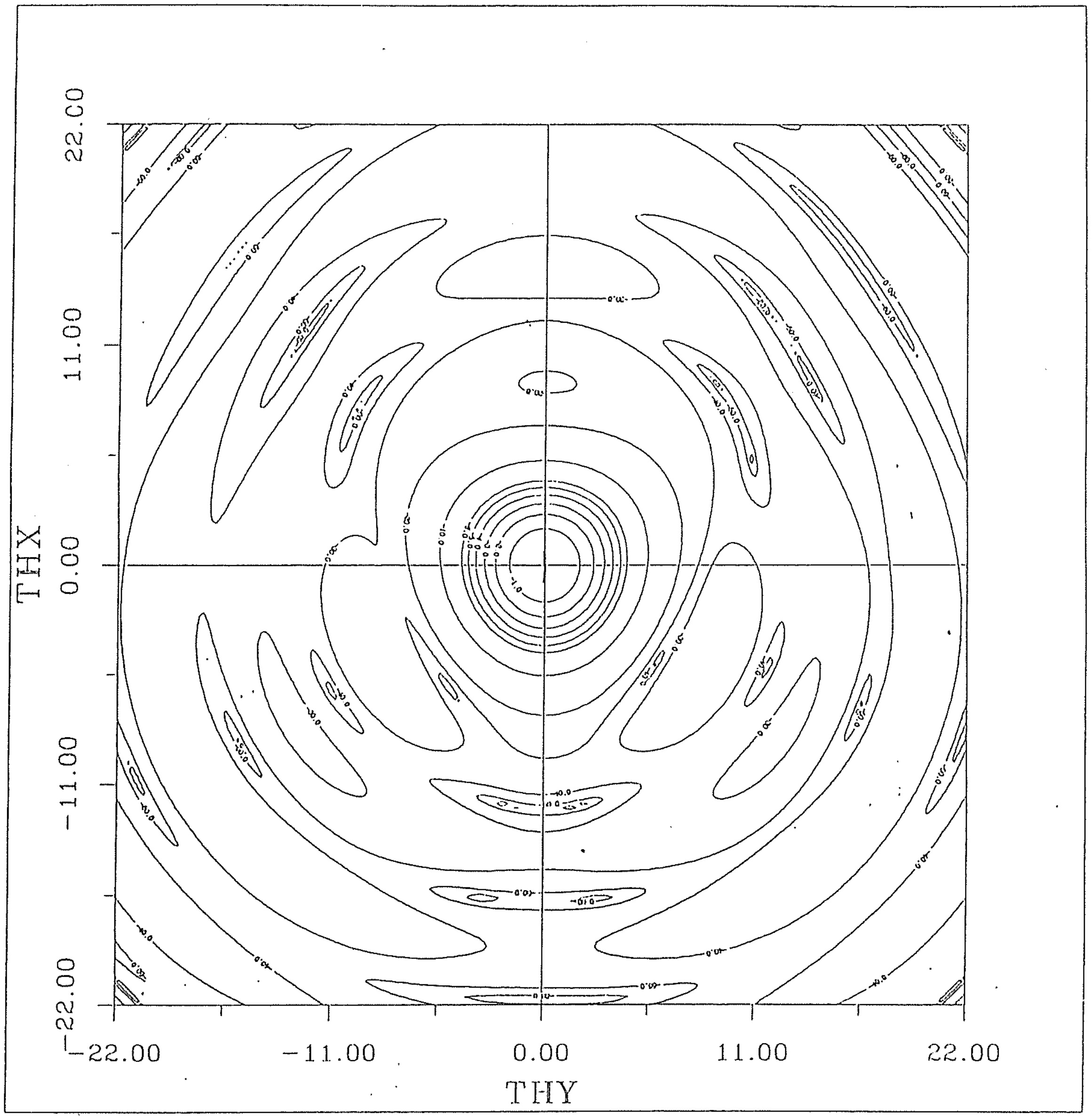


Figure D-11: Forward and Return Antenna Contour of Center Beam

ATTACHMENT B

FINANCIAL QUALIFICATIONS

As pointed out in its original Odyssey™ application, TRW brings to the communications satellite market the ability to self-finance its proposed system. As the information provided herein demonstrates, TRW is financially qualified under the rules and policies set forth by the Commission in its Report and Order in CC Docket No. 92-166, released October 14, 1994 (FCC 94-261).

A. Anticipated System Costs

The total anticipated capital investment, expenses and operating costs for the twelve-satellite system (plus two spares) through the first year of operation are approximately $1.8 billion. Since TRW will itself manufacture the spacecraft, satellite costs have been based upon internal company data premised upon years of experience in satellite construction, and no incentive payments -- with the possible exception of subcontracted items which are generally nominal in amount -- are applicable. The projected costs for launch, insurance, earth station and TT&C facility construction, and other associated items, are premised upon current industry experience.

statements are available), a copy of which is attached hereto as Appendix 2, TRW has sufficient current assets ($1,994 million) and operating income ($359 million) to fund the construction, launch and first year operating costs of the proposed satellite system over the multi-year time-frame involved. See also Declaration of Ronald D. Sugar, TRW Chief Financial Officer, Appendix 3 hereto.

C. Commitment from Management to Expend Necessary Funds

As demonstrated in the attached Declaration of TRW's Chief Financial Officer, TRW Inc. has committed, absent a material change in circumstances, to expend the funds necessary to construct, launch, and operate the Odyssey™ system. This is all that is required by new Section 25.143(b)(3) of the Commission's Rules, and the Commission's Report and Order in CC Docket No. 92-166.

* * *

Having thus demonstrated its ability to meet all system costs through the first year of operation, TRW has satisfied the Commission's financial showing for satellite applicants in these frequency bands. Accordingly, it is financially qualified to be authorized as a Commission licensee as requested herein.

APPENDIX 1

System Cost By Year
($ Millions)

	1995	1996	1997	1998	1999	2000	TOTAL
Spacecraft	77	260	231	166	162	162	1,058
U.S. Earth Stations & TT&C	23	26	35				84
Launch & Launch Support		81	156	187	140	48	612
Pre-Launch Expenses & Contingency	1	1	2	2			6
Launch Insurance		10	15	14	19		58
First 2 Years Operating Costs					11	15	26
TOTAL	101	378	439	369	332	225	1,844

Notes

- Spacecraft includes 12 operational and 2 spare satellites.
- U.S. Earth Stations & TT&C includes two U.S. earth stations (East & West Coasts) and one TT&C facility.
- First 2 Years Operating Costs include TT&C & U.S. earth stations operating costs plus G&A, marketing, etc. allocable to U.S. (25% of total). Two years shown instead of just the required first year because Odyssey can begin service with six satellites, so first year of operations occurs in year prior to completed space segment.

Current estimated system costs (in $ millions) for the system are:*/

• Spacecraft (12 operational and 2 spares)	$1,058
• Earth Station and TT&C Facility	84
• Launches & Launch Support	612
• Pre-Launch Expenses & Contingency	6
• Launch Insurance	58
• First-Year Operations - TT&C, G&A, Sales, etc.**/	26
Total	$1,844

The capital costs and pre-launch expenses will be incurred in varied annual amounts from the date of grant of conditional permit authorization by the FCC to the anticipated launch date for the final spacecraft in the Odyssey™ system.

B. Source of Funds

As demonstrated in the audited consolidated financial statement of TRW Inc. for the period ending December 31, 1993 (the most recent period for which audited

*/ If the figures stated in this estimate of the system costs of Odyssey were to be adjusted for inflation to "then-year" dollars, system costs could be expected to increase by approximately 15%. Nevertheless, TRW would still be financially qualified under the applicable standard.

**/ The operating cost projections included in this table contain both first and second year operating costs. First year-only operating cost projections for Odyssey™ represent $11 million of the $26 million total. A table showing TRW's system costs by year for Odyssey™ is included as Appendix 1 hereto.

APPENDIX 2

Report of management

Management of TRW is responsible for the preparation of the accompanying consolidated financial statements of the company and its subsidiaries. The financial statements have been prepared in conformity with generally accepted accounting principles and include the estimates and judgments of management. The financial statements have been audited by Ernst & Young, independent auditors, whose report appears below.

Management has established and is responsible for maintaining a system of internal accounting controls that it believes provides reasonable assurance that assets are safeguarded and transactions are executed and recorded in accordance with management's authorization. The system is tested and evaluated regularly by the company's internal auditors as well as by the independent auditors in connection with their annual audit.

TRW has an audit committee composed of four directors who are not members of management. The committee meets regularly with management, the internal auditors and the independent auditors in connection with its review of matters relating to the company's financial statements, the company's internal audit program, the company's system of internal accounting controls and the services of the independent auditors. The committee also meets with the internal auditors as well as the independent auditors, without management present, to discuss appropriate matters. The committee also recommends to the directors the designation of the independent auditors.

Joseph T. Gorman
Chairman and Chief Executive Officer

Peter S. Hellman
Executive Vice President and
Chief Financial Officer

Carl G. Miller
Vice President and Controller

February 8, 1994

Report of Ernst & Young, independent auditors

Shareholders and Directors
TRW Inc.

We have audited the accompanying consolidated balance sheets of TRW Inc. and subsidiaries as of December 31, 1993 and 1992, and the related consolidated statements of earnings, cash flows and changes in shareholders' investment for each of the three years in the period ended December 31, 1993. These financial statements are the responsibility of the company's management. Our responsibility is to express an opinion on these financial statements based on our audits.

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

In our opinion, the financial statements referred to above (appearing on pages 23 through 39 of this annual report) present fairly, in all material respects, the consolidated financial position of TRW Inc. and subsidiaries at December 31, 1993 and 1992, and the consolidated results of their operations and their cash flows for each of the three years in the period ended December 31, 1993, in conformity with generally accepted accounting principles.

As discussed in the notes to financial statements, effective January 1, 1993, the company changed its method of accounting for postemployment benefits and, effective January 1, 1992, its methods of accounting for postretirement benefits other than pensions and income taxes.

Ernst & Young

Cleveland, Ohio
February 8, 1994

Statements of Earnings

TRW Inc. and subsidiaries

In millions except per share data

Years ended December 31	1993	1992	1991
Sales	$ 7,948	$ 8,311	$ 7,913
Cost of sales	6,368	6,617	6,307
Gross profit	1,580	1,694	1,606
Administrative and selling expenses	707	826	841
Research and development expenses	378	393	346
Restructuring expense(income)	7	(29)	343
Interest expense	138	163	190
Other expense(income)-net	(9)	(7)	15
Earnings(loss) before income taxes and cumulative effect of accounting changes	359	348	(129)
Income taxes	139	154	11
Earnings(loss) before cumulative effect of accounting changes	220	194	(140)
Cumulative effect at beginning of the year of accounting changes, net of income taxes	(25)	(350)	–
Net earnings(loss)	$ 195	$ (156)	$ (140)
Per share of common stock			
Fully diluted			
Before cumulative effect of accounting changes	$ 3.35	$ 3.09	$ (2.30)
Cumulative effect of accounting changes	(.38)	(5.60)	–
Net earnings(loss) per share	$ 2.97	$ (2.51)	$ (2.30)
Primary			
Before cumulative effect of accounting changes	$ 3.39	$ 3.09	$ (2.30)
Cumulative effect of accounting changes	(.38)	(5.60)	–
Net earnings(loss) per share	$ 3.01	$ (2.51)	$ (2.30)

See notes to financial statements.

Balance Sheets

TRW Inc. and subsidiaries

In millions

December 31	1993	1992
Assets		
Current assets		
Cash and cash equivalents	$ 79	$ 66
Accounts receivable	1,219	1,289
Inventories		
Finished products and work in process	237	263
Raw materials and supplies	173	159
Total inventories	410	422
Prepaid expenses	69	69
Deferred income taxes	217	270
Total current assets	1,994	2,116
Property, plant and equipment-on the basis of cost		
Land	104	96
Buildings	1,461	1,442
Machinery and equipment	3,555	3,514
	5,120	5,052
Less accumulated depreciation and amortization	2,793	2,741
Total property, plant and equipment-net	2,327	2,311
Intangible assets		
Intangibles arising from acquisitions	499	552
Capitalized data files	421	418
Other	36	46
	956	1,016
Less accumulated amortization	279	299
Total intangible assets-net	677	717
Other assets	338	314
	$5,336	$5,458

Balance Sheets (continued)

TRW Inc. and subsidiaries

In millions

December 31	1993	1992
Liabilities and shareholders' investment		
Current liabilities		
Short-term debt	$ 295	$ 260
Accrued compensation	281	286
Trade accounts payable	563	583
Other accruals	599	752
Dividends payable	30	30
Income taxes	10	85
Current portion of long-term debt	48	16
Total current liabilities	1,826	2,012
Long-term liabilities	803	804
Long-term debt	870	941
Deferred income taxes	235	222
Minority interests in subsidiaries	68	63
Shareholders' investment		
Serial Preference Stock II (involuntary liquidation $11 million and $12 million)	1	1
Common stock (shares outstanding 64.1 million and 62.9 million)	40	39
Other capital	293	222
Retained earnings	1,178	1,105
Cumulative translation adjustments	36	53
Treasury shares — cost in excess of par value	(14)	(4)
Total shareholders' investment	1,534	1,416
	$5,336	$5,458

See notes to financial statements.

Statements of Cash Flows

TRW Inc. and subsidiaries

In millions

Years ended December 31	1993	1992	1991
Operating activities			
Net earnings(loss)	$ 195	$ (156)	$ (140)
Adjustments to reconcile net earnings(loss) to net cash provided by operating activities:			
Cumulative effect of accounting changes, net of taxes	25	350	–
Depreciation and amortization	458	481	469
Restructuring	(61)	(96)	227
Deferred income taxes	49	5	27
Other-net	12	25	47
Changes in assets and liabilities, net of effects of businesses acquired or sold:			
Accounts receivable	(46)	(104)	(56)
Inventories and prepaid expenses	(5)	(46)	22
Accounts payable and other accruals	(107)	227	30
Other-net	(30)	(42)	(14)
Net cash provided by operating activities	490	644	612
Investing activities			
Capital expenditures	(482)	(530)	(537)
Proceeds from divestitures	97	371	52
Investments in other assets	(51)	(62)	(95)
Proceeds from sales of property, plant and equipment	24	11	51
Other-net	(11)	11	(25)
Net cash used in investing activities	(423)	(199)	(554)
Financing activities			
Increase(decrease) in short-term debt	104	(229)	69
Proceeds from debt in excess of 90 days	255	198	462
Principal payments on debt in excess of 90 days	(344)	(351)	(495)
Dividends paid	(120)	(114)	(111)
Other-net	33	18	4
Net cash used in financing activities	(72)	(478)	(71)
Effect of exchange rate changes on cash	18	24	16
Increase(decrease) in cash and cash equivalents	13	(9)	3
Cash and cash equivalents at beginning of year	66	75	72
Cash and cash equivalents at end of year	$ 79	$ 66	$ 75

See notes to financial statements.

APPENDIX 3

Declaration of Ronald D. Sugar

I, Ronald D. Sugar, hereby declare under penalty of perjury of the laws of the United States and the State of Ohio, that:

1. I am Executive Vice President and Chief Financial Officer of TRW Inc.

2. The foregoing is a true and correct copy of the consolidated financial statement of TRW Inc. for the period ended December 31, 1993, including the report of Ernst & Young, the Company's independent certified public accountants.

3. TRW Inc. has sufficient current assets and operating income to fund the construction, launch and first year operating costs of its proposed satellite system.

4. Absent a material change in circumstances, TRW Inc. is committed to expend the funds necessary to construct, launch and operate the Odyssey system.

Ronald D. Sugar
Executive Vice President and
Chief Financial Officer
TRW Inc.

Date: November 9, 1994

ATTACHMENT C

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. If 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:

TRW Inc.
One Space Park
Redondo Beach, CA 90278

2. (Area Code) Telephone Number: 310-812-4321

3. If this report supercedes a previously filed report, specify its date: July 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? Ohio

6. List the common carrier and satellite radio services in which Filer has applied or is a current licensee or permittee: TRW applied on May 31, 1991 for authority to construct a new non-geostationary mobile satellite service system called Odyssey (File Nos. 20-DSS-P-91(12) and CSS-91-015). In August 1991, TRW applied for authority to establish an international geostationary fixed-satellite service system (File No. CSS-91-012). The FSS application was granted in September 1993; in September 1994, TRW relinquished its conditional FSS authorization.

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.* See Exhibit V ☒ 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.

No entity or individual owns or votes 10 percent or more of the capital stock of TRW (other than TRW Inc.'s employee stock ownership plan).

(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? See Exhibit IX ☒ 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*): TRW Inc.	Typed or Printed Name: Timothy W. Hannemann
	Signature: Timothy W. Hannemann		Title: Executive Vice President and General Manager

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.

Principals of TRW

(Response to FCC Form 430 Question 10(b))

The directors and corporate officers of TRW Inc. are:

Name	Title	Business Address
Michael H. Armacost	Director	Asia/Pacific Research Center Encina Hall, Room 200 Stanford University Stanford, CA 94305-6055
William L. Aamoth	Assistant Treasurer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Edward L. Bennardo	Assistant Treasurer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Martin A. Coyle	Executive Vice President, General Counsel & Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
James C. Diggs	Assistant General Counsel & Assistant Secretary	TRW Inc. One Federal Systems Park Dr. Fairfax, VA 22033
Charles T. Duncan	Director	Messrs. Reid & Priest Market Square 701 Pennsylvania Ave., N.W. Washington, D.C. 20004
Edsel D. Dunford	Director, President & Chief Operating Officer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Martin Feldstein	Director	National Bureau of Economic Research 1050 Massachusetts Ave. Cambridge, MA 02138

William E. Gallas	Assistant General Counsel & Assistant Secretary	TRW Inc. One Space Park Redondo Beach, CA 90278
Thomas A. Gasparini	Assistant General Counsel & Assistant Secretary	TRW Inc. 505 City Parkway W., 10th Fl. Orange, CA 92668
Robert M. Gates	Director	1905 West Big Lake Blvd. Mt. Vernon, WA 98273
David B. Goldston	Assistant General Counsel & Assistant Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Joseph T. Gorman	Director, Chairman of the Board & Chief Executive Officer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Carl H. Hahn	Director	Volkswagen AG Porschestrasse 53 38440 Wolfsburg, Germany
Timothy W. Hannemann	Executive Vice President & General Manager	TRW Inc. One Space Park Redondo Beach, CA 90278
Crawford T. Harvie	Associate General Counsel & Assistant Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
George H. Heilmeier	Director	Bellcore Room 1E-310 290 West Mt. Pleasant Ave. Livingston, NJ 07039
Peter S. Hellman	Executive Vice President & Assistant President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Karen N. Horn	Director	Bank One, Cleveland, NA 600 Superior Ave. Cleveland, OH 44114

John A. Janitz	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
E. Bradley Jones	Director	30195 Chagrin Blvd. Suite 104W Pepper Pike, OH 44124
William S. Kiser	Director	The Cleveland Clinic Foundation One Clinic Center 9500 Euclid Ave. Cleveland, OH 44195
Marsha A. Klontz	Assistant General Counsel & Assistant Secretary	TRW Inc. One Rancho Carmel San Diego, CA 92128
Howard V. Knicely	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Robert J. Kohler	Executive Vice President	TRW Inc. One Rancho Carmel San Diego, CA 92128
John E. Lanz	Assistant Controller	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
William B. Lawrence	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 33124
Philippe Lemaitre	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
James T. Lynn	Director	6901 Radnor Rd. Bethesda, MD 20817
Chester O. Macey	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 33124

Carl G. Miller	Vice President & Controller	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Richard W. Pogue	Director	Jones, Day, Reavis & Pogue North Point 901 Lakeside Ave. Cleveland, OH 44114
Paul T. Pope	Assistant Treasurer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44114
James M. Roosevelt	Assistant General Counsel & Assistant Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Jean M. Schmidt	Assistant Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
William C. Seeger	Vice President & Treasurer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
D. Van Skilling	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Richard C. Sneed	Assistant General Counsel & Assistant Secretary	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
John P. Stenbit	Executive Vice President	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
Ronald D. Sugar	Executive Vice President & Chief Financial Officer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124
William A. Warren	Assistant Treasurer	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124

R. Gordon Williams	Vice President & Deputy General Manager	TRW Inc. One Space Park Redondo Beach, CA 90278-1001
Martin I. Zelman	Assistant Controller	TRW Inc. 1900 Richmond Rd. Cleveland, OH 44124

Judicial Determinations

(Response to FCC Form 430 Question 7(c))

Rider A

The Company has undertaken internal investigations and has made voluntary disclosures to the United States Government concerning cost-estimating, mischarging and other irregularities discovered in certain of its current or former Government contracting businesses in the mid-1980s and has cooperated in any United States Government investigations regarding these matters.

After completion of the investigations relating to one of these matters, a subsidiary of the Company, TRW Electronic Products Inc. ("EPI"), pleaded guilty on September 3, 1987 to 10 counts of false statements and agreed to pay criminal fines totaling $100,000 to settle mischarging issues on certain Government contracts. The settlement also involved payments and credits of $4.1 million by EPI to settle civil and certain administrative claims.

In a separate settlement (the "Settlement") on September 3, 1987, the Department of Defense agreed not to debar or suspend the Company from Government contracting based on either the EPI guilty plea or information that had been provided to the Department relating to the three other matters voluntarily disclosed by the Company in connection with unrelated incidents of improper charging in the Company's current or former Government contracting businesses in San Diego, California, Cleveland, Ohio and Sunnyvale, California. As part of the Settlement, the Company made a good-faith payment of $17 million (including the payment by EPI) as restitution for estimated Government losses in the four matters. The Company also agreed to take certain corrective action internally and to continue to demonstrate its commitment to contractor integrity.

In connection with the Government contract accounting irregularities at TRW's former Compressor Components Division in Cleveland, Ohio, the Company pleaded guilty on August 25, 1988 to three counts of conspiracy to defraud the United States Government and agreed to pay criminal fines and penalties of $3 million. All issues relating to the payment of restitution were referred to a civil proceeding (see discussion below). The Company also made an additional payment of $3 million as restitution for estimated Government losses with respect to the Government contract accounting irregularities that occurred in Cleveland.

On April 4, 1986, a civil claim was filed against TRW in the United States District Court for the Northern District of Ohio by three former employees of TRW's Compressor Components Division in Cleveland, Ohio, seeking damages on behalf of the United States Government under the Federal False Claims Act. Later in 1986, the United States Department of Justice assumed control of the action for the Government. The action was based primarily on Government contract accounting irregularities at certain of the Company's operating units which previously had been disclosed by the Company voluntarily to the United States Government. TRW reached a settlement of the suit with the Department of Justice on April 15, 1994. Under the terms of the Settlement, TRW agreed to pay the government $12.6 million as part of a total settlement of $29 million. TRW had previously paid the government $16.4 million in 1987 and 1988 as part of its efforts to resolve the matter and make restitution.

In a separate settlement agreement dated April 15, 1994, TRW and the Defense Logistics Agency ("DLA") agreed to a final resolution of the San Diego matter involving TRW Military Electronic & Avionics Division's voluntary disclosure of government accounting irregularities in December 1986. The terms of the agreement require TRW to pay the DLA $1.5 million plus interest in three installments over a three-year period.

Other Radio Station Licenses

TRW Inc. holds the following licenses in the Experimental Radio Services:

Call Sign	KM2XDO	(airborne mobile stations)
Call Sign	KM2XDR	(hand-held mobile terminals)
Call Sign	KM2XDT	(mobile gateway station)

TRW Inc. also holds a license in the Business Radio Service, Call Sign WPBE835, in conjunction with its Radiometric Oil Spill Surveillance System.

FCC Form 430
November 1994
Exhibit IX

Non-U.S. Citizens

(Response to FCC Form 430 Question 10(d))

Carl H. Hahn, a TRW director, is a citizen of Germany and Chester O. Macey, an officer of TRW, is a citizen of Canada.

ATTACHMENT D

<u>Construction and Launch Schedule for Odyssey</u>

Event	1994	1995	1996	1997	1998	1999	2000	2001
Commencement of Construction/ Procurement of Long Lead Items (per 319(d) waiver)	Δ							
Grant of Conditional Authorization		Δ						
Commence Construction of Odyssey 1/Odyssey 2 Spacecraft	...	Δ						
Commence Construction of Odyssey 3 through Odyssey 12 Spacecraft	...	Δ						
Complete Construction of Odyssey 1/Odyssey 2 Spacecraft					Δ			
Complete Construction of Odyssey 3 through Odyssey 12 Spacecraft					Δ.	....	..Δ	
Launch Odyssey 1 through Odyssey 12 Spacecraft					Δ..	....	......Δ	
Commence Commercial Operation of Odyssey System						Δ		
Full System Operational							Δ	

CERTIFICATION

I, Timothy W. Hannemann, hereby certify, under penalty of perjury, that I have reviewed the foregoing Amendment, including the attachments thereto, and found the information presented therein to be complete and accurate to the best of my knowledge and belief.

TRW Inc.

By: Timothy W. Hannemann
Timothy W. Hannemann,
Executive Vice President
and General Manager

Dated: November 15, 1994

ANTI-DRUG ABUSE ACT CERTIFICATION

I, Timothy W. Hannemann, hereby certify, under penalty of perjury, that no party to this application, as defined in Section 1.2002(b) of the Commission's rules, 47 C.F.R. § 1.2002(b), is subject to a denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 853a.

TRW Inc.

By: Timothy W. Hannemann

Timothy W. Hannemann
Executive Vice President
and General Manager

Dated: November 15, 1994

November 15, 1994

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
Room 222
1919 M Street, N.W.
Washington, D.C. 20554

Re: Application Of TRW Inc. For Authority To Launch And Operate An MSS Above 1 GHz Satellite System

Dear Mr. Caton:

TRW Inc. ("TRW") hereby applies for authority to launch and operate its proposed satellite system in the new Mobile-Satellite Service Above 1 GHz ("MSS Above 1 GHz") service. TRW hereby incorporates by reference its application for authority to construct an MSS Above 1 GHz system, and the qualifications showings and operational descriptions contained therein. See Application of TRW Inc., File Nos. 20-DSS-P-91(12) and CSS-91-015, as amended.

No party to this TRW application, as defined in Section 1.2002(b) of the Commission's rules, 47 C.F.R. § 1.2002(b), is subject to a denial of federal benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 853a.

As Executive Vice President and General Manager of TRW Inc., I hereby certify under penalty of perjury that the matters stated in this request for authority to launch and operate the TRW MSS Above 1 GHz satellite system are true and correct to the best of my knowledge and belief.

Respectfully yours,

Timothy W. Hannemann

Timothy W. Hannemann
Executive Vice President
and General Manager
TRW Inc.

Appendix E

Emission Designators

Appendix E

EMMISSION DESIGNATORS

Voice:

* Mobile Link (user-to-satellite & satellite-to-user)

  2M5G1EDC

* Feeder Link (satellite-to-earth station & earth station to user)

  2M5G7EDC

Data:

* Mobile Link (user-to-satellite & satellite-to-user)

  2M5G1DDC

* Feeder Link (satellite-to-earth station & earth station to user)

  2M5G7DDC

TT&C:

* Telecommand

  1K00F9D

* Telemetry

  2K40G9D

TECHNICAL CERTIFICATE

The undersigned hereby certify under penalty of perjury that we are the technically qualified persons responsible for the preparation of the technical information in the foregoing Amendment to the Application of TRW Inc., that we are familiar with Part 25 of the Commission's Rules, and that we have reviewed the technical information in the foregoing Amendment and found it to be complete and accurate to the best of our knowledge and belief.

Roger Rusch
Odyssey™ Program Manager
TRW Inc.

Eric R. Wiswell
Odyssey™ Communication System
Technical Manager
TRW Inc.

Dated: November 14, 1994