AKIN GUMP STRAUSS HAUER & FELD LLP
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New York, New York 10036
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Ira S. Dizengoff
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Sarah Link Schultz

Counsel to the TSC Debtors

UNITED STATES BANKRUPTCY COURT
SOUTHERN DISTRICT OF NEW YORK

In re:	)	Chapter 11
TERRESTAR CORPORATION, *et al*.,[1]	)	Case No. 11-10612 (SHL)
Debtors.	)	Jointly Administered

NOTICE OF FILING DOCUMENTS SUBMITTED BY JEFFREY M. SWARTS

PLEASE TAKE NOTICE that, at the request of the Court, the TSC Debtors are filing documents provided by Jeffrey M. Swarts attached as Exhibit A through Exhibit S as follows:

Exhibit	Title
A	Philip A. Rubin, PE - President & CEO
B	Arnold L. Berman, PhD - Chief Scientist
C	Ted M. Kaplan - COO

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[1] The debtors in these chapter 11 cases, along with the last four digits of each debtor's federal taxpayer-identification number, are: (a) TerreStar Corporation [6127] and TerreStar Holdings Inc. [0778] (collectively, the "***February Debtors***"); and (b) TerreStar New York Inc. [6394]; Motient Communications Inc. [3833]; Motient Holdings Inc. [6634]; Motient License Inc. [2431]; Motient Services Inc. [5106]; Motient Ventures Holding Inc. [6191]; and MVH Holdings Inc. [9756] (collectively, the "***Other TSC Debtors***" and, collectively with the February Debtors, the "***TSC Debtors***").

Exhibit	**Title**
D	Jeffrey B. Freedman, PhD - CTO
E	Enhanced Beam Former
F	TerreStar Genus Launches with AT&T
G	GRM
H	General Services Administration, Federal Acquisition Service, Authorized Federal Supply Schedule Price List
I	Multipath Tools
J	News
K	Products & Solutions
L	Resource Optimization
M	Satellite Phone Analysis Tool
N	Services & Capabilities
O	Spectrum and Link Budget Analysis Tools
P	Technical Staff
Q	Letter from Mark Reger, Chief Financial Officer, Office of Managing Director, Federal Communications Commission, to Joseph A. Godles, Esq. (June 16, 2000)
R	Letter from Joseph A. Godles, Attorney for PanAmSat Corporation, to Magalie R. Salas, Secretary, Federal Communications Commission (Jan. 14, 2000)
S	U.S. Patent No. 6,871,045 B2 (filed July 18, 2001) (issued Mar. 22, 2005)

New York, New York
Dated: August 20, 2012

/s/ Ira S. Dizengoff
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Sarah Link Schultz

Counsel to the TSC Debtors

Exhibit A

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Home About RKF Services & Capabilities Products & Solutions Leadership & RKF Team Government Solutions Clients & Partners

Home > Leadership & RKF Team > Philip A. Rubin, PE - President & CEO

Leadership & RKF Team

Summary
Philip A. Rubin, PE - President & CEO
Jeffrey B. Freedman, PhD - CTO
Ted M. Kaplan - COO
Arnold L. Berman, PhD - Chief Scientist
Technical Staff

Philip A. Rubin, PE - President & CEO

aaaa

Mr. Rubin's extensive professional career of over fifty years has focused primarily on satellite communications and has been diversified in scope and achievements. He served as the ITU's first satellite expert and was responsible for building the Center of Research and Training in Satellite Communications in India in 1965. Starting in 1970 Mr. Rubin served as the Director of Engineering and Chief Scientist for public broadcasting for over 13 years during the birth of NPR and the expansion of PBS to a satellite-based interconnection system. In 1984 he helped found the first private commercial satellite company, PanAmSat, where he was responsible for PanAmSat's engineering as Chief Scientist for 17 years.

He began his engineering career at the ITT Laboratories where he designed and built traveling wave tube amplifiers. While at ITT, he worked on the first commercial earth station ever licensed by the FCC. He left ITT for Hughes Aircraft Company where he worked on Syncom 3, the world's first geostationary satellite launched in 1963, Early Bird and the ATS 1-5 satellite.

Mr. Rubin founded a consulting company together with Robert Bednarek in 1983 which became RKF Engineering in 2003. He is an IEEE Life Fellow and a recipient of IEEE's Centennial Medal for his contributions to satellite communications. He was the Editor of IEEE Transactions on Broadcast Technology for more than 15 years and IEEE's representative to the ATSC, where he worked on the design of ATSC, the high definition television system now in operation in the US. Mr. Rubin graduated from the University of the City of New York with a degree in Physics and Electrical Engineering and is a registered Professional Engineer in the District of Columbia.

Awards: IEEE Centennial Medal
IEEE Life Fellow
IEEE Broadcast Society Service Award
Harvey Aderholt Memorial Award for Significant Achievements in Education Telecommunications
NASA's Apollo Achievement Award in 1969

Patents: TV Set Top Box Using GPS
GPS TV Set Top Box w/Regional Restrictions
GPS Data Access System
In-Orbit Reconfigurable Communication Satellite

RKF Engineering Solutions, LLC | 1229 19th Street NW | Washington, DC 20036-2413

Exhibit B

site map | contact us

Home | About RKF | Services & Capabilities | Products & Solutions | Leadership & RKF Team | Government Solutions | Clients & Partners

Home > Leadership & RKF Team > Arnold L. Berman, PhD - Chief Scientist

Leadership & RKF Team

- Summary
- Philip A. Rubin, PE - President & CEO
- Jeffrey B. Freedman, PhD - CTO
- Ted M. Kaplan - COO
- Arnold L. Berman, PhD - Chief Scientist
- Technical Staff

Arnold L. Berman, PhD - Chief Scientist

aaaa

Dr. Arnold Berman is RKF's Chief Scientist and has fifty years of experience in engineering, most of which was spent in space telecommunications. Dr. Berman holds thirty-six patents and has authored twenty papers in the field of satellite telecommunications.

Dr. Berman has previously served as Vice President of Technology for Boeing Space Systems, Chief Technologist for Hughes Space and Communications and as the Assistant Director of COMSAT Labs.

Dr. Berman is the Recipient of the Hughes Aircraft Corporation Hyland Award, the Hughes Aircraft Company Chairman's Award and the Hughes Aircraft Company Patent Award. Dr. Berman holds an S.B. from the Massachusetts Institute of Technology in Electrical Engineering. His Master's and Ph.D. degrees are from George Washington University in Electrical Engineering and Science, respectively. Dr. Berman was a part of the advanced management post-graduate program at Harvard Business School.

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Exhibit C

Leadership & RKF Team

- Summary
- Philip A. Rubin, PE - President & CEO
- Jeffrey B. Freedman, PhD - CTO
- Ted M. Kaplan - COO
- Arnold L. Berman, PhD - Chief Scientist
- Technical Staff

Ted M. Kaplan - COO

aaaaa Ted Kaplan is a satellite communications engineer with more than 25 years experience. Mr. Kaplan is the Chief Operating Officer and Chief Systems Engineer for RKF Engineering. He joined RKF in November of 1998. In his current position Mr. Kaplan provides system engineering, analysis and regulatory support to numerous RKF clients. He is currently the technical pillar for wireless communications for the DARPA F6 program. Mr. Kaplan was one of the chief architects of sharing agreements reached in the ITU and FCC between non-GSO and GSO systems.

In January 1997, he joined COMSAT where he was involved in system design, modeling and tradeoff studies of various commercial satellite systems including Cyberstar, Worldspace, Intelsat, Ellipso, and MTSAT. Previously, Mr. Kaplan was employed for 10 years by Stanford Telecom (STel) where he specialized in simulation and analysis of SATCOM systems for use with NASA's Communications Link Analysis and Simulation System (CLASS). He was the lead system engineer for CLASS, where he evaluated advanced coding and modulating techniques for the Tracking and Data Relay Satellite System (TDRSS) and studied the performance of SATCOM systems in environments with RFI, mutual interference, and hardware distortions. Prior to STel he worked for IIT Research Institute where he specialized in Low Probability of Intercept (LPI) systems and vulnerability assessments of military communication systems. He recieved the B. S. degree from the University of Pennsylvania and the M. S. degree from George Washington University, both in electrical engineering.

Exhibit D

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Home | About RKF | Services & Capabilities | Products & Solutions | Leadership & RKF Team | Government Solutions | Clients & Partners

Home > Leadership & RKF Team > Jeffrey B. Freedman, PhD - CTO

Leadership & RKF Team

- Summary
- Philip A. Rubin, PE - President & CEO
- Jeffrey B. Freedman, PhD - CTO
- Ted M. Kaplan - COO
- Arnold L. Berman, PhD - Chief Scientist
- Technical Staff

Jeffrey B. Freedman, PhD - CTO

aaa

As CTO of RKF Engineering Solutions, LLC; Dr. Freedman provides technical vision and direction for the company as well as overseeing technical analyses, the development of technologies and software product designs. Dr. Freedman leads RKF's efforts in designing satellite systems, software systems, communication networks and supporting technologies for customers such as TerreStar, PanAmSat, Cisco, Intelsat, DirecTV, Disney, Turner and others.

Dr. Freedman has led development efforts for several national award winning software packages including "CAGE" which won the 1998 GSFC NASA's Software Of The Year Award, and "3d Choreographer" which won Windows Magazine's 1995 Win 100 Award.

Dr. Freedman's twenty plus years of system engineering experience includes work with geosynchronous satellites, low earth orbiting satellites, mobile satellite networks, broadcast satellites, terrestrial ad-hoc networks, antenna design/modeling, ground and space based beam forming. Dr. Freedman received his B.S. from North Carolina State University, his M. Eng. from Cornell University and his Ph.D. from the University of Maryland.

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Exhibit E

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Home About RKF Services & Capabilities Products & Solutions Leadership & RKF Team Government Solutions Clients & Partners

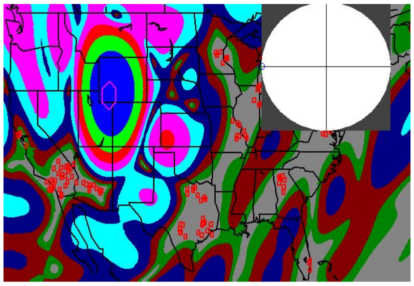
Home > Products & Solutions > GRM

Products & Solutions

- Summary
- GRM
- Enhanced Beamformer
- Dynamic Simulation Environment
- Satellite Phone Analysis Tool
- Resource Optimization
- Tools
    - Spectrum and Link Budget Analysis Tools
    - Ad Hoc Network Tool
    - Multipath Tools
    - Other Software Tools

Enhanced Beam Former

RKF provides beam forming and beam laydown solutions for fixed and mobile satellite and terrestrial applications. Utilizing several patent pending approaches RKF can improve the capacity, coverage, and performance of spot or shaped beam satellite systems. RKF's suite of software tools and applications accept a combination of business and technical requirements to optimize existing satellite communication networks or optimize the design of future systems. Companies such as DirecTV and TerreStar have used RKFs services to maximize capacity, and performance of their respected networks.



For ground or space based beamforming networks actual beam coefficients are optimized to maximize capacity, and performance while meeting regulatory constraints. Coefficients are generated either for shaped or spot beam usage and can be generated taking into consideration:

Hard regulatory limits (such as not to exceed levels)

System design consideration such as the power amplifier limitations and unique antenna characteristics

Performance metrics such as maximized SNR or target SNR

Variable target performance across service area

All beams simultaneously in a joint optimization (e.g. sum of all sidelobes must not exceed…)

Joint optimization of coefficients and frequency and channel plans

With these advance approaches, RKF can dramatically improve the capacity and performance of fixed and shaped beam networks.

RKF software performs joint optimizations of beamforming coefficients, beam locations/coverage, channel/frequency plans while at the same time meeting regulatory constraints. For example optimizations be constrained by localized PFD limits on the ground taking into consideration frequency plans and beam shapes. A summary of joint optimization capability is provided in the table shown below.

Joint Optimization of Coverage, Frequency and Channel Plans

Optimization Metrics	Optimized Parameters	Constraints/ Flexibility
Capacity	Beam Locations	Candidate antenna architecture(s)
Performance: G/T, EIRP, C/I…	Beam shape (for beam formed systems)	ITU/FCC Rules
Coverage: Population, Average income, Targeted market areas…	Beam Size	Business Objectives
Flexibility: Failure backup, market backup	Feed Locations	Interference/Capacity thresholds
Combined resource and beam shape optimization	Frequency Plans	Spacecraft constraints: RF path (PA,MPA, Switches…)

		Antenna (gimbal limits, feed spacing, dish size..), Signal distortions
	Channel Allocations	
	Number of Apertures/Size of Aperture(s)	

RKF used these software tools optimize beam locations, channel plans, frequency plans, coding for nearly one hundred spot beams two satellites and a ground spare for DirecTV 10 and 11. These satellites are presently in orbit delivering high definition television service to more than a hundred markets across the United States.

For TerreStar, RKF software optimizes beam coefficients while simultaneously optimizing resource and channel and frequency plans. In the first quarter of 2010 Terrestar will use RKF software to provide mobile telephony over the satellite throughout North America.

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Exhibit F

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Home About RKF Services & Capabilities Products & Solutions Leadership & RKF Team Government Solutions Clients & Partners

Home > About RKF > News > TerreStar Genus Launches with AT&T

About RKF

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- Contact Us

TerreStar Genus Launches with AT&T

Dallas TX/Reston VA, Sept. 21 - RKF Engineering, in support of TerreStar Networks, is pleased to announce the launch of the TerreStar GENUS; the worlds first dual-mode cellular/satellite smartphone on the newly formed AT&T Satellite Augmented Mobile Service. RKF collaborated with TerreStar Networks in the design of the GENUS smartphone and the entire satellite network and ground-based beamforming component. The dual-mode GENUS operates using cellular wireless capability as the primary mode of operation and satellite access as a secondary option for voice, data and messaging. For a full announcement please visit: http://www.prnewswire.com/news-releases/terrestar-genus-dual-mode-cellularsatellite-smartphone-now-available-from-att-103409814.html.

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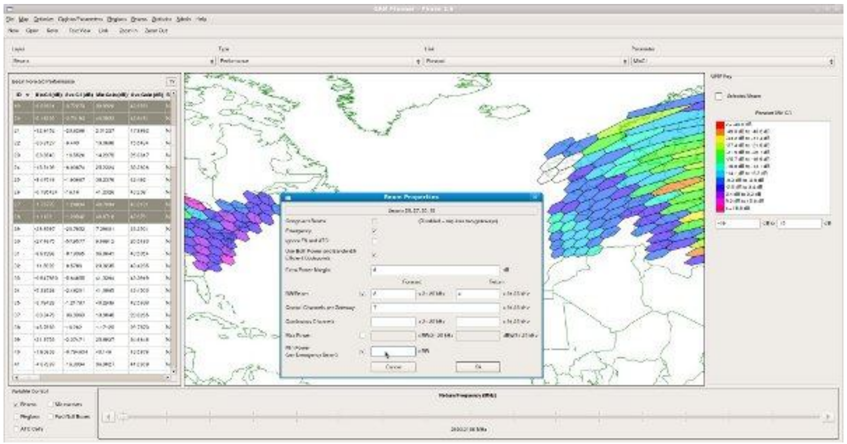
Exhibit G

Products & Solutions

- Summary
- GRM
- Enhanced Beamformer
- Dynamic Simulation Environment
- Satellite Phone Analysis Tool
- Resource Optimization
- Tools
  - Spectrum and Link Budget Analysis Tools
  - Ad Hoc Network Tool
  - Multipath Tools
  - Other Software Tools

GRM

The Global Resource Manager (GRM) optimizes spectrum, beam, power levels, coverage and other resources for next generation mobile satellite systems. The GRM establishes resource plans which coordinate between satellite and terrestrial networks to allow for spectrum sharing and the determination of operational rules for satellite base stations. Additionally, the GRM optimizes beam coefficients to achieve desired regional and spot beam shapes. Requirements may be assigned to beams individually or may be assigned to a group of beams within a specified region. Numerous other constraints can be built directly into the GRM, such as frequency and power sharing with ancillary terrestrial component (ATC) stations as well as specific Federal Communication Commission (FCC), International Telecommunication Union (ITU) and satellite limits. As such, the GRM provides a complete solution for generating resource plans for Mobile Satellite Service (MSS).



The GRM was developed for the Terrestar satellite and terrestrial 4G mobile telecommunication network program and operates in their Network Control Center (NCC). The TerreStar satellite has a ground based active beamformer that generate over five hundred beams across North America. The GRM optimizes power, frequency and coverage plans as well as beam shapes that intelligently suppress sidelobes in order to maximize capacity while meeting interference constraints to legacy ground based fixed service stations.

For additional information on RKF's GRM please send email to: info@rkf-engineering.com .

Exhibit H

GENERAL SERVICES ADMINISTRATION

Federal Acquisition Service
Authorized Federal Supply Schedule Price List

On-line access to contract ordering information, terms and conditions, up-to-date pricing, and the option to create an electronic delivery order is available through **GSA** *Advantage*!™, a menu-driven database system. The Internet address for **GSA** *Advantage*!™ is: **http://www.GSAAdvantage.gov**.

Professional Engineering Services

Federal Supply Group: 871 **Class:** R425

Contract Number: GS-10F-0378U

Contract Period: September 30, 2008 through September 29, 2013

RKF Engineering Solutions, LLC

1229 19th Street, N.W.
Washington, DC 20036

Web Site: www.rkf-engineering.com

RKF Engineering is a veteran owned, small business

Contract Administration:

Contact: Thomas B Kennedy
E-mail: tkennedy@rkf-engineering.com
Phone: (202) 536-9310
Fax: (202) 463-0344

For more information on ordering from Federal Supply Schedules
click on the FSS Schedules button at http://www.fss.gsa.gov

CUSTOMER INFORMATION:

1a. Awarded Special Item Numbers (SINs) and Primary Engineering Disciplines (PEDs):

871-1 (EE), 871-1RC, 871-2 (EE), 871-2RC, 871-3 (EE), 871-3RC, 871-6 (EE), 871-6RC

SIN	SIN Description	PED	Page
871-1	Strategic Planning for Technology Programs/Activity	Electrical	6
871-2	Concept Development and Requirements Analysis	Electrical	7
871-3	System Design, Engineering and Integration	Electrical	7
871-6	Acquisition and Life Cycle Management	Electrical	7

The following SINs are incorporated to include Recovery Purchasing in accordance with Section 833 of the National Defense Authorization Act for Fiscal Year 2007 for disaster relief: 871-1, 871-2, 871-3, 871-4, 871-5, and 871-6RC, the pricing for the SIN with the suffix "RC" is the same as the corresponding SIN awarded without the suffix.

1b. RKF Engineering GSA PES Labor Rates/Price List

The following Labor Rates/Price List are applicable to all SINs & PEDs awarded under this contract.

Labor Category	Year 1 FY 2009	Year 2 FY 2010	Year 3 FY 2011	Year 4 FY 2012	Year 5 FY 2013
Chief Scientist	$232.98	$241.13	$249.57	$258.31	$267.35
Principal Scientist	$201.50	$208.55	$215.85	$223.41	$231.23
Engineer	$130.98	$135.56	$140.31	$145.22	$150.30
Associate Engineer	$110.83	$114.71	$118.72	$122.88	$127.18

All Fiscal Years listed above run from October 1st through the following September 30th (i.e Federal FY)

1c. RKF Engineering GSA PES Labor Category Descriptions

The following Labor Categories are applicable to all SINs & PEDs awarded under this contract.

Title: Chief Scientist

Functional Duties/Responsibilities: The Chief Scientist is a recognized (national or international) authority in a highly specialized area related to electrical engineering. The Chief Scientist is a resource who can provide guidance on many projects, simultaneously and at many different levels. His experience includes managing large engineering teams in the planning, development and design of complicated engineering projects. In support of programs the Chief Scientist is relied upon as an expert in all SIN areas including, but not limited to the definition and Interpretation of high level organization engineering requirements and objectives, provides project vision and defines project scope; evaluate technical approaches, determining feasibility and associated costs; responsible for developing system requirements documentation and the development of the Concept of Operations (CONOPS); oversees development of the system specifications, performs risk identification and analysis and oversees system development.

Minimum Education: Bachelor's degree.

Minimum Experience Requirements: 25 years of relevant work experience, or master's degree plus 23 years of relevant work experience or doctoral degree plus 20 years of relevant work experience.

Title: Principal Scientist

Functional Duties/Responsibilities: Functions as the highest technical authority in an engineering discipline. Possesses expert knowledge of scientific practices and principles in formulating or approving technical applications in broad areas of assignment. Has significant latitude for independent action and decision making. The Principal Scientist can oversee all areas of project planning and development. He interfaces with customers and is responsible for the completion of projects on time and within cost. Responsibilities and duties include analyzing objectives and requirements and assisting clients in program planning; analyzing engineering processes to determine most efficient methods of accomplishing work; developing work breakdown structures, performing risk assessments, developing reports and overseeing system development.

Minimum Education: Bachelor's degree.

Minimum Experience Requirements: 20 years of relevant work experience, master's degree plus 18 years of relevant work experience or doctoral degree plus 15 years of relevant work experience.

Title: Engineer

Functional Duties/Responsibilities: Develops solutions to particular engineering problems or develops analytical or software capabilities needed for the solution of a class of engineering problems. Receives technical guidance and support, as needed, from more experienced technical staff. May be responsible for providing project-level technical support to other staff.

Minimum Education: Bachelor's degree.

Minimum Experience Requirements: Bachelor's degree plus 5 years of relevant work experience, master's degree plus 3 years of relevant work experience or doctoral degree. The degree(s) must be in electrical engineering, computer science, mathematics, or a related discipline

Title: Associate Engineer

Functional Duties/Responsibilities: Functions in a support role leading to the solution of a particular engineering problem, the development of a capability or program required to solve a class of engineering problems. Receives technical guidance and training from the more experienced technical staff to which the individual is assigned.

Minimum Education: Bachelor's degree in engineering or a related scientific discipline.

Minimum Experience Requirements: 2 years of relevant work experience or master's degree.

2. **Maximum Order:** $750,000.00

3. **Minimum Order:** $100.00

4. **Geographic Coverage (delivery Area):** Domestic delivery within the 48 contiguous states, Alaska, Hawaii, and Washington DC.

5. **Point(s) of production (city, county, and state or foreign country):** Washington, DC.

6. **Discount from list prices or statement of net price:** Prices shown herein are Government net prices (discounts already included).

7. **Quantity discounts:** None Offered

8. **Prompt payment terms:** 0%; Net 30 days

9a. Notification that Government purchase cards are accepted up to the micro-purchase threshold: Yes

9b. Notification whether Government purchase cards are accepted or not accepted above the micro-purchase threshold: Yes, up to ordering agency's limits

10. **Foreign items (list items by country of origin):** None

11a. Time of Delivery: Determined by individual Task Order

11b. Expedited Delivery: Determined by individual Task Order

11c. Overnight and 2-day delivery: Determined by individual Task Order

11d. Urgent Requirements: Determined by individual Task Order

12. **F.O.B Points:** FOB Destination subject to item #4 above.

13a. Ordering Address:

RKF Engineering
Attn: GSA Orders
1229 19th Street NW
Washington, DC 20036

13b. Ordering procedures: For supplies and services, the ordering procedures, information on Blanket Purchase Agreements (BPA's), and a sample BPA can be found at the GSA/FSS Schedule homepage (fss.gsa.gov/schedules).

14. **Payment addresses:** Payment via check/US Mail

RKF Engineering
Attn: GSA Accounts Receivable
1229 19th Street NW
Washington, DC 20036

Please contact Toby Kennedy at (202) 536-9310 or tkennedy@rkf-engineering.com for payment via wire transfer.

15. **Warranty provision:** Contractor's standard commercial warranty.

16. **Export Packing Charges (if applicable):** N/A

17. **Terms and conditions of Government purchase card acceptance (any thresholds above the micro-purchase level):** N/A

18. **Terms and conditions of rental, maintenance, and repair (if applicable):** N/A

19. **Terms and conditions of installation (if applicable):** N/A

20. **Terms and conditions of repair parts indicating date of parts price lists and any discounts from list prices (if applicable):** N/A

20a. **Terms and conditions for any other services (if applicable):** N/A

21. **List of service and distribution points (if applicable):** N/A

22. **List of participating dealers (if applicable):** N/A

23. **Preventive maintenance (if applicable):** N/A

24a. **Environmental attributes, e.g., recycled content, energy efficiency, and/or reduced pollutants:** N/A

24b. **If applicable, indicate that Section 508 compliance information is available on Electronic and Information Technology (EIT) supplies and services and show where full details can be found (e.g. contactor's website or other location.):** N/A

25. **Data Universal Numbering System (DUNS) number:** 14-0725891

26. **Notification regarding registration in Central Contractor Registration (CCR) database:** RKF Engineering Solutions, LLC maintains current registration in the CCR. CAGE Code: 3MTM2

GSA Schedule 871 Description of Primary Engineering Disciplines (PEDs)

TFTP-MC-990871-B Refresh: 11

Engineering Disciplines – There are four primary engineering disciplines (PEDs) in the engineering field and hundreds of sub-disciplines or specialties associated with engineering disciplines.

RKF Engineering is awarded the Primary Engineering Discipline in Electrical Engineering under this contract; below is a listing of that PED with a partial list of sub-disciplines or specialties contemplated under PES.

Electrical Engineering: Planning, design, development, evaluation and operation of electrical principles, models and processes. It includes, but is not limited to, the design, fabrication, measurement and operation of electrical devices, equipment and systems (e.g., signal processing; telecommunication; sensors, microwave, and image processing; micro-fabrication; energy systems and control; micro- and nano-electronics; plasma processing; laser and photonics; satellites, missiles and guidance systems, space vehicles, fiber optics, robotics, etc.).

Within the electrical engineering PED, there are several specialties within the scope of this work; a partial listing follows:
- Aerospace and Electronic Systems • Antennas and Propagation • Broadcast Technology
- Circuits and Systems • Computer • Communications • Consumer Electronics
- Components Packaging, and Manufacturing Technology • Dielectrics and Electrical Insulation
- Education • Control Systems • Remote Sensing • Engineering Management
- Electromagnetic Compatibility • Information Theory • Lasers & Electro-Optics • Industrial Electronics
- Intelligent Transportation Systems • Industry Applications • Instrumentation and Measurement
- Nuclear and Plasma Sciences • Magnetics • Microwave Theory and Techniques • Power Electronics
- Neural Networks Council • Oceanic Engineering • Reliability • Robotics & Automation
- Professional Communication • Solid-State Circuits • Systems, Man, and Cybernetics
- Vehicular Technology • Ultrasonics, Ferroelectrics, and Frequency Control
- Signal Processing on Social Implications of Technology

RKF Engineering offers the Primary Engineering Discipline of Electrical Engineering for the following SINs: 871-1 (EE), 871-1RC, 871-2 (EE), 871-2RC, 871-3 (EE), 871-3RC, 871-6 (EE), 871-6RC

GSA Schedule 871 Description of Special Item Numbers (SINs)

TFTP-MC-990871-B Refresh: 11

871-1 Strategic Planning for Technology Programs/Activities

Services required under this SIN involve the definition and interpretation of high level organizational engineering performance requirements such as projects, systems, missions, etc., and the objectives and approaches to their achievement. Typical associated tasks include, but are not limited to an analysis of mission, program goals and objectives, requirements analysis, organizational performance assessment, special studies and analysis, training, and consulting.

Example: The evaluation and preliminary definition of new and/or improved performance goals for navigation satellites such as launch procedures and costs, multi-user capability, useful service life, accuracy and resistance to natural and man made electronic interference.

RKF Engineering is awarded the following primary engineering disciplines (PEDs) under this Special Item Number: Electrical Engineering (EE)

871-2 Concept Development and Requirements Analysis

Services required under this SIN involve abstract or concept studies and analysis, requirements definition, preliminary planning, the evaluation of alternative technical approaches and associated costs for the development of enhancement of high level general performance specifications of a system, project, mission or activity. Typical associated tasks include, but are not limited to requirements analysis, cost/cost performance trade-off analysis, feasibility analysis, regulator compliance support, technology/system conceptual designs, training, and consulting.

Example: The development and analysis of the total mission profile and life cycle of the improved satellite including examination of performance and cost tradeoffs.

RKF Engineering is awarded the following primary engineering disciplines (PEDs) under this Special Item Number: Electrical Engineering (EE)

871-3 System Design, Engineering and Integration

Services required under this SIN involve the translation of a system (or subsystem, program, project, activity) concept into a preliminary and detailed design (engineering plans and specifications), performing risk identification/analysis, mitigation, traceability, and then integrating the various components to produce a working prototype or model of the system. Typical associated tasks include, but are not limited to computer-aided design, design studies and analysis, high level detailed specification preparation, configuration, management and document control, fabrication, assembly and simulation, modeling, training, and consulting.

Example: The navigation satellite concept produced in the preceding stage will be converted to a detailed engineering design package, performance will be computer simulated and a working model will be built for testing and design verification.

RKF Engineering is awarded the following primary engineering disciplines (PEDs) under this Special Item Number: Electrical Engineering (EE)

871-6 Acquisition and Life Cycle Management

Services required under this SIN involve all of the planning, budgetary, contract and systems/program management functions required to procure and or/produce, render operational and provide life cycle support (maintenance, repair, supplies, engineering specific logistics) to (technology based) systems, activities, subsystems, projects, etc. Typical associated tasks include, but are not limited to operation and maintenance, program/project management, technology transfer/insertion, training and consulting.

Example: During this stage the actual manufacturing, launch, and performance monitoring of the navigation satellite will be assisted through project management, configuration management, reliability analysis, engineering retrofit improvements and similar functions.

RKF Engineering is awarded the following primary engineering disciplines (PEDs) under this Special Item Number: Electrical Engineering (EE)

Overview of RKF Engineering Solutions

RKF Engineering Solutions, LLC, (RKF) is a veteran owned, small company providing system engineering and design of communication systems. Since 1983, RKF staff specialized in creating innovative solutions to extremely challenging problems in the satellite and wireless communication industries for both government and commercial clients. RKF designs technologically advanced and cost-effective communication systems spanning broadcast satellite services, fixed satellite services, hybrid mobile terrestrial & satellite systems, and fixed service networks.

RKF Engineering integrates strategic level planning and feasibility analysis, concept(s) of operations, system engineering and design with exceptional spectrum and regulatory expertise, modeling and simulation, optimization and software development. RKF combines the nimbleness of a compact, responsive team with the substantial breadth and depth of staff expertise. RKF principals have decades of experience and are recognized in their respective fields. This broad expertise is matched with a streamlined structure and low overhead to bridge discrete specialties into integrated solutions while speedily responding to the client's needs.

A sampling of RKF Engineering's solutions and accomplishments include:

- TerreStar – Hybrid terrestrial and satellite mobile communications system optimized as an adaptive, robust and redundant network for first responders and homeland security response
- IRIS – DoD/STRATCOM effort to quickly develop signal processing package for inclusion in a traditional bent pipe satellite providing flexible Internet-Protocol routing in space – RKF established feasibility/EIA including define system concept/design, develop integration plan and SWAP assessment. RKF is also providing independent validation/verification (IV&V) services to Cisco Systems for this development.
- GRM – designed and developed a Global Resource Manager network planning tool to coordinate ATC & satellite resources; optimize spectrum, power & capacity; define coverage for network operations.
- Hosted payloads – RKF is exploring fast and cost-effective solutions to providing additional capacity and bandwidth utilizing hosted payloads on commercial satellites
- GSO/NGSO sharing – RKF served as the technical lead and negotiator for the United States with the ITU in crafting rules governing NGSO operations to minimize interference with geosynchronous orbit satellites
- 13.75-14GHz – for the Dept of the Navy, provided technical analysis and created the regulatory argument to mitigate interference to ship-board radar systems from shore-based FSS
- Ka Band satellites – design/optimization for DirecTV, principal architect for Pegasus DBS network
- PanAmSat – served as Office of the Chief Scientist for 17 years; oversaw development of first 10 satellites
- Technical due diligence – satellite system oversight/fleet assessment; acquisition and life cycle evaluation/ management; RKF has detailed knowledge of the world's commercial satellite fleet(s)
- Satellite coordination, slot mining & negotiations for national governments, organizations & corporations

Spectrum is a critical, finite and increasingly valuable resource; RKF has a proven record in spectrum management, increasing spectral efficiency, resource optimization and regulatory expertise. RKF addresses spectrum conflicts and congestion by marrying spectral design and resource optimization tools with extensive regulatory experience in front of the FCC and ITU (International Telecommunications Union). RKF staff have participated in WRCs (World Radiocommunication Conferences) negotiations and rulemaking going back decades.

Regulatory & Spectrum Management specialties include:

• Applications for satellites and earth gateways (FCC & ITU) • Satellite coordination • Identify available spectrum, slot mining & negotiations • Spectrum clearing & support	• File for new US and international systems • Rule compliance/out-of-band emissions • Spectral optimization and interference mitigation	• Monitoring of ITU/FCC filings (IFICs) • Participation in WRC and preparatory/technical meetings • Technical analyses and simulations

Given RKF's significant experience in performing technical due diligence for private equity firms and analyzing and validating the technical underpinnings of business models, the company is uniquely qualified to create technically advanced solutions that are efficient, deployable and cost-effective.

Strategic Planning	**Concept Development**	**System Engineering & Design**
• Feasibilty analysis • Mission and requirements analysis • Opportunities research and analysis • High level cost-benefit analysis • Regulatory environment assessment • International coordination and slot evaluation	• System specifications and requirements analysis • Trade analyses • Concept of operations • Conceptual design • System architecture • High level costing • Initial engineering assessments • Antenna concepts • Air Interface and protocol definition • Regulatory compliance support	• Satellite & terrestrial communications system design • Technical monitoring of satellite development and acquisition • Space & terrestrial radio networks • Beam forming & laydown • Signal processor design • ASIC design • Terminal & antenna development • Handset & chipsets development • Linear & non-linear system and component design/modeling • System integration • Risk assessment & mitigation

Over the past 25 years, RKF has extensive, detailed and ongoing cooperative interactions with satellite and equipment manufacturers, broadcast and telecommunications companies, communication operators, government agencies and regulatory organizations worldwide. RKF is a recognized expert in geosynchronous satellite systems. RKF principals have been responsible for the definition and system design of dozens of satellites currently in orbit or under development.

Other major capabilities include alternatives to traditional methods that RKF uses to rapidly and iteratively develop solutions. These incorporate software development, resource optimization tools and specialized modeling and simulation packages to create custom applications that address each client's specific requirements.

Software Development & Applications	**Resource Optimization**	**Modeling & Simulation**
• Global Resource Manager – custom application • Beam laydown software • DSE – network visualization tool • Software defined radios • Rapid prototyping	• CESROD – multi-beam satellite optimization tool used to iteratively design DTV 10 & 11 HDTV satellites • Dynamic resource allocation – rain fade mitigation, load balancing, code & symbol rate adaptation, configurable QoS parameter • Antenna aging	• Ad-Hoc network simulator • Traffic and Air Interface • Visualization and animation for both 3d/2d environments • Diverse custom modeling and simulation solutions, including: non-linear amplifier, hybrid matrix amplifier, adaptive smart antenna modeling, etc

RKF staff currently serve on IEEE 802.16 WiMax standards committee. RKF staff have been awarded over 50 patents and have authored/presented dozens of technical papers. RKF Staff have been honored with significant awards for technical achievement including HAC Hyland Award, IEE Centennial Medal and an IEEE Fellow.

Exhibit I

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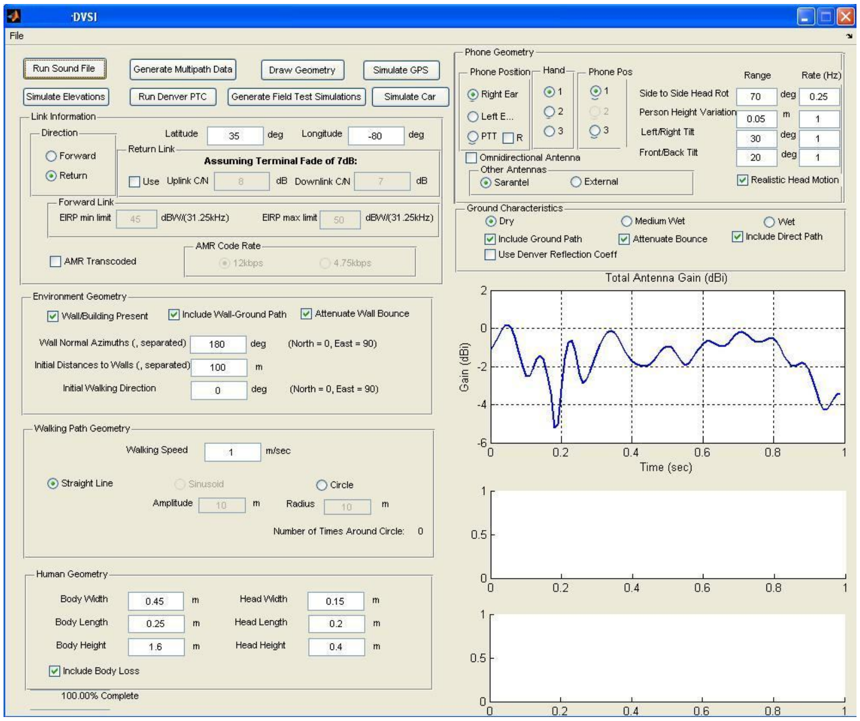
Multipath Tools

RKF Engineering has developed 3D simulation tools which model dynamic multipath channels. These tools enable the simulation and evaluation of satellite and terrestrial user terminal and vehicular antenna patterns. The simulation tools model custom multipath environments, including parameters such as user elevation and azimuth angle to a satellite or terrestrial base station, natural human motion, electromagnetic reflections off the grounds and structures of variable materials, body losses, user speed, and more. In addition, RKF's custom tools can be interfaced to quantify the Quality of Service expected from a particular measured or modeled antenna pattern.

3D ray-tracing multipath tools, such as the ones developed at RKF, also enable terrestrial and satellite companies to calculate the capacity of their wireless network. By choosing a desired/current antenna pattern, the tools simulate users in a variety of environments, thus calculating the required transmit power to maintain a certain Quality of Service - possibly quantified by Frame Error Rate. Thus, such tools allow trading off antenna designs based on realistic fading environments. In addition, the tools are useful prior to conducting handset field tests since users are allowed to set the reflective parameters pertinent to the location of the particular field test.



Link Information
Direction: ○ Forward ● Return
Latitude 35 deg Longitude -80 deg
Return Link
Assuming Terminal Fade of 7dB:
☐ Use Uplink C/N 8 dB Downlink C/N 7 dB
Forward Link
EIRP min limit 45 dBW/(31.25kHz) EIRP max limit 50 dBW/(31.25kHz)
☐ AMR Transcoded
AMR Code Rate: ● 12kbps ○ 4.75kbps

Environment Geometry
☑ Wall/Building Present ☑ Include Wall-Ground Path ☑ Attenuate Wall Bounce
Wall Normal Azimuths (, separated) 180 deg (North = 0, East = 90)
Initial Distances to Walls (, separated) 100 m
Initial Walking Direction 0 deg (North = 0, East = 90)

Walking Path Geometry
Walking Speed 1 m/sec
● Straight Line ○ Sinusoid ○ Circle
Amplitude 10 m Radius 10 m
Number of Times Around Circle: 0

Human Geometry
Body Width 0.45 m Head Width 0.15 m
Body Length 0.25 m Head Length 0.2 m
Body Height 1.6 m Head Height 0.4 m
☑ Include Body Loss
100.00% Complete

Phone Geometry
Phone Position: ● Right Ear ○ Left E... ○ PTT ☐ R
Hand: ● 1 ○ 2 ○ 3
Phone Pos: ● 1 ○ 2 ○ 3
☐ Omnidirectional Antenna
Other Antennas: ● Sarantel ○ External

	Range		Rate (Hz)
Side to Side Head Rot	70	deg	0.25
Person Height Variation	0.05	m	1
Left/Right Tilt	30	deg	1
Front/Back Tilt	20	deg	1

☑ Realistic Head Motion

Ground Characteristics
● Dry ○ Medium Wet ○ Wet
☑ Include Ground Path ☑ Attenuate Bounce ☑ Include Direct Path
☐ Use Denver Reflection Coeff

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Exhibit J

TerreStar Genus Launches with AT&T

Dallas TX/Reston VA, Sept. 21 - RKF Engineering, in support of TerreStar Networks, is pleased to announce the launch of the TerreStar GENUS; the worlds first dual-mode cellular/satellite smartphone on the newly formed AT&T Satellite Augmented Mobile Service. RKF collaborated with TerreStar Networks in the design of the GENUS smartphone and the entire satellite network and ground-based beamforming component. The dual-mode GENUS operates using cellular wireless capability as the primary mode of operation and satellite access as a secondary option for voice, data and messaging. For a full announcement please visit: http://www.prnewswire.com/news-releases/terrestar-genus-dual-mode-cellularsatellite-smartphone-now-available-from-att-103409814.html.

RKF Team Wins NASA METS II Contract

Greenbelt, MD., August 27, 2010 – **RKF Engineering** wins the NASA Goddard Space Flight Center Multi-Disciplinary Engineering and Technology Services II, or **METS II**, contract as part of the ASRC team. The contract is valued at $250 million and has a five-year performance period, which will begin after a 30-day phase-in period. Prime on the contract is ASRC Management Services and members of the winning team include RKF Engineering, Ball Aerospace, Orbital Sciences Corporation and Hawk Aerospace. **RKF Engineering** is responsible for all the RF Systems Engineering on the contract.

The NASA announcement can be found at: http://www.nasa.gov/home/hqnews/2010/jul/HQ_C10-042_GSFC_METS_II.html. Additionally, the ASRC Management Services METS-II website is located at: http://www.asrcms.com/METS-II/Pages/Home.aspx.

On-Orbit Handover of DirecTV-12

El Segundo, CA., May 17, 2010 – Today the on-orbit handover of the DIRECTV 12 satellite from Boeing to DirecTV was completed. DIRECTV will use the Boeing 702HP satellite to provide high-definition television (HDTV) broadcasting to local and national markets throughout the United States. RKF Engineering was responsible for the design of DirecTV’s Ka-band HDTV satellites beginning with DIRECTV 10 and DIRECTV 11. DIRECTV 12 is the third of RKF’s successful designs. The new satellite will boost DIRECTV’s HD capacity by 50 percent to more than 200 HD channels, increase the local HD markets DIRECTV will serve and significantly expand movie choices on the DIRECTV Cinema and DIRECTV on Demand services.

The DIRECTV announcement can be found at: http://dtv.client.shareholder.com/releasedetail.cfm?ReleaseID=471227.

RKF Supports the First Internet Router in Space

On **November 23rd, 2009** Intelsat 14 launched from **Cape Canaveral, Florida**, complete with a payload demonstrating Internet Routing in Space (IRIS) for the U.S. military. IRIS is the first dedicated U.S. military payload to reach orbit on a commercial satellite. RKF performed an initial engineering and integration assessment study (EIA) for IRIS to provide an in-orbit demonstration of the feasibility of a space-based Internet Protocol (IP) routing communications system. RKF also provided system engineering expertise for the IRIS project to both the DoD and Cisco Systems as well as providing the payload systems engineering for the project. Additional RKF responsibilities for the IRIS project included feasibility analysis, system design, supplier interface, system integration, SWAP assessment, link & coverage analysis, air interface definition, design tradeoffs and roadmaps. A joint press release from Intelsat and Cisco Systems detailing the launch of Intelsat 14 and the IRIS payload can be found at: **Internet Routing Blasts Into Space**.

RKF provides systems engineering for successful in-orbit test of TerreStar-1

Mobile communications provider TerreStar Networks Inc. (TerreStar), a majority-owned subsidiary of TerreStar Corporation (NASDAQ:TSTR), announced on **August 27th, 2009** from **Reston, VA** the successful completion of in-orbit testing (IOT) for TerreStar-1, the world's largest, most advanced commercial communications satellite. This successful IOT came in short order after the successful launch of TerreStar-1 on July 1st, 2009 and the first successfully completed phone call over TerreStar-1 using TerreStar handsets on July 20th, 2009. Details concerning the successful IOT and launch of TerreStar-1 can be found at: **TerreStar Announces Successful Completion of Satellite In-Orbit Testing** and **TerreStar Successfully Launches World's Largest, Most Powerful Commercial Communications Satellite**.

RKF's Global Resource Manager Promises most Advanced Operational Capabilities for TerreStar

Washington, DC - November 20, 2009 - RKF Engineering Solutions, LLC today passed the Critical Design Review for Version 1.6 of its Global Resource Manager (GRM) software. The Global Resource Manager (GRM) optimizes spectrum, beam, power levels, coverage and other resources for next generation mobile satellite systems. The GRM establishes resource plans which coordinate between satellite and terrestrial networks to allow for spectrum sharing and the determination of operational rules for satellite base stations. Additionally, the GRM optimizes beam coefficients to achieve desired regional and spot beam shapes. Requirements may be assigned to beams individually or may be assigned to a group of beams within a specified region. Numerous other constraints can be built directly into the GRM, such as frequency and power sharing with ancillary terrestrial component (ATC) stations as well as specific Federal Communication Commission (FCC), International Telecommunication Union (ITU) and satellite limits. As such, the GRM provides a complete solution for generating resource plans for Mobile Satellite Service (MSS).

The GRM was developed for the Terrestar satellite and terrestrial 4G mobile telecommunication network program and operates in their Network Control Center (NCC). The Terrestar satellite has a ground based active beamformer that generate over five hundred beams across North America. The GRM optimizes power, frequency and coverage plans as well as beam shapes that intelligently suppress sidelobes in order to maximize capacity while meeting interference constraints to legacy ground based fixed service stations.

Version 1.6 of the GRM represents an advance over Version 1.5. New in Version 1.6:

- Ability to receive usage statistics from satellite base-station subsystems and display this information in a user-friendly GUI environment
- Mapping Table to compute input drive levels on satellite amplifiers
- Enhance Beam-Plan Analysis and Beam Layout Improvement Recommendations

Exhibit K

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Products & Solutions

RKF offers a host of products and solutions developed in-house including custom software, system engineering designs and regulatory support. RKF has sold or licensed products and services to dozens of commercial and government clients. Recently, RKF licensed its global resource manager (GRM) to TerreStar networks to establish resource plans to coordinate between satellite and terrestrial networks to allow for spectrum sharing and the determination of operational rules for satellite base stations.

Examples of RKF software solutions include:

- Global Resource Manager
- Enhanced Beamformer
- Dynamic Simulation Environment
- Satellite Phone Analysis Tool
- Resource Optimization
- Spectrum and Link Budget Analysis Tools
- Ad Hoc Networking Tools
- Multipath Tools
- Data Visualization

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Resource Optimization

Most communication systems squander a tremendous amount of spectral resources. Systems are designed and spectrum allocations are set up based on worst-case assumptions that reserve unused spectral resources years in advance. Huge spectrum, spatial and temporal holes typically exist in any commercial or government deployment of communication assets.

RKF specializes in improving the spectral efficiency of satellite and terrestrial communication systems. As spectral resources become scarce and with new high bandwidth military and civil/commercial applications being developed, improvement of spectral efficiency is essential. In that regard, RKF has helped commercial companies such as News Corp., DirecTV, Pegasus, PanAmSat and Terrestar improve spectral efficiency of both current and future systems.

RKF has developed numerous software packages that optimize spectral resources. Packages developed by RKF to optimize spectral resources include the Global Resource Manger (GRM) for optimizing power, resources, and beam plans, as well as CESROD (Cognitive Environment for Spectral Resource Optimization and Design) for use in the design of space craft communication systems with optimal coverage and capacity. The AHNPO (Ad Hoc Network Protocol Optimizer) is designed to test ad hoc network protocols in a large number of environments determining their weaknesses and strengths.

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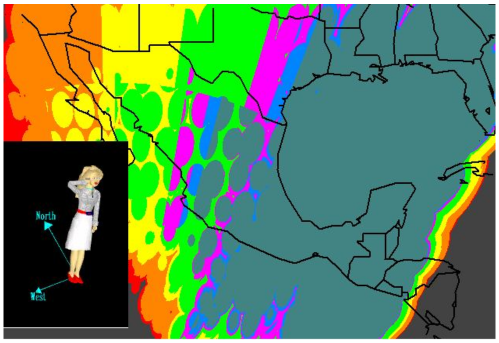
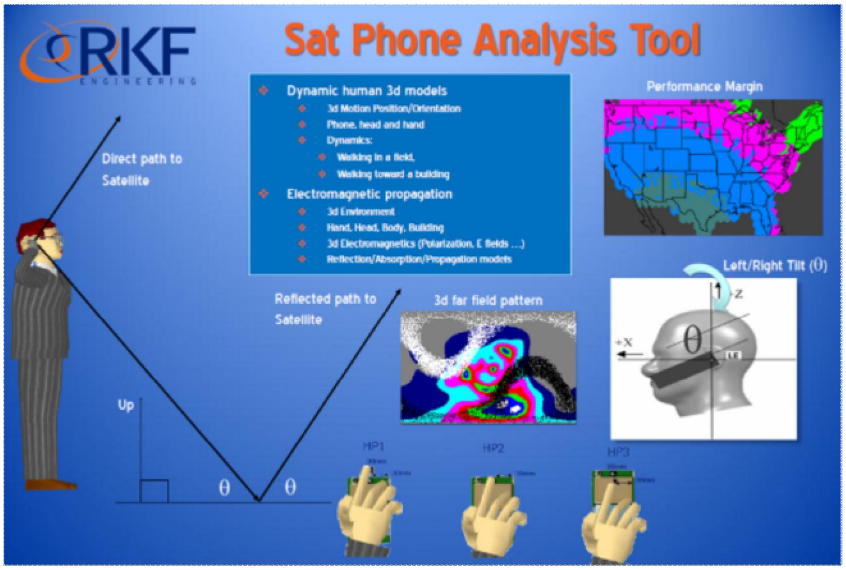
Satellite Phone Analysis Tool

RKF's satellite phone tool is used to analyze the effects of the dynamic human 3d models and electromagnetic propagation on a phone's performance margin and 3d far field pattern.



Impairments taken into account by the satellite phone analysis tool include: 3d motion position/orientation, the human head and hand (along with the phone itself), user motion (e.g. walking in a field or toward a building), 3d electromagnetic propagation, reflection/absorption and 3d propagation models.



Sat Phone Analysis Tool

- Dynamic human 3d models
  - 3d Motion Position/Orientation
  - Phone, head and hand
  - Dynamics:
    - Walking in a field,
    - Walking toward a building
- Electromagnetic propagation
  - 3d Environment
  - Hand, Head, Body, Building
  - 3d Electromagnetics (Polarization, E fields ...)
  - Reflection/Absorption/Propagation models

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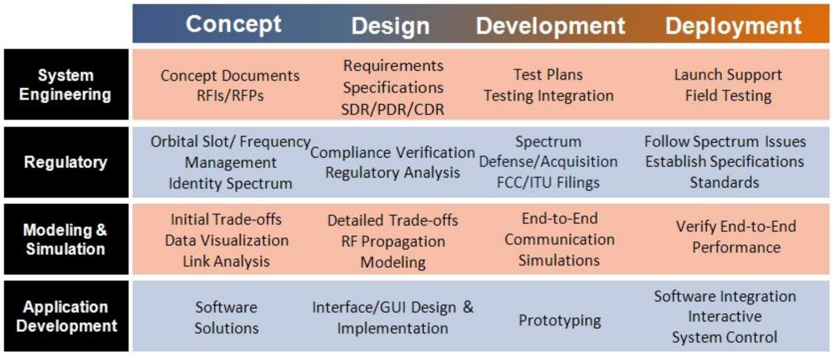
- Modeling & Simulation
- Professional Services
- Software Development & Applications
- Work Experience
  - TerreStar
  - IRIS
  - DirecTV
  - PanAmSat
  - DARPA TTO SETA

Services & Capabilities

RKF Engineering Solutions, LLC has provided internationally renowned expertise for over 25 years in the fields of satellite and telecommunications. RKF specializes in communication systems engineering & design, regulatory expertise & spectrum management, software development & applications, modeling & simulation, and professional standards. In its over 25 years of operation RKF has performed system engineering for some of the most complicated commercial and government satellites ever built. RKF's experience and diligent problem solving methodology allow us to provide our customers with exceptional services and capabilities.

The figure below details some of the capabilities RKF possesses as it brings satellite and terrestrial communication systems from conception to real-world implementation. These capabilities fall into the categories of system engineering, regulatory services, modeling & simulation and application development.



	Concept	Design	Development	Deployment
System Engineering	Concept Documents RFIs/RFPs	Requirements Specifications SDR/PDR/CDR	Test Plans Testing Integration	Launch Support Field Testing
Regulatory	Orbital Slot/ Frequency Management Identity Spectrum	Compliance Verification Regulatory Analysis	Spectrum Defense/Acquisition FCC/ITU Filings	Follow Spectrum Issues Establish Specifications Standards
Modeling & Simulation	Initial Trade-offs Data Visualization Link Analysis	Detailed Trade-offs RF Propagation Modeling	End-to-End Communication Simulations	Verify End-to-End Performance
Application Development	Software Solutions	Interface/GUI Design & Implementation	Prototyping	Software Integration Interactive System Control

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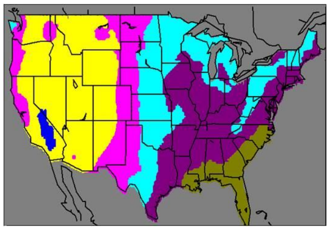
Spectrum and Link Budget Analysis Tools

RKF develops custom spectrum analysis tools for clients and in-house analyses. These tools aid in the development of spectrum sharing techniques by calculating the amount of potential interference to legacy spectrum users and new users of a particular frequency band. RKF spectrum analysis tools have served many satellite and terrestrial communication companies interested in optimizing the use of their allocated spectrum. These customers have traditionally been concerned with estimating the amount of interference that their receivers will see from newly deployed secondary users of their spectrum or they have been interested in bidding for newly available spectrum.



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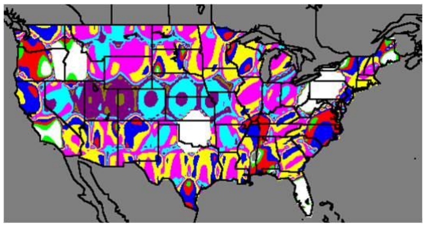

For example, in recent analyses performed for DirecTV, RKF determined the effect of improperly pointed satellite dishes on the interference received from neighboring satellites. In other analyses for DirecTV, RKF analytically and experimentally verified the amount of interference received from newly deployed Multichannel Video and Data Distribution Service (MVDDS) stations sharing their satellite broadcast band. RKF provides tools and analyses which account for 3D antenna patterns, rain losses, 3D geometries, the operating frequency, as well as other link budget items.

In addition, RKF has a vast amount of experience developing detailed and extensive link budgets and link budget tools for complex systems, such as CISCO's IRIS, TerreStar's TerreStar-1, and DirecTV's satellites. These link budgets include analysis of all end-to-end losses and gains, including ITU models for rain, cloud, gaseous, scintillation, and other attenuations types.

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Leadership & RKF Team

- Summary
- Philip A. Rubin, PE - President & CEO
- Jeffrey B. Freedman, PhD - CTO
- Ted M. Kaplan - COO
- Arnold L. Berman, PhD - Chief Scientist
- Technical Staff

Technical Staff

The Technical Staff at RKF is comprised of top technical talent in areas critical to the success of our organization. Over 90% of our staff possess advanced degrees and 40% hold a Ph.D. As a group we hold over 50 patents and excel in communication systems engineering, engineering consulting, software development, and regulatory services. Members of the Technical Staff at RKF are driven by their sincere interest to solve the most challenging engineering problems facing next generation communication systems.

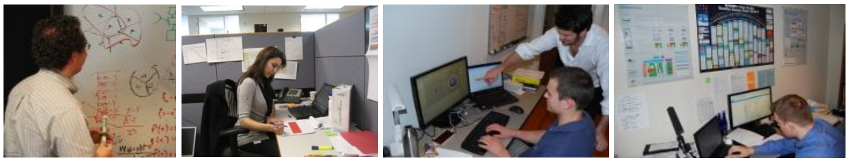

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Exhibit Q

FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C. 20554

CREDIT & DEBIT MANAGEMENT
Group, [redacted] OMD

JUN 16 2000

OFFICE OF
MANAGING DIRECTOR

Joseph A. Godles, Esquire
Goldberg, Godles, Wiener & Wright
1229 19th Street, N.W.
Washington, D.C. 20036

Re: PanAmSat Corporation
Fee Control # 9905198210333001

Dear Mr. Godles:

This responds to the request you filed on behalf of PanAmSat Corporation ("PanAmSat") for a waiver and refund of the fee payment it submitted in connection with its application for authority to construct, launch and operate a satellite.

You represented that PanAmSat filed the application and the associated fee payment, in the amount of $89,460.00, in order to obtain authority to construct, launch and operate a "C/Ku-band hybrid fixed-satellite service satellite, to be known as Galaxy X-R." You further represented that Galaxy X-R was intended to be a replacement satellite, and that its technical requirements were to be identical with those of its previously authorized Galaxy X satellite, which suffered a launch failure on May 8, 1998. *See PanAmSat Corporation*, DA 00-91 (January 18, 2000). You maintained that because the Commission previously had "passed on the various technical and operational aspects of Galaxy X," its review of the instant application was "minimal" and thus sought a waiver and refund of the fee payment.

In *Fee Decisions (Hughes Communications Galaxy, Inc.)*, 9 FCC Rcd 2223, 2230-2231 (Office of Managing Director 1994), we considered a similar request for waiver and refund of a fee payment filed in connection with an application to construct, launch and operate a replacement satellite. Specifically, we found that the fee requirement bore "scant relationship to [the Commission] resources required to process the replacement satellite's authorizations because much of the processing is insignificantly different from that required for [the] initial satellite." *Id.* at 2231. We concluded that "the processing of [the] application for construction, launch and operational authority [of a replacement satellite] is consistent with the processing burden for an application to modify a space station." Accordingly, we assessed the licensee the fee specified for an application to modify a space station authorization, granting it a partial waiver and fee refund (the difference between the fee associated with a construction permit application to launch and operate a satellite and an application to modify a satellite authorization).

Consistent with *Hughes Communications Galaxy, Inc.*, PanAmSat will be assessed a fee in the amount of $6,390.00, the fee associated with an application to modify a satellite authorization.

Accordingly, your request is granted to the extent specifically indicated above. We will assess PanAmSat a total fee of $6,390.00 to cover its application to construct, launch and operate its replacement Galaxy X-R replacement satellite. Therefore, PanAmSat is entitled to a refund of $83,070.00. A check, made payable to the maker of the original check and drawn in the amount of $83,070.00, will be sent to you at the earliest practicable time. If you have any questions concerning this refund, please contact the Credit & Debt Management Group at (202) 418-1995.

Sincerely,

Mark Reger
Chief Financial Officer

9905198210333001

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

RECEIVED
MAY 18 1999
FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of the Application of)
)
PANAMSAT CORPORATION) File No.
)
For Authority To Launch and Operate)
A Replacement C/Ku Hybrid Fixed-Satellite)
Service Space Station)

REQUEST FOR WAIVER AND REFUND OF FILING FEES

PanAmSat Corporation ("PanAmSat"), pursuant to Section 8(d)(2) of the Communications Act of 1934, as amended, 47 U.S.C. § 158(d)(2), and Sections 1.1113 and 1.1117 of the Commission's rules, hereby requests that the Commission waive and refund the filing fee for the attached application for authority to launch and operate a replacement satellite.

Under the Commission's rules, the Commission may waive filing fees "where good cause is shown and where waiver ... of the fees would promote the public interest."[1] Any fee so waived should be returned or refunded to the applicant.[2]

The attached application seeks authority to launch and operate a C/Ku-band hybrid fixed-satellite service ("FSS") satellite, to be known as Galaxy X-R, to replace PanAmSat's Galaxy X satellite, which suffered a launch failure on May 8, 1998. PanAmSat proposes to launch and operate Galaxy X-R as a replacement for Galaxy-X.

Galaxy X-R will have substantially the same technical characteristics as Galaxy-X. As a result, the Commission will be required to engage in minimal regulatory review of the attached application. Because the Commission already has passed on the various technical and operational aspects of Galaxy X, and because the attached application raises no new policy issue, the "fees contained in the fee schedule bear scant relationship to the resources required to process the replacement

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[1] 47 C.F.R. § 1.1117(a).

[2] 47 C.F.R. § 1.1113(a)(5).

satellite's authorizations."[3] Accordingly, PanAmSat requests refund and waiver of the filing fee submitted in connection with the attached application for authority to launch and operate the Galaxy X-R replacement satellite.[4]

Respectfully submitted,

PANAMSAT CORPORATION

By: ______________________
Joseph A. Godles

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1229 19th Street, NW
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(202) 429-4900

Its Attorneys

May 18, 1999

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[3] See Fee Decisions of the Managing Director, 9 FCC Rcd 2223, 2230-31 (1994) (granting partial fee waiver for application to construct, launch, and operate replacement satellite).

[4] Under similar circumstances, the Commission refunded to PanAmSat $74,620 of an $80,360 fee paid in connection with an application for authority to construct, launch, and operate the PAS-2R replacement satellite. See Letter from Marilyn J. McDermett, FCC Associate Managing Director, to Joseph A. Godles, Attorney for PanAmSat (Feb. 24, 1997).

PanAmSat Corporation

Exhibit 1
FCC Form 312

Hughes Electronics Corporation ("HE") indirectly owns over 80% of the issued and outstanding stock of PanAmSat Corporation ("PanAmSat"). HE Holdings, Inc. ("HEH"), a wholly-owned subsidiary of HE formerly known as Hughes Aircraft Company, pled guilty to two felony counts in 1990. The full details of this matter are included in a Form 430 for Hughes Communications Galaxy, Inc., dated August 19, 1991.

On June 15, 1992, HEH was found guilty of one felony count with regard to the testing of microelectronics components. The full details of this matter are included in a Form 430 for Hughes Communications Galaxy, Inc., dated August 12, 1992.

The conduct at issue in these two cases has no relevance to the FCC authorizations and applications of PanAmSat. HEH was merged into the Raytheon Company in 1997 and therefore is no longer affiliated with PanAmSat or any party to this application. HE, moreover, had no ownership interest in the PanAmSat system when the conduct occurred at HEH. In addition, conduct in these matters is wholly unrelated to the communications area and does not reflect in any way upon the FCC-related activity of PanAmSat, whose operations are largely independent of HEH.

PanAmSat Corporation

Exhibit 2
FCC Form 312
Page 1

Names, addresses, citizenship, and percentage interests of stockholders owning of record and/or voting 10 % or more of voting stock

Hughes Communications, Inc. c/o Hughes Electronics Corporation P.O. Box 956-ES/001-A-106 El Segundo, CA 90245	USA	81%

Names and addresses of Officers and Directors of PanAmSat Corporation

Mr. Patrick J. Costello
c/o PanAmSat Corporation
One Pickwick Plaza
Greenwich, CT 06830

Mr. Steve D. Dorfman
c/o PanAmSat Corporation
One Pickwick Plaza
Greenwich, CT 06830

Ms. Roxanne Austin
c/o PanAmSat Corporation
One Pickwick Plaza
Greenwich, CT 06830

Mr. Michael T. Smith
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Mr. Frederick A. Landman
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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of the Application of)
)
PANAMSAT CORPORATION) File No.
)
For Authority To Launch and Operate)
A Replacement C/Ku-band Hybrid)
Fixed-Satellite Service Space Station)

APPLICATION

PanAmSat Corporation ("PanAmSat"), hereby requests authority to launch and operate a replacement C/Ku-band hybrid fixed-satellite service ("FSS") satellite, to be known as Galaxy X-R, to replace PanAmSat's Galaxy X satellite, which suffered a launch failure on August 8, 1998. PanAmSat proposes to locate Galaxy X-R at 123° W.L., which is the orbital location that had been assigned to Galaxy X.

Significantly, because Galaxy X-R will be providing service from the orbital location previously assigned to Galaxy X, PanAmSat is not herein seeking the assignment of an additional orbital location, nor will grant of PanAmSat's Application increase congestion in the satellite arc. Galaxy X-R is a replacement for a previously authorized space station. In accordance with the Commission's policies and rules, PanAmSat respectfully requests that its application for a replacement satellite be processed outside of the context of a processing round.[1]

INTRODUCTION

PanAmSat operates the PanAmSat and Galaxy satellite systems, which are comprised of nineteen commercial communications satellites spanning the globe. Using these satellites, PanAmSat and its predecessors have provided a wide variety of reliable satellite services for many years. PanAmSat's satellites provide the means for commercial television and radio distribution, teleconferencing, video backhaul, high speed image transmission, and private data networks, among other services. Countless end users across the world rely on these services every day.

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[1] See, e.g., In the matter of Loral Spacecom Corp., 13 FCC Rcd. 16438 (1998); In the Matter of GE American Communications, 10 FCC Rcd 13775, 13776 (1995).

Galaxy X was intended to be an integral part of PanAmSat's global satellite network. Because of Galaxy X's launch failure, PanAmSat requests authority to launch and operate a replacement satellite, to be known as Galaxy X-R, using the same orbital location.

In support of this Application, PanAmSat submits the following information:

Item A. Name, Address, and Telephone Number of Applicant

PanAmSat Corporation
One Pickwick Plaza
Greenwich, CT
(203) 622-6664

Item B. Correspondence

Inquiries or correspondence with respect to this application should be sent to the following person at the above address and telephone number:

James W. Cuminale
Senior Vice President, General Counsel & Secretary

With a copy to:

Joseph A. Godles, Esq.
Goldberg, Godles, Wiener & Wright
1229 19th Street, N.W.
Washington, D.C. 20036
(202) 429-4900

Item C. System Description

See attached Engineering Statement.

Item D. General Technical Information

See attached Engineering Statement.

Item E. Milestones

See Exhibit 1.

Item F. Financial Qualifications

Exhibit 2 and the attached full financial showing demonstrate that PanAmSat has the current financial ability to meet the estimated costs of constructing Galaxy X-R launching the satellite, and operating it for one year.

Item G. Legal Qualifications

The portions of the application appearing on FCC Form 312 establish PanAmSat's legal qualifications, which are a matter of public record. See also Hughes Communications, Inc. et al., 12 FCC Rcd. 7534 (1997).

Item H. Type of Operations

PanAmSat proposes to market all of the transponders on Galaxy X-R on a non-common carrier basis, pursuant to the Commission's decisions in Domestic Fixed-Satellite Transponder Sales, 90 F.C.C.2d 1238 (1982), and Martin Marietta Communications Systems, Inc., 60 R.R.2d 779 (1986). PanAmSat will retain the flexibility to market transponders to common carriers and resellers. Thus, although common carrier services may be offered using its transponders, they will not be offered by the applicant, PanAmSat.

Item I. Public Interest Considerations

Grant of this Application will enable PanAmSat to meet growing customer demand and expand the competitive choices available in the marketplace as the Commission concluded in authorizing Galaxy X.[2]

WAIVERS/CERTIFICATIONS

PanAmSat waives any claim to the use of any particular frequency or of the electromagnetic spectrum as against the regulatory power of the United States because of

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[2] Hughes Communications Galaxy, Inc., 11 FCC Rcd. 16425 (1996).

the previous use of the same, whether by license or otherwise, and requests launch and operating authority in accordance with this Application. All statements made in the attached exhibits are a material part hereof, and are incorporated herein as if set out in full in this Application.

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

The undersigned also certifies that neither PanAmSat nor any party to this Application is subject to a denial of federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 853a.

CONCLUSION

For the foregoing reasons, PanAmSat respectfully requests that the Commission grant this Application.

Respectfully submitted,

PANAMSAT CORPORATION

By: ____________________
Kalpak Gude
Vice President &
Associate General Counsel

Of Counsel:

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May 18, 1999

EXHIBIT 1

GALAXY X-R MILESTONES

EVENT	COMPLETION DATE
Spacecraft RFP issued	Completed
Spacecraft contractor selected	Completed
Spacecraft contract executed	Completed
Launch services contract executed	Completed
Spacecraft launched	1 Q 2000
Spacecraft in service	2 Q 2000

EXHIBIT 2

GALAXY X-R CAPITAL REQUIREMENTS

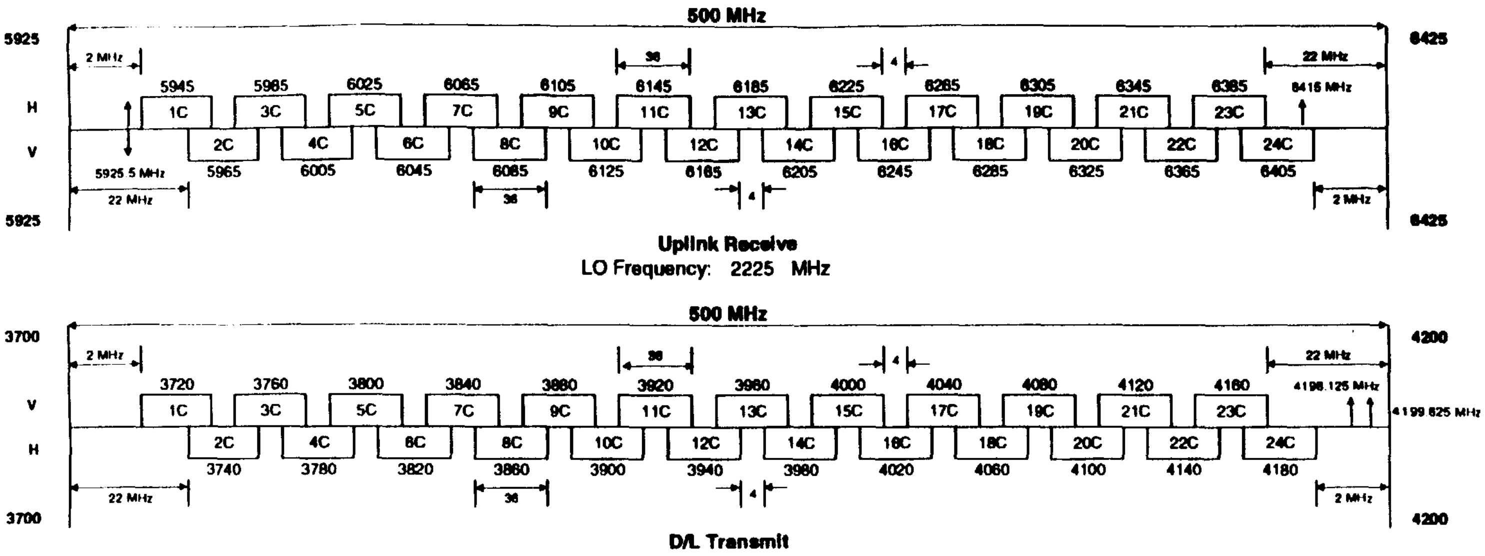
REQUIREMENT	ESTIMATED COST
Construction, launch, insurance premium, first year expenses	**$200 Million**

Figures 1 and 2. During the satellite's transfer orbit, command signals will be received through an forward and aft pipes at both the higher and lower band-edge of the C-Band receive frequencies. When the satellite is at its final orbit position, the primary command uplink will be received at the higher edge of the standard C-Band frequencies through the main reflector, with backup through the bicone and in other cases, the lower band frequency as well through the aft and forward pipes. The command uplink will use government-approved command encryption. The two C-Band telemetry frequencies using the bicone antenna will allow simultaneous transmission of two separate or redundant telemetry data streams with backup available on the forward and aft pipes. The Ku-Band downlink ULPC signals will be continuously transmitted by the satellite and used by earth station operators as a calibrated reference to compensate for rain attenuation and to adjust antenna pointing. These ULPC frequencies will be transmitted on the global horn and will be availble anywhere within the satellite's coverage area.

The satellite communication subsystem will include appropriate filtering at the inputs and outputs of the satellite to minimize internal interchannel interference, noise effects outside the satellite frequency band, and out-of-band spurious transmissions.

Figure 1. C-Band Frequency Plan

C-Band (Primary)



C-Band (Alternate)

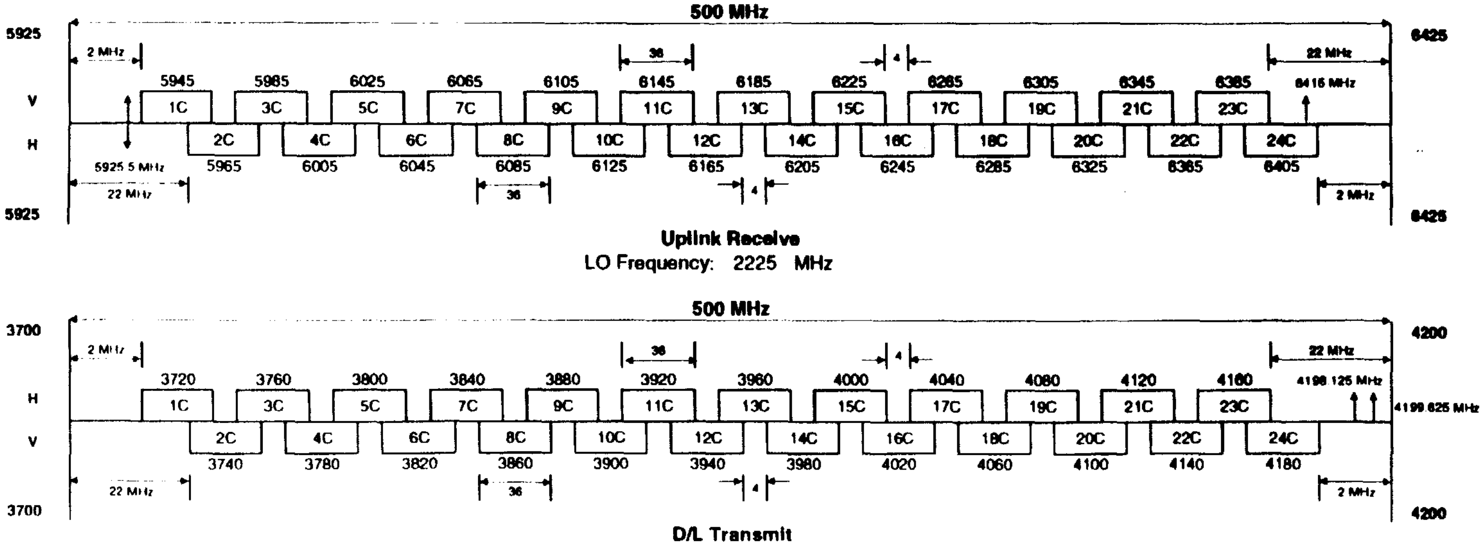
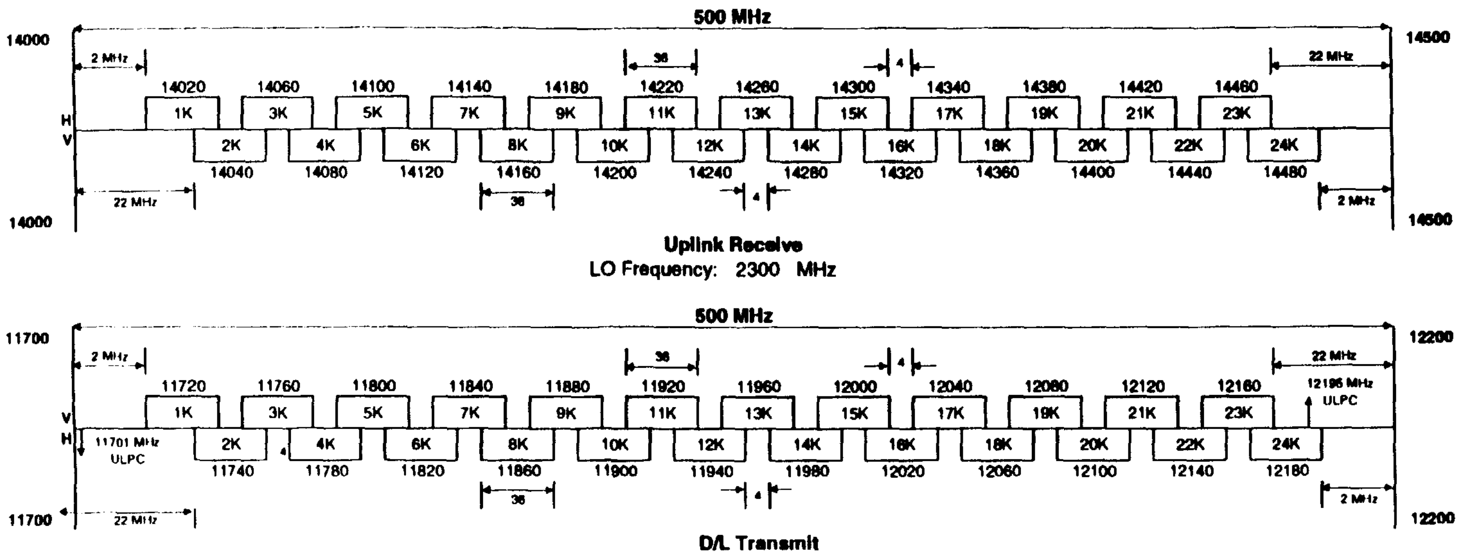


Figure 2. Ku-Band Frequency Plan

Ku-Band (Primary)



Ku-Band (Alternate)

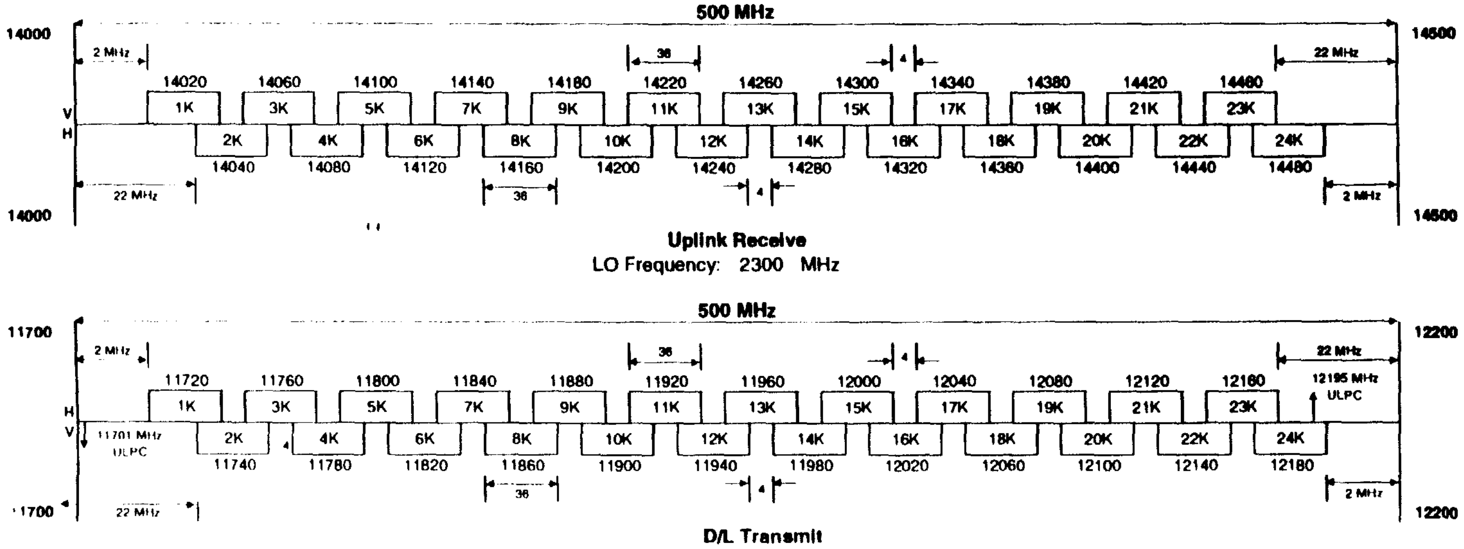


Table 1a. C-Band Frequency Assignments

Transponder	Uplink Pol	Uplink Frequency (MHz)	Downlink Pol	Downlink Frequency (MHz)	Channel Bandwidth (MHz)
1	H	5945	V	3720	36
3	H	5985	V	3760	36
5	H	6025	V	3800	36
7	H	6065	V	3840	36
9	H	6105	V	3880	36
11	H	6145	V	3920	36
13	H	6185	V	3960	36
15	H	6225	V	4000	36
17	H	6265	V	4040	36
19	H	6305	V	4080	36
21	H	6345	V	4123	36
23	H	6385	V	4160	36
2	V	5965	H	3740	36
4	V	6005	H	3780	36
6	V	6045	H	3820	36
8	V	6085	H	3860	36
10	V	6125	H	3900	36
12	V	6165	H	3940	36
14	V	6205	H	3980	36
16	V	6245	H	4020	36
18	V	6285	H	4060	36
20	V	6325	H	4100	36
22	V	6365	H	4140	36
24	V	6405	H	4180	36

Pol = Polarization
V = Vertical Polarization
H = Horizontal Polarization

Table 1b. Ku-Band Frequency Assignments

Transponder	Uplink Pol	Uplink Frequency (MHz)	Downlink Pol	Downlink Frequency (MHz)	Channel Bandwidth (MHz)
1	H	14020	V	11720	36
2	V	14040	H	11740	36
3	H	14060	V	11760	36
4	V	14080	H	11780	36
5	H	14100	V	11800	36
6	V	14123	H	11820	36
7	H	14140	V	11840	36
8	V	14160	H	11860	36
9	H	14180	V	11880	36
10	V	14200	H	11900	36
11	H	14220	V	11920	36
12	V	14240	H	11940	36
13	H	14260	V	11960	36
14	V	14280	H	11980	36
15	H	14300	V	12300	36
16	V	14320	H	12320	36
17	H	14340	V	12340	36
18	V	14360	H	12360	36
19	H	14380	V	12380	36
20	V	14400	H	12100	36
21	H	14420	V	12123	36
22	V	14440	H	12140	36
23	H	14460	V	12160	36
24	V	14480	H	12180	36

Pol = Polarization
V = Vertical Polarization
H = Horizontal Polarization

5. Emission Designators

Emission designators for the communications carriers, telemetry, telecommand and ULPC (and downlink beacon) signals are shown in Table 2 below. RF link budgets for TT&C are shown in Tables 7 and 8 while certain illustrative communication carrier link budgets can be found in Appendix A.1 through A.12.

Table 2. Emissions Designators

Signal	Emission Designator
Command	300KF9DXX
Telemetry/Ranging	123KF9DXX
Downlink Beacon (ULPC)	25KON0N
Single carrier TV	36M0F3F
Digital MCPC (QPSK, R3/4)	36M0G7W
Digital MCPC (8PSK, R2/3)	36M0G7W
9MHz SCPC (QPSK, R3/4)	9M00G7W
6MHz SCPC (QPSK, R3/4)	6M00G7W
3MHz SCPC (QPSK, R3/4)	3M00G7W
Digital voice	24K3G1W
Digital (outroute) data	1M23G1W
Digital (64 kbps) data	48K6G1W
Digital T1 (QPSK, R1/2)	2M20G7W
64Kbps Carrier (QPSK, R1/2)	100KG7W
64Kbps Carrier (BPSK, R1/2)	200KG7W
FM Audio (Narrow-Band)	50K0F3E
FM Audio (Wide-Band)	150KF3E

Communications Coverage

The GALAXY X-R receive/transmit patterns are depicted in Figures 3 through 6. The beams are produced by two Gregorian antennas (one for each frequency band) which provide both uplink and downlink coverages of the 48 contiguous states, Southern Canada and Mexico plus Alaska and Hawaii, and those Carribean Islands visible from this orbital location.

Figure 7 is intended to show coverage of the TT&C Global Horn, one of three different TT&C antennas. This figure actually shows coverage from two orbital slots, 123WL and 127WL.

FIGURE 3

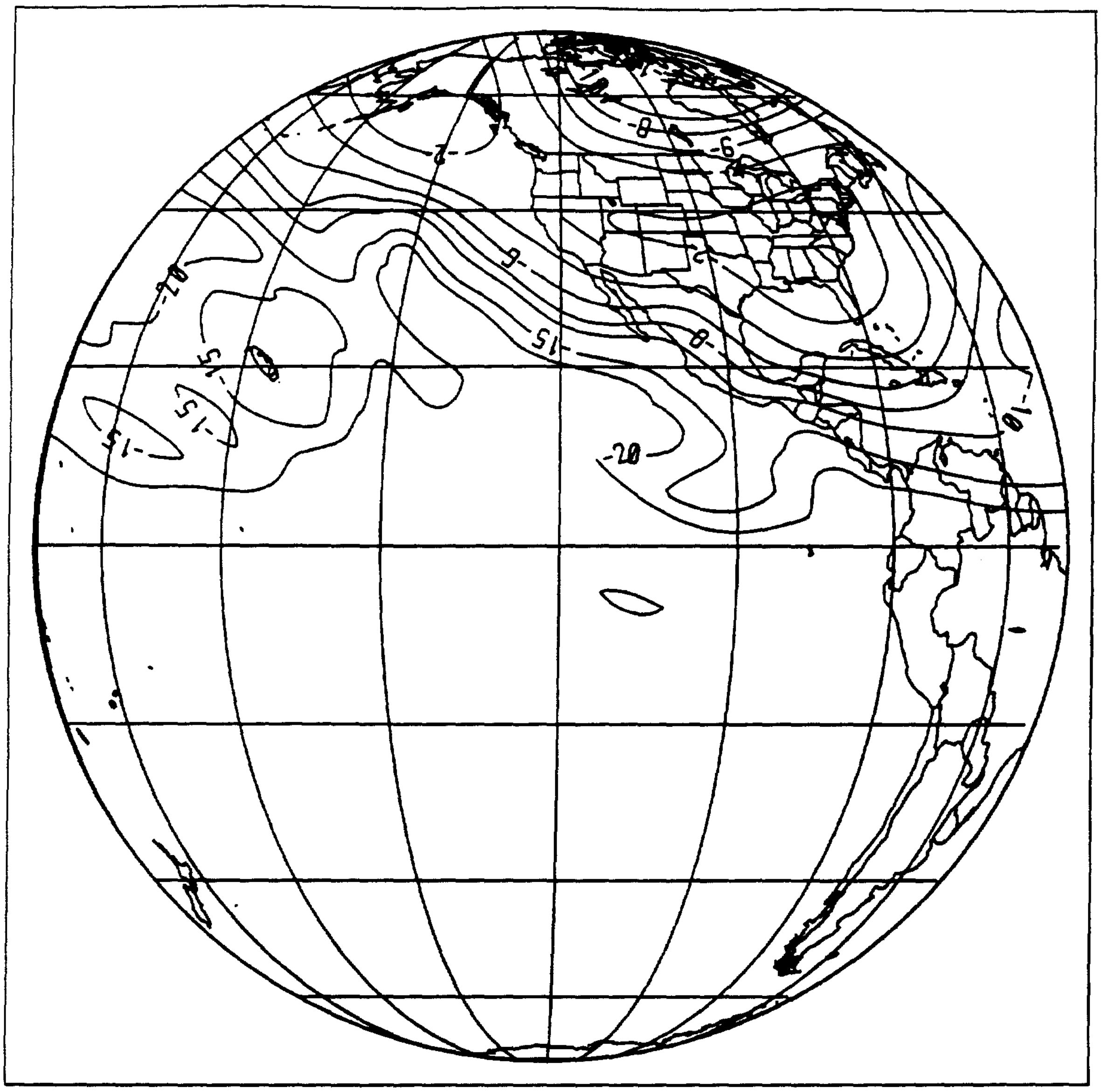
Galaxy 10-R C-Band Vertical Uplink Beam

NOTES:

1. Peak Gain = 32.9 dBi, Conversion Factor = 29.4 dB/K
2. X = Peak Gain or Boresight
3. Mid-Band Frequency = 6.185 GHz

FIGURE 4

Galaxy 10-R C-Band Horizontal Downlink Beam

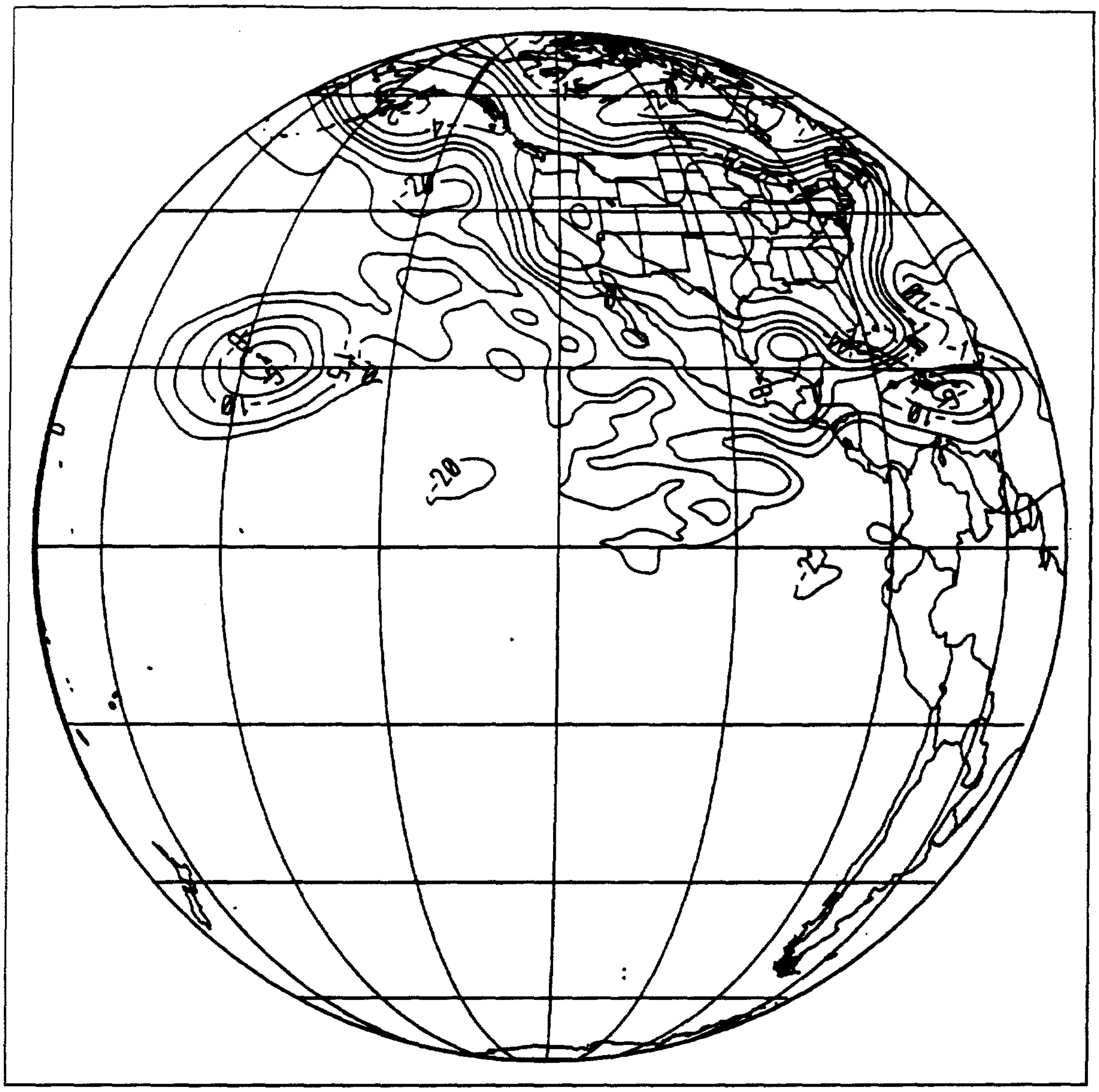


NOTES:

1. Peak Gain = 30.9 dBi, Conversion Factor = 13.2 dBW
2. X = Peak Gain or Boresight
3. Mid-Band Frequency = 3.960 GHz

FIGURE 5

Galaxy 10-R Ku-Band Horizontal Uplink Beam

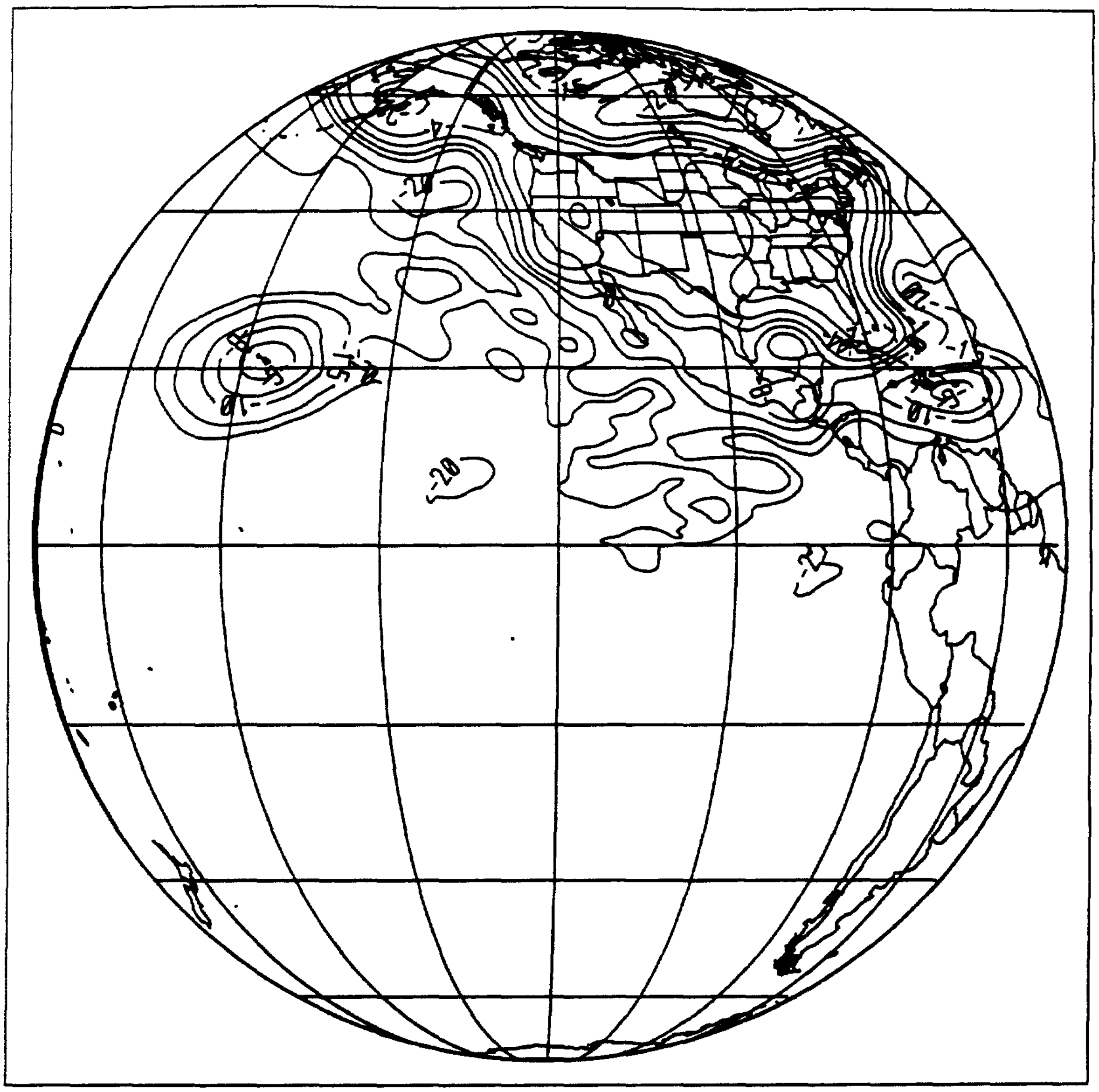


NOTES:

1. Peak Gain = 33.8 dBi, Conversion Factor = 29.6 dB/K
2. X = Peak Gain or Boresight
3. Mid-Band Frequency = 14.240 GHz

FIGURE 6

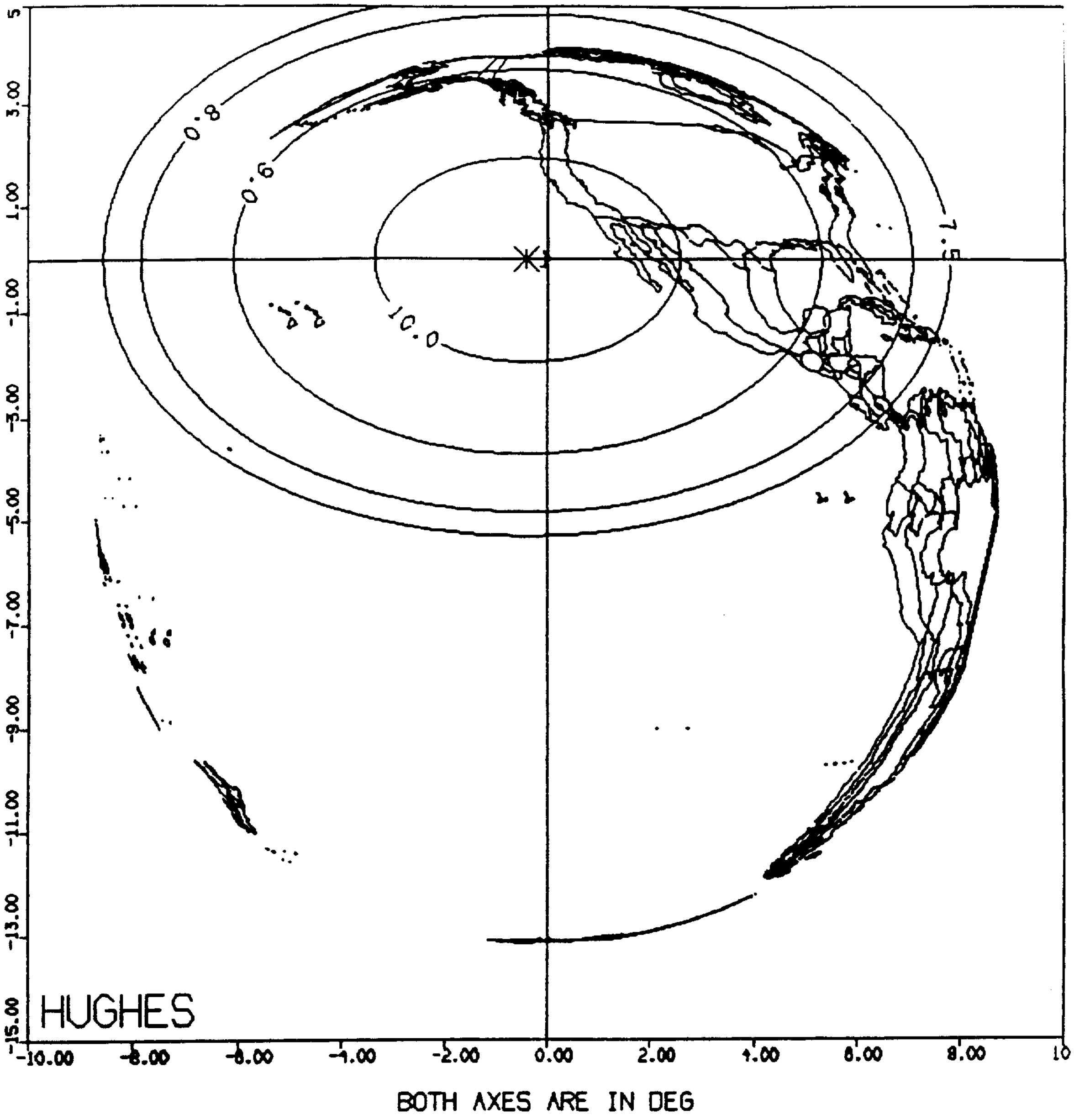
Galaxy 10-R Ku-Band Vertical Downlink Beam



NOTES:

1. Peak Gain = 33.8 dBi, Conversion Factor = 17.2 dBW
2. X = Peak Gain or Boresight
3. Mid-Band Frequency = 11.960 GHz

Figure 7. Ku-Band Global Horn Coverage



d. Power Flux Density Level

The power flux density limits for space stations are specified in Section 25.208 of the FCC Rules. Using the contours in Figures 4 and 6, it will be shown that the GALAXY X-R satellite will meet the Commission's regulations.

For the C-Band US beam:

Maximum EIRP in US Beam (dBW)	44.2
Path Loss to US Beam boresite (dB)	-196.0
Gain of 1m^2 Antenna (dB)	33.4
Bandwidth of Spreading of TV Carrier (dB)	-66.0
Conversion to 4kHz (dB)	36.0
Maximum Power Flux Density (dBW/m^2/4kHz)	-148.4

For the Ku-Band US beam:

Maximum EIRP in US Beam (dBW)	51.0
Path Loss to US Beam boresite (dB)	-205.0
Gain of 1m^2 Antenna (dB)	43.1
Bandwidth of Digital TV Carrier (dB)	-75.6
Conversion to 4kHz (dB)	36.0
Maximum Power Flux Density (dBW/m^2/4kHz)	-150.5

As can be seen from the results of these calculations, none of GALAXY X-R beams exceed the flux density limitations employed by the Commission and the ITU.

2. Satellite characteristics

The major characteristics of the spacecraft are shown below in Table 3. The estimated weight and power budgets, are provided in Tables 4 and 5, are based on a mission life of 15 years and assume sufficient redundancy to allow for random failures.

Tables 6 and 7 show the estimated receive gain-to-noise temperature (G/T) and EIRP budgets, respectively.

Table 3. Spacecraft Characteristics

General		
spacecraft bus		Hughes, HS-601-HP
stabilization		
transfer orbit		spin stabilization
on station		3 axis, momentum bias
mission life		15 years (estimated)
eclipse capability (60 transponders)		100 percent
orbital location		123° WL
stationkeeping		
north-south		+/-0.05°
east-west		+/-0.05°
antenna pointing		
earth sensor		+/-0.1° n-s and e-w WL
Communications		
frequency		
receive		14000 to 14500 MHz 5925 to 6425 MHz
transmit		11700 to 12200 MHz 3700 to 4200 MHz
polarization	C-	uplink: H/V linear downlink: V/H linear
	Ku-	uplink: H/V linear downlink: V/H linear
number of transponders		48
transponder bandwidth		36 MHz

Table 3. (cont'd.)

saturated transponder gain	170 to 195 dB
receive saturation at -2 dB/K contour and adjustable by ground command in 2 dB steps	-100 to -82.5 dBW/m^2
transmitter RF power	40W C-Band 108W Ku-Band
transmitter redundancy	28 for 24 (C-Band) 28 for 24 (Ku-Band)
emission limitations (percentage of authorized bandwidth)	
50 to 100%	>20 db attenuation in any 4kHz
100 to 250%	>40 db attenuation in any 4kHz
greater than 250%	>50 db attenuation in any 4kHz
telemetry/ranging	vertical, linear
peak deviation	
command, ranging	±300 kHz
modulation index	
telemetry/ranging	1.0 ± 0.1 radians
telemetry eirp	
transfer orbit	7.0 dBW maximum
on station	22.0 dBW maximum
command threshold (flux density)	
transfer orbit	-82.0 dBW/m^2
on station	-111.0 dBW/m^2

Table 3. (cont'd.)

command	
transfer orbit	forward/aft pipes
on station	reflector/bicone
telemetry	
transfer orbit	forward/aft pipes
on station	reflector/bicone
command, ranging	6415MHz on station 5925.5MHz transfer orbit
telemetry and ranging	4198.125MHz, 4199.625MHz
ULPC beacon	11701 MHz, 12195 MHz
polarization	
command	
transfer orbit	RHCP
on station	horizontal, linear
telemetry	
transfer orbit	RHCP
on station	vertical, linear

Table 4. Weight Budget

Category	Weight, kgs.
communications subsystem weight	1,000
bus weight	1,300
estimated spacecraft dry weight	2,300
fuel, expendables	1,400
total launch weight	3,700

Table 5. Power Budget

Category	Power, watts
communications subsystem power	9,720
bus power	1,200
total power requirement	10,920
beginning-of-life array capability	11,980
beginning-of-life margin	1,060
end-of-life array capability(12 years)	10,995
end-of-life margin	75

3. Satellite Description

a. General

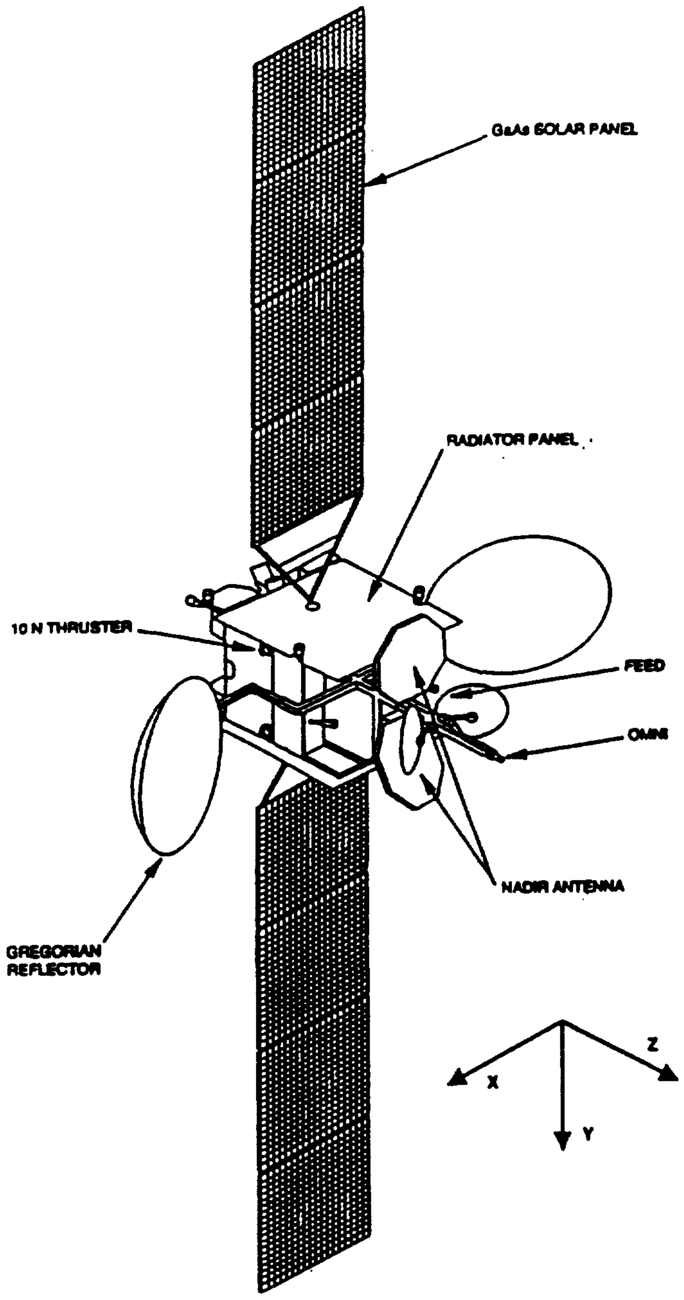
The on-orbit satellite configuration is shown in Figure 8. The spacecraft bus is based upon the Hughes Space and Communications Company HS-601-HP series body-stabilized bus. The satellite design is compatible with launch by one of the currently available commercial launch vehicles. Final injection into geosynchronous orbit is accomplished by an on-board liquid propulsion system.

Deployment of antennas and solar wings takes place in several separate operations. The forward and aft pipe antennas, used for command, telemetry, and ranging, are launched in a transfer orbit configuration. After the spacecraft has been injected into synchronous orbit, the communications antennas and radiator panels are deployed and the solar wings are extended.

b. Structural Design

The spacecraft takes advantage of a modular design for ease of manufacturing and integration. Communications equipment is mounted on the payload module that forms the forward portion of the spacecraft. Propulsion equipment is mounted on a central structure with tank loads being carried by a four bolt interface to the launch vehicle. A bus module forms the aft portion of the spacecraft.

Figure 8. On Orbit Configuration



c. Thermal Control

Thermal control is accomplished with heaters and heat pipes, heat rejection surfaces are the north and south facing radiators, using quartz mirrors,and a radiator area extended with the use of deployable radiators. Battery temperatures are maintained within limits by using direct radiating surfaces plus heaters.

d. Power

Satellite power will be provided by a solar array of fused silica-covered gallium arsenide solar cells that convert solar energy to the required electrical power. The solar wings are deployed after the satellite attains synchronous orbit. Nickel-Hydrogen batteries provide sufficient electrical power during eclipse to operate the full communications and housekeeping loads. The electrical power subsystem has been designed so that no single failure in the subsystem will cause a spacecraft failure. Sufficient power will be available at the end of the satellite's life to support all 48 active transponder channels and the housekeeping loads.

e. Attitude Control

The Attitude Control Subsystem (ACS) maintains the spacecraft attitude during the transfer orbit, initial acquisition period, and geostationary operations. The ACS employs sun and earth sensors to perform all attitude determination functions. Control of attitude and spacecraft orbit is accomplished by using reaction wheels and by pulsed or continuous firing of selected thrusters by the ACS during ground controlled maneuvers.

f. Propulsion

The spacecraft will use both a liquid bipropellent and a Xenon Ion Propulsion system (XIP's). The liquid bipropellant system is based on proven technology from earlier PanAmSat programs. XIP's technology has been incorporated into the PAS-5 and PAS-6B satellites as well as being incorporated into Galaxy-4R, Galaxy-11 and GALAXY X-R.

g. Communication Payload

(i) Antenna Subsystem

The GALAXY X-R satellite antenna subsystem contains two east-west reflectors and two nadir reflectors. Each reflector is fed by two feed horns which are frequency diplexed to allow each horn to be used for transmit and receive functions. Relative to the desired polarization, the cross-polarization component of the receive and transmit signals will be at least 30 dB over the required coverage regions.

(ii) Communications Subsystem

The communications subsystem consists of two types of communications repeaters:

(1) a C-Band repeater employing 40 watt SSPAs,

(2) a Ku-Band repeater employing 108 watt TWTAs,

Subsystem components are selected to optimize performance in conjunction with ground terminals on customer premises.

A block diagram of the communication subsystem is provided in Figures 9 and 10.

Figure 9. Ku-Band Subsystem Block Diagram

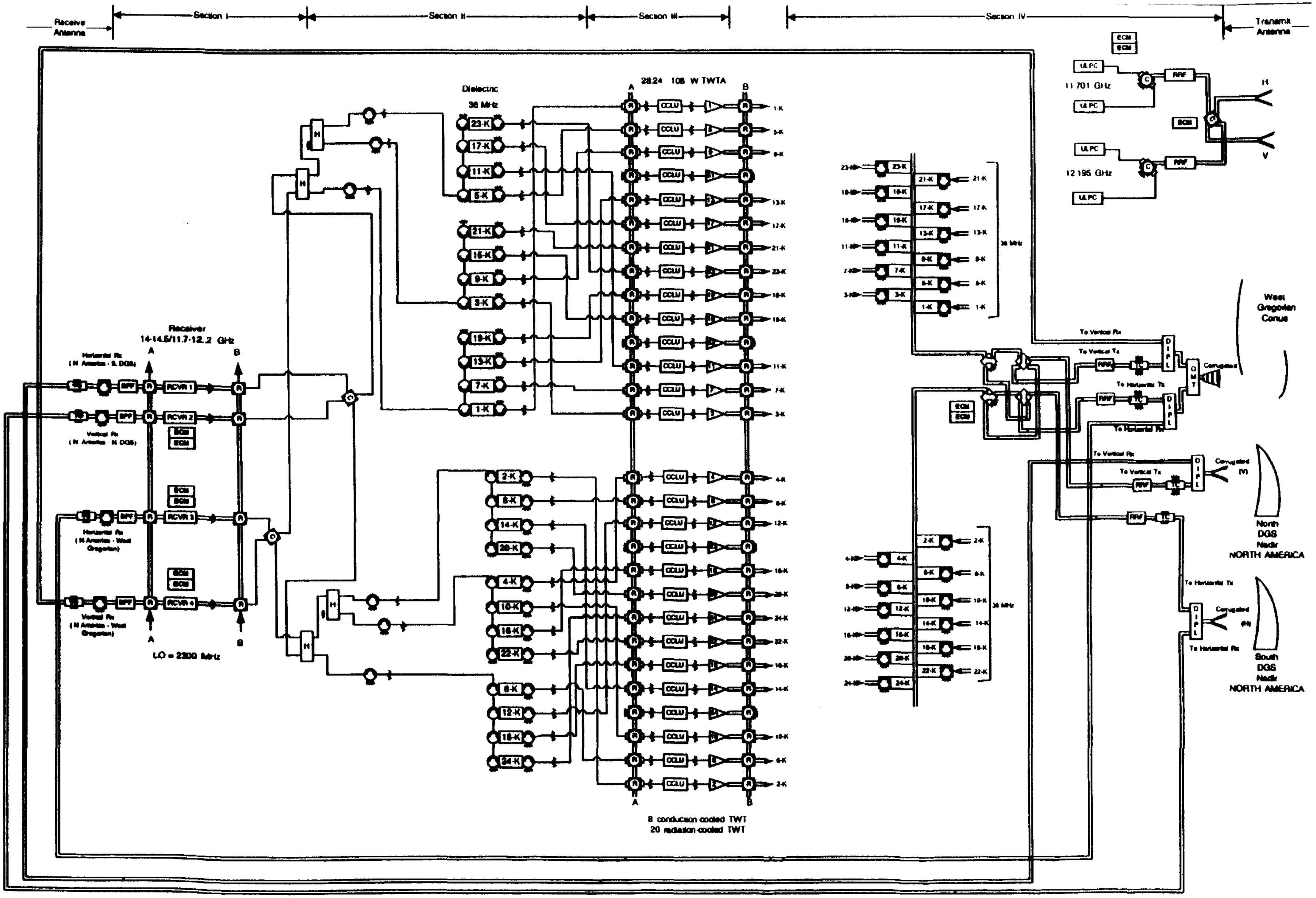
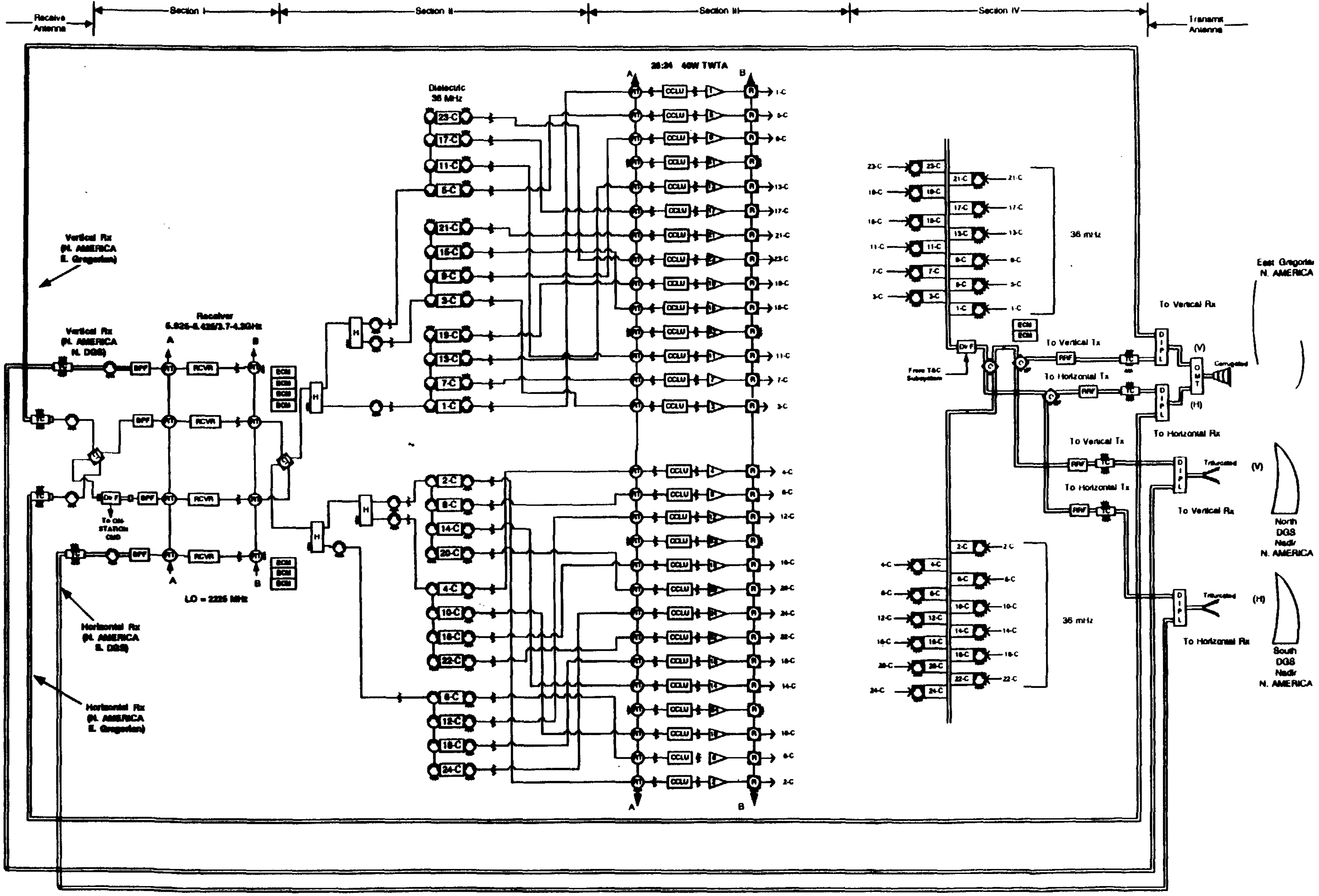


Figure 10. C-Band Subsystem Block Diagram



Redundant wideband receivers will be connected directly to the receive antenna. Each wideband receiver has been designed to have high sensitivity (good noise performance) and low crosstalk coefficients (good linearity characteristics). The high sensitivity is required for detection and amplification of extremely low-level signals received by the satellite from the earth station transmitters. The low crosstalk coefficients are necessary since many separate signals pass through the wide-Band receivers prior to channelization by the narrow bandpass filters. A highly linear receiver is necessary in order to minimize coupling of interference among these signals in the receiver.

The wide-Band receiver will consist of a low noise amplifier followed by a downconverter that will translate the input frequencies to the satellite transmit frequencies without frequency inversion. Variations in net translation frequency over one day will not exceed a total of one part in 10^6, including eclipse effects. Following the downconverter will be a medium-level amplifier that will amplify the translated signals sufficiently to drive the channel amplifier in each transponder.

Following the input filters is a bank of redundancy switches and combining hardware which form the channel amplifier redundancy combining network. Next, the commandable step attenuators provide ground commandable attenuation of up to 16.0 dB in 2 dB increments. Finally, the HPAs output the signals to a redundancy combining network followed by the output multiplexer filters.

Spurious emissions that are beyond the usable bandwidth of each transponder and within the C- and Ku- transmission bands are attenuated by a combination of input and output multiplexer filters. Out-of-band emissions beyond the C- and Ku transmission bands, including harmonics, are attenuated by a combination of the output multiplexer filter and low pass filtering.

h. Satellite Useful Lifetime

The design lifetime of the satellite in orbit (other than with respect to stationkeeping) is 15 years. This has been determined by a conservative evaluation of the effect of the synchronous orbit environment on the solar array, the effect of the charge-discharge cycling on the life of the battery, and the wearout of the amplifiers. The mass allocation of propellant for spacecraft stationkeeping is 15 years. To enhance the probability of survival, spacecraft equipment will be redundant wherever possible. Materials and processes will be selected so that aging or wearing effects will not adversely affect spacecraft performance over the estimated life. The following paragraphs discuss dominant lifetime factors.

(i) Fuel

A conservative mission analysis indicates a 15 year lifetime. The mission has not yet been optimized since the exact sequence of maneuvers will be determined after the actual selection of the launch vehicle. Any remaining spacecraft weight margin can be converted to fuel life.

(ii) Battery

Life testing to date indicates that a longevity of 15 years can be achieved. In order to ensure this longevity, the spacecraft design incorporates the following required provisions: C/20 charge rate at end of life, thermal control during all phases, and proper selection of cell components.

(iii) Solar Array

Predictions concerning the useful life of the solar array are backed by decades of Hughes experience in predicting and measuring in-orbit solar panel performance. These predictions are based on conservative assumptions concerning the radiation environment.

(iv) Electronics

All critical electronics units and components are redundant. There is a 4 for 2 receiver redundancy employed for each communications payload and at least 28 for 24 redundancy rings employed for the power amplifier chains. For other electronic units a minimum of two-for-one redundancy is employed. The electrical design follows well-established criteria regarding parts selection, testing and design, among others.

(v) Non-Electronic

Full redundancy has been employed for non-electronic components wherever possible.

i. Satellite Stationkeeping

Inclination of the satellite orbit will be maintained to +/-0.05 degrees or less, and the satellite will be maintained to within +/-0.05 degrees of the nominal longitude position. Attitude of the satellite will be maintained to an accuracy consistent with the achievement of the specified communications performance, after taking into account all error sources (e.g., attitude perturbations, thermal distortions, misalignments, orbital tolerances, and thruster perturbations).

In addition to the propellant required for operational attitude and orbital control, extra propellant will be incorporated to provide correction of the initial orbit, initial attitude acquisition, and one orbital repositioning maneuver at a drift rate of 1 degree per day. Sufficient propellant will be included in the satellite to permit a 15-year operational life.

j. Telemetry, Command and Ranging ("TC&R")

The telemetry, command and ranging ("TC&R") subsystem will perform the monitoring and command functions necessary for spacecraft control.

(i) Telemetry

The telemetry system will have two identical links consisting of two encoders that modulate either of two transmitters via a cross-strap switch. Data pertaining to unit status, spacecraft attitude, and spacecraft performance will be transmitted continuously for spacecraft management and control. The telemetry transmitter will also serve as the downlink transmitter for ranging tones and command verification. The primary telemetry data mode will be PCM. For normal on-station operation, both of the telemetry transmitters will operate via the bicone antenna.

In transfer orbit, each telemetry transmitter will drive one of the two pipe antennas to provide adequate telemetry coverage. Selection of this high level mode, which may also be used for emergency backup on station, will be by ground command.

(ii) Command

The command system will control spacecraft operation through all phases of the mission by receiving and decoding commands to the spacecraft. Additionally, it will serve as the uplink receiver for ranging signals. The command signals will be fed through a filter diplexer into a redundant pair of command receivers. The composite signal of the receivers' total output will drive a pair of redundant decoders. The decoders will provide command outputs for all satellite functions. The pipe antennas will be used in transfer orbit for command and ranging and the bicone antenna will be used on-station.

(iii) TC&R Performance Characteristics

Telemetry and command summaries are given in Tables 6 and 7. The satellite system requires a command receiver input nominal power of -135 dBW for command execution. With a nominal ground station EIRP of 83.5 dBW, the command threshold requirements are met with margin through the omni and reflector antennas, respectively. See Table 7 for the command link budget. The telemetry link budget for on-station operation is given in Table 8.

Table 6. TT&C- System Parameters

	Spacecraft Antenna	
Parameter	**Omni**	**Reflector**
Command frequency	5925.5 MHz	6415 MHz
Earth station command EIRP (typical)	81.5 dBW	81.5 dBW
Command carrier modulation	PM	PM
Telemetry frequency	4198.125 MHz 4199.4 MHz	4198.125 MHz 4199.5 MHz
Telemetry modulation	PM	PM
Telemetry EIRP (max)	5.0 dBW	5.0 dBW
On-station ranging accuracy	21	21

Table 7. COMMAND BUDGET - SPRING CREEK, NY

PARAMETER	UNIT	OMNI	DISH	PIPE
POL		PERP TO Z AXIS	HORIZONTAL	RHCP
FREQUENCY	MHz	6415	6415	5925.5
TWT POWER	dBW	30.77	30.77	30.77
IFL LOSS	dB	3	3	3
ANTENNA GAIN	dBi	53.7	53.7	53.7
E/S EIRP	dBW	81.47	81.47	81.47
DISPERSION LOSS	dB/m2	162.9	162.9	162.9
LIN TO CIRC LOSS dB	0	0	3	
FLUX DENSITY	dBW/m2	-81.43	-81.43	-84.43
COMM THRESHOLD	dBW/m2	-85	-105	-85
		Performance summary		
MARGIN	dB	3.57	23.57	0.57
RAIN OUTAGE	%	N/A	N/A	N/A

Table 8. Telemetry Link Budget - Filmore, CA.

PARAMETER	UNIT	OMNI	DISH	PIPE	
POL		PAR TO Z AXIS	VERTICAL	RHCP	
TLM 1	MHz	4198.125	4198.125	4198.125	
TLM2	MHz	4199.5	4199.5	4199.5	
EIRP EXPECTED	dBW	5	5	0	
DISPERSION LOSS	dB/m2	163.1	163.1	163.1	
ISOTROPIC AREA	dB-m2	-33.9	-33.9	-33.9	
LINEAR TO CIRC LOSS		dB	0	0	3
GROUND STATION G/T		dB/K	26.8	26.8	26.8
BOLTSMAN'S CONSTANT		dBW/HzK	-228.6	-228.6	-228.6
DOWNLINK C/No	dB/Hz	63.39	63.39	55.39	
DEMODULATOR FACTOR		dB	5	5	5
S/No	dB/Hz	58.39	58.39	50.39	
IMPLEMENTATION LOSS		dB	2.5	2.5	2.5
BIT RATE, 1000 BPS	dBHz	30	30	30	
BIT RATE, 4000 BPS	dBHz	36	36	36	
EB/No, 1000 BPS	dB	25.89	25.89	17.89	
EB/No, 4000 BPS	dB	19.89	19.89	11.89	
Eb/No, BER = 10E-6	dB	11	11	11	
MARGIN, 1000 BPS	dB	14.89	14.89	6.89	
MARGIN, 4000 BPS	dB	8.89	8.89	0.89	
RAIN OUTAGE, 1000 BPS		%	N/A	N/A	N/A
RAIN OUTAGE, 4000 BPS		%	N/A	N/A	N/A
OUTAGE, 1000 BPS	Min/Year	N/A	N/A	N/A	
OUTAGE, 4000 BPS	Min/Year	N/A	N/A	N/A	

k. System Reliability

(1) Satellite

The satellite will be designed for an operational and mission life of 15 years. Mission lifetime is determined primarily by the amount of stationkeeping propellant that can be loaded into the tanks within the allowable launch weight and by the wearout of the TWTAs. To ensure highly reliable performance, TWTA redundancy rings of at least 28 for 24 are provided.

Life and reliability will be maximized by using proven reliability concepts in equipment design. All subsystems and units have a minimum design life of 15 years; standby redundancy is used in the attitude control subsystem and in the communications receivers, and active redundancy is used in the power subsystem. All avoidable single-point failure modes will be eliminated. All components and subsystems will be flight-qualified, and all components will be derated in accordance with design guidelines.

(2) Eclipse Conditions

Eclipse conditions occur when a satellite passes through the earth's shadow. Satellite outages during eclipse conditions are avoided by providing each satellite with sufficient on-board battery capacity to power all required spacecraft and communications payload functions. The battery capacity will be more than adequate to power all amplifiers during eclipses throughout the mission life.

(3) Sun Outages

During predictable twice-yearly periods of approximately eight days, the sun briefly transits the field of view of an earth station pointing at a geostationary satellite. The rise in thermal noise in the earth station receivers caused by the sun's radiation disrupts satellite reception (i.e., causes sun outage). Such disruption of satellite reception is predictable and is well understood by satellite users.

Item E. Performance Requirements and Operational Characteristics

GALAXY X-R is to be a general purpose communications satellite and has been designed to support all of the various services offered within PanAmSat's satellite system. Depending upon the needs of the users, the transponders on GALAXY X-R can accomodate television, radio, voice, or data communications. Typical types of communications services to be offered include:

1. Frequency modulated television (FM-TV).
2. High speed digital data.
3. Digital single channel per carrier (SCPC) data channels carrying wide-Band T1 data.

4. Digital SCPC with data channels carrying 56 Kbps data.
5. Frequency Modulated Audio SCPC (FM Audio SCPC).
6. Compressed Digital Video

The characteristics and associated link analyses for representative C- and Ku-Band services are presented in Appendix A. The link budgets demonstrate that GALAXY X-R will allow all potential services to meet their respective performance objectives while maintaining sufficient link margin.

Item F. Adjacent Satellite Interference Analysis

The interference levels generated between GALAXY X-R and adjacent domestic satellite systems have been examined using PanAmSat's computer programs which have been used in many previous coordinations.

The analyses demonstrate that GALAXY X-R does not generate any more interference than other domestic satellite's previously approved by the Commission. In addition, the sensitivity of GALAXY X-R to adjacent satellite interference is substantially equivalent to that of previously approved satellite systems. No cases occurred where the analysis indicated an incompatibility between specific service types of GALAXY X-R and the adjacent satellites. Any incompatibilities would not be due to the GALAXY X-R design, but rather are a fundamental characteristic of the two-degree spacing environment. Such interference situations will be avoided or minimized through normal coordination arrangements made within the PanAmSat operations department.

In summary, the preliminary interference examination has established that the design of GALAXY X-R is in compliance with the requirements of the Commission for 2-degree spacing.

Item G. Orbital Location

1. Location

PanAmSat respectfully requests that it be assigned the 123° W.L. orbital location for GALAXY X-R. This location is presently occupied by PanAmSat's SBS-5 and GALAXY-IX satellites. GALAXY X-R which is the same satellite as the failed GALAXY X will replace both SBS-5 and GALAXY-IX. The 123° W.L. location satisfies GALAXY X-R's requirements for optimizing coverage, elevation angles, and service availability, and ensures that the maximum operational, economic, and public interest benefits will be derived.

2. Orbital Arc Limitations

GALAXY X-R is intended to provide video, audio, and data services to satellite users in North, South, and Central America. The 123° W.L. position affords reasonable earth station elevation angles, which is important when serving existing users as well as those who will be installing new antennas, and will require no repointing of dishes currently aimed at SBS-5 and GALAXY IX.

PanAmSat proposes to serve North America in both FSS bands (C- and Ku-) from the orbital slot 123° W.L. with GALAXY X-R. The attractiveness of GALAXY X-R to this market would be severely diminished if service to all of these areas is not possible.

3. Service Capabilities

Provided that an orbital assignment to 123° W.L. is made, all C-Band and Ku-Band transponders on GALAXY X-R will be capable of providing commercial-grade service to the targeted service areas. The description of transponders, antenna beams, and other technical parameters are set forth in other portions of this Application.

4. Use of System

GALAXY X-R will continue providing services previously offered by SBS-5 and GALAXY IX with increased service areas in Mexico and Southern Canada. As previously noted, other nearby PanAmSat satellites are an integral part of PanAmSat's GALAXY satellite network and are providing services to thousands of customers in conjunction with GALAXY X-R.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION SUBMITTED IN THIS APPLICATION

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in this Application, that I am familiar with Part 25 of the Commission's Rules, that I have prepared the engineering information submitted in this Application, and that it is complete and accurate to the best of my knowledge. I am a registered Professional Engineer in Washington, D.C. and my seal is shown below.

By: ______________________________

Philip A. Rubin
Chief Scientist
PanAmSat

PHILIP A. RUBIN
No. 10087

Appendix A. Technical Characteristics And Link Analyses

This section presents the technical characteristics and associated link analyses for a representative sampling of services which the GALAXY X-R satellite may be used to support. The link analyses demonstrate that the GALAXY X-R satellite allows all of the potential services to achieve their respective performance objectives while maintaining sufficient link margin.

The following assumptions and models were used in the link analyses:

1. Earth Station and Satellite Locations

In the sample link budgets, earth stations (uplink and downlink) are assumed to be located within the edge of coverage, and the satellite is at an assumed position of 123° W.L.

2. Rain Effects

For the Ku-Band services, performance for clear weather, uplink rain and downlink rain conditions were calculated. For C-Band services, only clear weather performance was calculated since rain attenuation is relatively insignificant at C-Band frequencies. North American rain attenuation predictions were derived using the rain model developed by R.K. Crane.[1] The predicted rain attenuation levels are dependent upon many factors including signal frequency, earth station location, and required link availability. In conditions of downlink rain, the link is degraded by both link attenuation as well as by an increase in the noise temperature of the receiving earth station. Both these factors are included in the link analyses.

3. Cross-Polarization Interference

The satellite antenna cross-polarization isolation is [30 dB] or greater for both transmit and receive signals over the coverage regions. The earth station cross-polarization isolation values are assumed to be 35 dB for transmit and receive antennas larger than 1.2 meters and 30 dB for antennas smaller than 1.2 meters.

The link cross-polarization isolation value for channels of opposite polarization is calculated by power summing the earth station and satellite antenna polarization isolation values as modified by the depolarization effects of rainfall. The rainfall depolarization factors are a function of frequency, rain attenuation, incident wave polarization, and elevation angle. The values used in the link budgets were calculated using the procedure described in CCIR Report 722.

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[1] Predictions of Attenuation by Rain, Robert K. Crane, IEE Trans. on Communication, Vol. COM-28, No. 9, September 1980, pp. 1717-1733.

In the link analyses, the cross-polarized interference signal is assumed to be identical to the desired signal. The resulting carrier-to-cross-polarized interference ratio is simply the composite link cross-polarization isolation value described above.

4. Intermodulation Interference

The values used for C/IM have been derived from a combination of laboratory measurements and computer simulations for those traffic modes in which several carriers are transmitted through a transponder.

5. Adjacent Satellite Interference

The model used for the calculation of potential interference into the GALAXY X-R satellite from adjacent satellites assumes a "worst case" constellation of homogeneous satellites at two-degree spacing.

For the Ku-Band analysis, each satellite of the constellation is assumed to be co-polarized with the GALAXY X-R satellite and to have an EIRP of 51 dBW. The adjacent satellites are assumed to be carrying traffic uplinked from a 2.4 meter antenna. Finally, for a worse case analysis, it is assumed adjacent satellite transponders are operated at saturation.

For the C-Band analysis, each satellite of the constellation is assumed to be cross-polarized with the GALAXY X-R satellite and to have a maximum EIRP of 44.2 dBW. The adjacent satellites are assumed to be carrying FM-TV traffic uplinked from a 9.2 meter antenna. It is assumed that the adjacent satellite transponders are operated at saturation.

A single-entry carrier-to-interference ratio (both on the uplink and on the downlink) is calculated for one of the closest adjacent satellites. All earth station antennas are assumed to comply with the current FCC sidelobe envelope requirement of [29 - 25 log θ] for off-axis performance. The single-entry carrier-to-interference ratio value is decreased by 4 dB to account for the interference contributions of all other adjacent satellites. The above assumptions, when compounded, result in a conservative estimate of adjacent satellite interference.

Table A.1

C-BAND
FM-TV ANALOG VIDEO

Transmission Characteristics	
Signal Characteristic	TV FM Analog Video
Modulation	NTSC
Video Bandwidth	4.2 MHz
Peak FM Deviation	10.75 MHz
Pre emphasis and weighting	12.8 dB
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Single Carrier Saturated EIRP (EOC)	40.5 dBW
Aggregate Output Back Off	0.0 dB
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	3.7m
Earth Station G/T	22dB/K
Performance Objectives	
Minimum Required C/N	10.0 dB
Net C/(N+I)	13.0 dB
SNR	51.0 dB
Excess Link Margin	3.0 dB

Table A.2

C-BAND
MCPC
(45 Mbps)

Transmission Characteristics	
Signal Description	Digital MCPC
Info Rate	45358 kbps
Modulation	QPSK
Code Rate	R7/8
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Single Carrier Saturated EIRP (EOC)	40.5 dBW
Carrier Output Back Off	0.0 dB
EIRP per Carrier	40.5dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	3.7m
Earth Station G/T	22.0dB/K
Performance Objectives	
Minimum Required C/N	8.4 dB
Net C/(N+I)	14.0 dB
Excess Link Margin	5.6 dB

Table A.3

C-BAND
SCPC
(3.0 Mbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	3000 kbps
Modulation	QPSK
Code Rate	R2/3
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Satellite Saturated EIRP (EOC)	40.5 dBW
Carrier Output Back Off	-22.0 dB
EIRP per Carrier	26.5dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	3.7m
Earth Station G/T	22dB/K
Performance Objectives	
Minimum Required C/N	5.8 dB
Net C/(N+I)	5.8 dB
Excess Link Margin	0.0 dB

Table A.4

C-BAND
SCPC
(56 kbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	56 kbps
Modulation	QPSK
Code Rate	R1/2
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Satellite Saturated EIRP (EOC)	40.5 dBW
Carrier Output Back Off	-18.4dB
EIRP per Carrier	26.1
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	3.7m
LNAEarth Station G/T	22.0 dB/K
Performance Objectives	
Minimum Required C/N	5.8 dB
Net C/(N+I)	-6.8 dB
Excess Link Margin	-1.0 dB

Table A.5

C-BAND
SCPC
(1.544 Mbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	1544 kbps
Modulation	QPSK
Code Rate	R3/4
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Satellite Saturated EIRP (EOC)	40.5 dBW
Input Back Off (Output Back Off)	8.0 dB (4.6 dB)
Transmit Earth Station	
Antenna Diameter	3.7m
Receive Earth Station	
Antenna Diameter	3.7m
LNA Noise Temperature	45 deg K
Performance Objectives	
Minimum Required C/N	10.1 dB
Net C/(N+I)	10.1 dB
Excess Link Margin	0.0 dB

Table A.6

C-Band
VSAT
(128kbps)

Transmission Characteristics	
Signal Description	VSat
Info Rate	128 kbps
Modulation	BPSK
Code Rate	R1/2
Transponder Characteristics	
Frequency	3.940 GHz
Bandwidth	36.0 MHz
G/T	-0.5 dB/K
Satellite Saturated EIRP (EOC)	40.5 dBW
Carrier Output Back Off	-31.8dB
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	3.7m
Earth Station G/T	22.0dB/K
Performance Objectives	
Minimum Required C/N	2.6 dB
Net C/(N+I)	3.6 dB
Excess Link Margin	1.0 dB

Table A.7

Ku-BAND
FM-TV ANALOG VIDEO

Transmission Characteristics	
Signal Characteristic	TV FM Analog Video
Modulation	NTSC
Video Bandwidth	4.2 MHz
Peak FM Deviation	10.75 MHz
Pre emphasis and weighting	12.8 dB
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Single Carrier Saturated EIRP (EOC)	49.0 dBW
Aggregate Output Back Off	0.0 dB
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	1.8m
Earth Station G/T	23.0 dB/K
Performance Objectives	
Minimum Required C/N	10.0 dB
Net C/(N+I)	14.0 dB
SNR	52.1 dB
Excess Link Margin	4.0 dB

Table A8

Ku-BAND
MCPC
(45 Mbps)

Transmission Characteristics	
Signal Description	Digital MCPC
Info Rate	45358 kbps
Modulation	QPSK
Code Rate	R7/8
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Single Carrier Saturated EIRP (EOC)	49.0 dBW
Carrier Output Back Off	0.0 dB
EIRP per Carrier	49.0 dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	2.4 m
Earth Station G/T	25.7 dB/K
Performance Objectives	
Minimum Required C/N	8.4 dB
Net C/(N+I)	15.0 dB
Excess Link Margin	6.6 dB

Table A.9

Ku-BAND
SCPC
(3.0 Mbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	3000 kbps
Modulation	QPSK
Code Rate	R2/3
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Satellite Saturated EIRP (EOC)	49.0 dBW
Carrier Output Back Off	-15.4 dB
EIRP per Carrier	33.6 dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	2.4 m
Earth Station G/T	25.7 dB/K
Performance Objectives	
Minimum Required C/N	5.8 dB
Net C/(N+I)	8.2 dB
Excess Link Margin	2.4 dB

Table A.10

Ku-BAND
SCPC
(56 kbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	56 kbps
Modulation	QPSK
Code Rate	R1/2
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Satellite Saturated EIRP (EOC)	40.5 dBW
Carrier Output Back Off	-30.4 dB
EIRP per Carrier	18.6 dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	1.8 m
LNAEarth Station G/T	23.0 dB/K
Performance Objectives	
Minimum Required C/N	6.8 dB
Net C/(N+I)	8.2 dB
Excess Link Margin	1.4 dB

Table A.11

Ku-BAND
SCPC
(1.544 Mbps)

Transmission Characteristics	
Signal Description	Digital SCPC
Info Rate	1544 kbps
Modulation	QPSK
Code Rate	R3/4
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Satellite Saturated EIRP (EOC)	49.0 dBW
Carrier Output Back Off	15.9 dB
EIRP per Carrier	33.1 dBW
Transmit Earth Station	
Antenna Diameter	4.6 m
Receive Earth Station	
Antenna Diameter	2.4 m
Earth Station G/T	25.7 dB/K
Performance Objectives	
Minimum Required C/N	10.1 dB
Net C/(N+I)	11.4 dB
Excess Link Margin	1.3 dB

Table A.12

Ku-Band
VSAT
(128kbps)

Transmission Characteristics	
Signal Description	VSat
Info Rate	128 kbps
Modulation	BPSK
Code Rate	R1/2 (Seq + RS)
Transponder Characteristics	
Frequency	11.94 GHz
Bandwidth	36.0 MHz
G/T	2.2 dB/K
Satellite Saturated EIRP (EOC)	49.0 dBW
Carrier Output Back Off	-24.2 dB
EIRP per Carrier	24.8 dBW
Transmit Earth Station	
Antenna Diameter	4.6m
Receive Earth Station	
Antenna Diameter	1.2m
Earth Station G/T	19.4 dB/K
Performance Objectives	
Minimum Required C/N	2.6 dB
Net C/(N+I)	4.1 dB
Excess Link Margin	1.5 dB

Exhibit R

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January 14, 2000

EX PARTE

Magalie R. Salas, Secretary
Federal Communications Commission
The Portals Building
445 12th Street, SW TW-A325
Washington, D.C. 20554

ET Docket No. 98-206

Dear Ms. Salas:

PanAmSat Corporation ("PanAmSat") hereby submits the enclosed reply comments on an ex parte basis.

Sincerely,

Joseph A. Godles
Attorney for PanAmSat
Corporation

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List A B C D E

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

In the Matter of	)	
	)	
Amendment of Parts 2 and 25 of the	)	ET Docket No. 98-206
Commission's Rules to Permit Operation	)	
Of NGSO FSS Systems Co-Frequency with	)	
GSO and Terrestrial Systems in the Ku-Band	)	
Frequency Range	)	

REPLY COMMENTS OF PANAMSAT CORPORATION

Joseph A. Godles
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January 14, 2000

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Before the
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Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Parts 2 and 25 of the	)	ET Docket No. 98-206
Commission's Rules to Permit Operation	)	
Of NGSO FSS Systems Co-Frequency with	)	
GSO and Terrestrial Systems in the Ku-Band	)	
Frequency Range	)	

REPLY COMMENTS OF PANAMSAT CORPORATION

The comments filed in response to the Commission's December 6th Public Notice demonstrate that NGSO/GSO sharing has been and continues to be controversial. While all parties agree that the CPM compromise should form the basis for the Commission's domestic regulation of Ku-band NGSO systems, the parties disagree - in some cases sharply - about the scope of that regulation.

In essence, the dispute turns on whether the Commission should take a passive or an active role in assuring compliance with the CPM compromise. In the view of GSO operators and some NGSO applicants, the Commission should take an active role, implementing and enforcing the CPM compromise in a way that will ensure that NGSO operators, both individually and collectively, live up to each of the obligations they have agreed to accept. In contrast, in the view of some NGSO applicants, the Commission should take a passive role, authorizing systems without first determining whether they can operate as their proponents contend and waiting to see if disaster strikes before taking any meaningful action.

In light of the divergent views expressed in the comments, PanAmSat is submitting this reply to clarify its proposed rules and to respond to specific objections made by SkyBridge, Boeing, and Loral.

I. SUMMARY

Several core considerations should guide the Commission in its analysis of the comments and its development of NGSO licensing, technical, and service rules:

- GSO FSS systems have primary status in the Ku-band and already exist. GSO satellite operators and end users have invested vast sums in these systems, and billions of users in the United States and around the world rely upon the communications services they support.
- NGSO systems are new, untested, and tremendously complex. Their ability to meet the CPM masks and limits depends on technically intricate, and as yet unverified, design and operational considerations.
- The CPM compromise is the result of years of negotiations and studies. Each element of the compromise is essential and must be implemented and enforced in a way that assures its integrity.

Based upon these considerations, PanAmSat submitted to the Commission a series of recommendations for implementing the CPM compromise. Briefly stated, PanAmSat discussed the need for a pre-licensing demonstration by each NGSO applicant that it can comply with the Additional Operational Limits (administered by the FCC) and with the Aggregate Limits (administered by the ITU BR). In addition, PanAmSat discussed the need for a meaningful, post-licensing process to enforce compliance with the Operational Limits. Finally, PanAmSat highlighted the absence of aggregate interference limits and discussed the implications of this gap on the Commission's licensing process.

Three of the NGSO proponents – SkyBridge, Boeing, and Loral – took exception to PanAmSat's proposals.[1] These entities argued that PanAmSat's proposals are unneeded, unworkable, and overly expensive, and would require the disclosure of proprietary information. As a result, they contended, the Commission should simply accept commitments from the applicants that their systems will meet the Operational Limits and the Additional Operational Limits, but should require no supporting information to verify either of those assertions.

For the reasons discussed herein, the Commission should reject the NGSO's recommendations and exert its regulatory authority in a way that does not defer action until it is too late.

II. THE VALIDATION LIMITS

The parties generally agree that the ITU should be the primary forum for determining whether a proposed system meets the validation limits. As long as verification is part of the initial filing process, and provided that an open process is used that allows individual Administrations to confirm compliance, the FCC need not duplicate the ITU's efforts.

SkyBridge proposes in its comments that, if an NGSO applicant or licensee changes its system's characteristics after the ITU has determined that the system complies with the validation limits, the licensee would be required to notify the FCC of the changes only if they would cause the system to perform outside the envelope defined by the initial parameters.[2] PanAmSat could accept this somewhat limited notification proposal (as opposed to an across-the-board notification requirement) as long as: (1) in such cases, the NGSO then is required to demonstrate that it still complies with the validation limits and the additional operational limits; and, (2) both the notification of changes and the

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[1] These parties were responding to an earlier PanAmSat submission, which described in a more summary fashion PanAmSat's recommended implementation of the CPM compromise.

[2] SkyBridge Comments at 14.

demonstration of continued compliance be put on Public Notice for comment by potentially affected parties.

III. THE ADDITIONAL OPERATIONAL LIMITS.

For GSO operators, the Additional Operational Limits (also referred to as the Operational Masks) are a critical component of the CPM compromise and the key means for protecting GSO FSS systems. Without these limits – or if these limits are not subject to meaningful, effective enforcement – there is no compromise.

As even the NGSO proponents concede, post-licensing enforcement of the Additional Operational Limits will be elusive at best and impossible at worst. SkyBridge and Loral, for example, both agree that it will be difficult to verify by measurement whether a system is in compliance with the Additional Operational Limits.[3] Moreover, as the comments of several NGSO proponents reflect, it is possible to make a pre-licensing compliance assessment.[4]

In light of the above considerations, and taking into account the central importance of the Additional Operational Limits, PanAmSat has proposed that the Commission require each NGSO license applicant to show compliance with the Additional Operational Limits before it could be licensed. Specifically, each applicant would be required to make a demonstration, with supporting information, consisting of:

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[3] SkyBridge Comments at 17; Loral Comments at 7.

[4] Boeing Comments at 5 ("Boeing could provide prior verification that its system meets operational limits..."); Virtual Geo Comments at 4 ("Virtual Geo would support a Commission-developed rule that would require non-GSO FSS systems to demonstrate their ability to meet all of the agreed validation and operational limits prior to receipt of any authorization."); see also Lockheed Martin Comments at 8 ("the Commission must develop rules that require each applicant for a Ku-band non-GSO FSS system to demonstrate, as a prerequisite to the issuance of any authorization, that its system will in fact comply with all applicable ITU limits."). Lockheed Martin is an applicant for an NGSO system in the Commission's second Ka-band processing round. Moreover, as discussed *infra*, both SkyBridge and Loral state that they will conduct an internal simulation to determine compliance with the Additional Operational Limits.

- a set of maps illustrating the geographic distribution of the maximum $\text{EPFD}_{\text{down}}$ levels within the United States; and,
- a means for determining the time distribution of $\text{EPFD}_{\text{down}}$ levels at any specific location in the United States.

Both types of information could be produced by means of software simulations, using software supplied by the NGSO applicant.[5] The Commission could establish a domestic industry study group to recommend a detailed set of requirements for the development of Additional Operational Limits verification software. Each NGSO applicant then would develop and present its own software (or, alternatively, the NGSO applicants could agree on a common software tool) for assessing compliance with the Additional Operational Limits.

The individualized approach proposed by PanAmSat is flexible: it gives each NGSO operator a choice between modeling its system to permit a wide variety of operational parameters and bounding specific aspects of the system. The more closely the model mirrors actual anticipated operations, the easier it will be for the NGSO system to comply with limits; at the same time, such a model will contain fewer options for future variations. In either case, the Commission and GSO operators will have a reasonable basis for determining whether a particular system, with particular operational parameters, will meet the Additional Operational Limits.

A. Additional Operational Limit Maps Are a Crucial Component of a Successful Sharing Regime.

The inclusion of the map requirement was intended to serve two purposes. First, the maps will demonstrate whether an NGSO applicant will

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[5] The NGSO applicant would be required to make available for public inspection and comment its software source code and all justifications and assumptions employed as part of its demonstration. Unless chosen by an NGSO applicant, the ITU BR Validation Limits software would not be used to determine compliance with the Additional Operational Limits.

comply with the Additional Operational Limits at each geographic location within the United States.

This type of pre-licensing demonstration is critical to an evaluation of whether NGSO systems can, in fact, operate within the limits.[6] Modifications and adjustments become substantially more difficult to require – both as a technical and a practical, political matter – once an NGSO system has been built and launched. Moreover, as noted above, there is as yet no way to measure an NGSO system's actual, operational compliance with the Additional Operational Limits. Hence, NGSO applicants' commitment to meet these limits once in operation is an empty promise: if there is no pre-launch assessment, there will be no assessment whatsoever.

A pre-licensing demonstration also is necessary to provide the Commission with an adequate basis for representations it must make to the ITU. As part of an NGSO satellite filing, the Commission must commit to the ITU that, when in service, each proposed NGSO system will meet the Additional Operational Limits.[7] It is difficult to envision how the Commission can make such a commitment if it lacks a reliable post-licensing measurement technique and does not require a pre-licensing demonstration of compliance.

The imposition of a pre-licensing "check," moreover, is particularly appropriate given the number of pending Ku-band NGSO systems (8) and the maximum number of systems that can be accommodated in this spectrum (3.5). The Commission has an obligation to use engineering solutions and threshold qualifications to avoid mutual exclusivity among the NGSO applicants.[8] Under these circumstances, it would be inappropriate for the Commission to license

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[6] Because the Validation Limits are inadequate to protect GSO systems, a demonstration of compliance with the Validation Limits cannot serve as a substitute for a pre-licensing demonstration of compliance with the Additional Operational Limits.

[7] CPM Report § 3.1.2.1.4(c).

[8] 47 U.S.C. § 309(j)(6)(E).

some but not all systems without first investigating whether each licensed system will be able to satisfy the CPM compromise's requirements.

In addition to making possible an evaluation of an NGSO system's ability to operate within the Additional Operational Limits, the map requirement will serve a second, related purpose: providing a much-needed tool for establishing where worst-case interference levels will occur and, as a result, making it possible for a GSO operator to determine which GSO links will require additional margin in order to achieve adequate protection.

A reliable means of predicting actual NGSO interference patterns is needed because the Additional Operational Limits will not provide protection against NGSO interference for all GSO links. There is no disagreement over this point in the ITU-R. Papers submitted by IntelSat [WP 4A(99)/371], PanAmSat [WP 4A(99)/329, CPM99/138] and France [WP 4A(99)/276] all demonstrated that the Additional Operational Limits will not protect all GSO links. In particular, as discussed in PanAmSat's comments, links in drier Rain Zones (such as in the western half of the United States) generally will not include enough margin to protect against the possible additional interference caused by some NGSO systems.

Without maps, GSO operators would have to assume that maximum $EPFD_{down}$ levels could occur anywhere, and would have to provide additional margin to all links in sensitive climatic regions in order to be sure of protecting the truly "at risk" links. This would represent a profoundly inefficient use of spectrum and would impose an unwarranted burden on GSO operators and end users. Use of the maps, in contrast, could produce a significant improvement in efficient use of the spectrum that could translate into financial savings to GSO operators and end users.

An example of the type of map proposed by PanAmSat is shown in Figure 1. This map assumes a fully loaded system, and an envelope of all scheduling algorithms. It is worth noting that, even with these maximum case assumptions, there is a significant geographic variation in the maximum EPFD$_{\text{down}}$ level, including variation in the more arid regions that require the most protection.

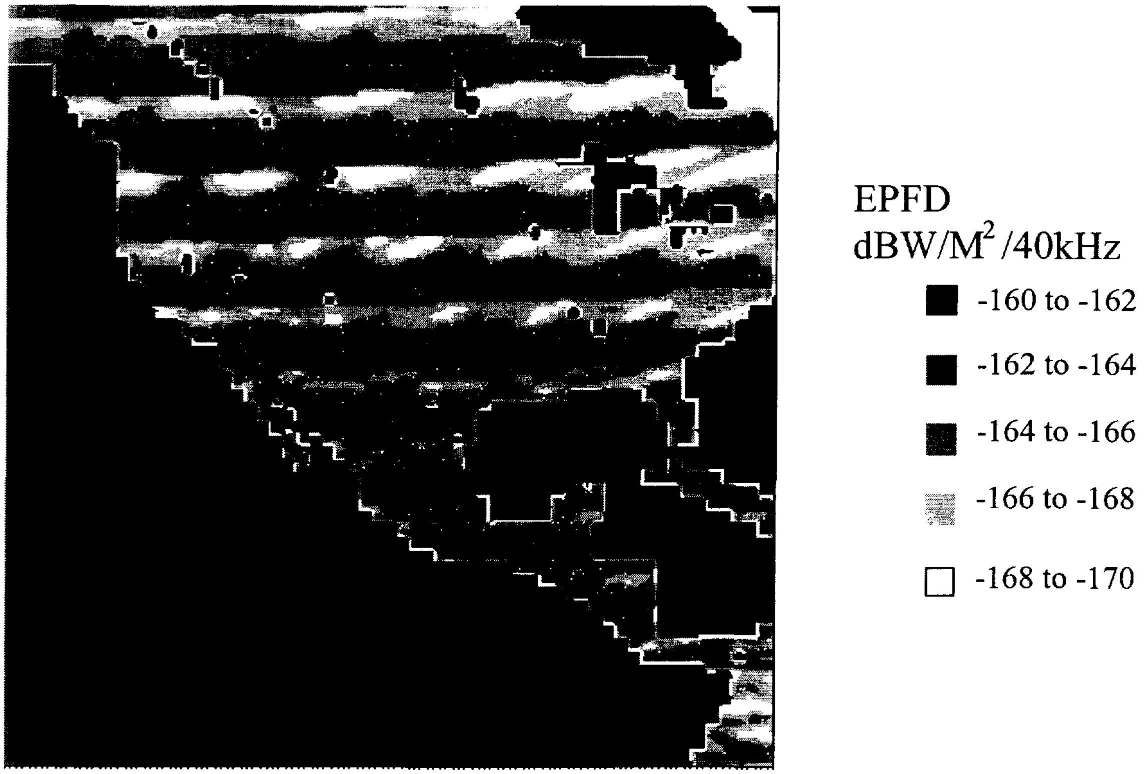

Figure 1. In-line maximum EPFD levels of F-SAT-MULTI-1B for fixed cells on the ground and for a specific Geostationary Satellite Orbit location.

The generation of the maps, moreover, should require little effort on the part of each NGSO applicant and will impose no additional restrictions on the operations of NGSO systems. The fundamental requirement for the generation of the maps is an accurate representation of the NGSO system's operation and its parameters. With that information, it is possible to develop, by means of well-accepted computer algorithms that simulate orbital mechanics and interference considerations, a computer program that can produce the requisite maps. As a demonstration of the level of effort involved, PanAmSat is submitting a proposed draft new recommendation to ITU-R working party 4A, which describes the procedures for generating these maps.

PanAmSat recognizes that the geographic distribution of maximum $\text{EPFD}_{\text{down}}$ levels for a specific NGSO network likely will change over time due to changes in the system's scheduling algorithms and traffic loading. NGSO applicants, however, can compensate for those changes by having the maps represent the envelope of maximum $\text{EPFD}_{\text{down}}$ levels that could occur over the life of the NGSO system. As discussed above, it would be up to each individual NGSO applicant to decide on an appropriate tradeoff between flexibility and ease of demonstrating compliance.

B. Enforcement of the Additional Operational Limits Also Must Take Into Account the Time Distribution of an NGSO System.

NGSO interference levels will be different at each specific point on the earth's surface. Moreover, as time passes the instantaneous level of interference at each earth point will vary.

The Additional Operational Limits do not merely limit $\text{EPFD}_{\text{down}}$ levels at any moment in time, they also set an upper bound the level of these emissions over time. As a result, it is imperative that some means be provided to verify that those limits can be met over time.

The Time Distribution software proposed by PanAmSat would serve this function. Without a means for determining the time distribution of $\text{EPFD}_{\text{down}}$ levels at any specific location in the United States, a key component of the Additional Operational Limits will be lost.[9]

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[9] The Additional Operational Limit Maps discussed above will be "snapshots" of interference levels, indicating what the highest level of interference will be at each point. They will not, however, provide a means for assessing a system's ability to meet the time duration limits over time at each point within the United States. As a result, they are necessary but not adequate to enforce the Additional Operational Limits.

C. The Objections To PanAmSat's Proposals For Enforcing the Additional Operational Limits Should Be Rejected.

1. The Proposed Demonstration Will Not Impose An Unreasonable Burden on NGSO Applicants.

While Boeing contends that PanAmSat's proposal for NGSO interference maps would be "unduly burdensome,"[10] this claim does not withstand scrutiny.

Both SkyBridge and Loral state that they would prepare "detailed simulations of [their] constellations, employing actual operational parameters" and use these simulations to determine, prior to licensing, their ability to comply with the Additional Operational Limits.[11] These determinations then would form the basis for their proposed certifications to the Commission that they could meet the Additional Operational Limits once in service.[12]

Presumably, these NGSO licensees also would revise their simulations to reflect modified operating parameters. Absent such revised assessments, they could not in good faith satisfy their compliance commitment to the Commission or ensure they were continuing to operate consistent with ITU and FCC requirements.

Thus, while SkyBridge and Loral protest that computer simulations modeling compliance with the Additional Operational Limits should not have to be provided to the Commission, neither they nor Boeing reasonably can claim that the simulations themselves are too difficult to perform, or that the products they generate are too difficult to produce.

Moreover, Boeing's claim that much of the alleged burden will arise from the fact that "[d]isagreements are bound to arise over the parameters of the

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[10] Boeing Comments at 7.

[11] SkyBridge Comments at 17; Loral Comments at 4 (chart), 7.

software and standards to be used to determine compliance"[13] confirms – rather than refutes – the need for a pre-licensing demonstration. Uncertainty about how to measure compliance is the principal reason why the question of how to determine compliance and how to resolve disputes cannot be deferred until after NGSO systems have been launched and placed into operation. The fact that the details of verification have not been resolved should be cause for action, not a justification for inaction.

2. Changes in Loading and Switching Algorithms Will Not Render The Maps Unreliable.

SkyBridge also claims that maps showing "worst case" locations for NGSO interference would be unreliable because changes in a system's loading and switching algorithms also would change the maps and render previously-provided maps outdated.[14]

PanAmSat acknowledges that NGSO network configurations will change over time. For that reason, PanAmSat proposed that the maps should represent an envelope of $\mathrm{EPFD_{down}}$ levels over the life of the NGSO system. NGSO systems, such as SkyBridge's, naturally will have a variation in maximum $\mathrm{EPFD_{down}}$ levels based on latitude, distance from the nearest NGSO gateway, and elevation angle from the GSO ground station to the supporting GSO spacecraft. PanAmSat recognizes that maximum loading in conjunction with an envelope of normal switching algorithms will provide a somewhat pessimistic result. Even with this limitation, however, PanAmSat believes that having an upper bound is much more useful for determining specific protection requirements than any proposed alternative.

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[12] Id. SkyBridge also agrees that, in the event a "credible" claim of a rule violation was made, the Commission could require the NGSO licensee to provide its simulations to the Commission. Id. at 18.

[13] Boeing Comments at 5.

[14] SkyBridge Comments at 17, 18, 19; see also Loral Comments at 7.

3. Loading and Switching Information Should Not Be Deemed Proprietary.

SkyBridge also claims that loading and switching information is proprietary and, therefore, cannot be disclosed.[15] SkyBridge, however, fails to explain the basis for its conclusion that this data is entitled to protection as proprietary information.

SkyBridge's conclusion, moreover, is unwarranted. The traffic loading and switching information that PanAmSat has proposed be disclosed need not include any specific end user location, traffic pattern, carrier usage or other similarly sensitive marketing information. Switching algorithms generally are not considered unique and, even if they were, are not the kind of information that affords any marketing or technological advantage.

The only new information that might be revealed as a result of the disclosures proposed by PanAmSat would be the aggregate level of traffic that an NGSO cell might experience. Considering that the specific cell area would be public information and the marketing potential for the served population could be ascertained by other means, it is difficult to understand what could be proprietary about the aggregate traffic information.

Indeed, the Commission's rules already require satellite operators, when filing applications for space station licenses, to provide similar information to the Commission in order to enable affected parties to evaluate the potential for interference.[16] These requirements initially were developed to facilitate GSO-to-GSO interference analysis. With the advent of NGSO operations, it would be appropriate for the Commission to update its rules to require NGSO operators to provide equivalent information and, thus, make it possible for GSO operators to conduct an NGSO-to-GSO interference determination.

Similarly, during coordination discussions satellite operators routinely are required to provide comparable data to the other parties to the coordination. NGSO applicants should be bound by similar information sharing requirements.

Finally, in the unlikely event that a particular subset of the data described by PanAmSat can be shown by a preponderance of the evidence to be proprietary, the NGSO applicant submitting that data may seek confidential treatment under Section 0.459 of the Commission's rules. The possibility that some data may be proprietary, however, does not warrant eliminating an effective method for pre-licensing determinations of compliance.

4. The ITU-R Has Not Rejected PanAmSat's Proposal.

SkyBridge also claims that PanAmSat's proposal for the mandatory submission of EIRP maps was "extensively discussed and rejected" within the ITU-R process.[17] SkyBridge is incorrect.

While there was discussion of this topic in the corridors during some of the CPM meetings, there never has been a formal debate on the concept, either at the CPM or by the ITU. The only rejection of the idea of which PanAmSat is aware occurred during private discussions with SkyBridge. At that time, PanAmSat offered the concept as part of a plan that would have allowed SkyBridge to meet the EPFD limits then being proposed by the United States on a limited part of the earth's surface. SkyBridge's rejection of this proposal, however, in no way constitutes an ITU rejection of the concept of EIRP maps. Indeed, the idea of requiring such maps, when informally proposed to other administrations and INTELSAT, has been well received.

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15 SkyBridge Comments at 17, 18.

[16] 47 C.F.R § 25.114.

[17] SkyBridge Comments at 20.

On a related note, SkyBridge claims that the PanAmSat proposals are inconsistent with the CPM consensus. However, the CPM "agreed that it is essential to develop as a matter of urgency recommendations to permit administrations to check compliance with the Additional Operational Limits."[18]. PanAmSat's proposals are designed to achieve exactly this objective and, thus, are fully consistent with the CPM's express conclusions.

5. The Proposed Demonstration Will Provide Necessary Protection To GSO Operators and Users.

Boeing's claim that PanAmSat's proposed demonstration "would provide no additional protection for GSO networks or their users"[19] is simply wrong. As discussed above, there currently is no way to measure compliance with the Additional Operational Limits; as a result, if pre-licensing computer simulations are not required, these essential limits will be reduced to a paper obligation with no real effect. Moreover, the maps proposed by PanAmSat will enable GSO operators and users to plan rationally for cases of extreme NGSO interference rather than squandering scarce satellite power on all potentially affected sensitive links. These benefits clearly justify the minimal effort the obligation to run a computer simulation would require of NGSO applicants.

6. The Commission's Existing Remedies Are Not Adequate.

Boeing also contends that a pre-licensing compliance determination is unnecessary because the Commission has available to it adequate post-launch enforcement mechanisms.[20] This claim ignores the difficulties inherent in demonstrating operational compliance with the Additional Operational Limits, as well as the problem of effective enforcement inherent in any post-licensing enforcement process. Moreover, it would shift onto GSO users and operators the burden of uncertainty; under any post-launch enforcement approach, GSO

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[18] CPM Report, Section 3.1.2.1.4 (c).

[19] Boeing Comments at 7.

operators and users will have to operate in an information vacuum and, in the event of NGSO interference, will have to suffer the consequences of that interference while evidence is collected, the source of the interference is isolated and, perhaps, even while the dispute is being resolved.

7. GSO/FS and NGSO/GSO Sharing Situations Are Not Comparable; As a Result, NGSO/GSO Sharing Rules Should Not Mirror GSO/FS Sharing Rules.

SkyBridge attempts to justify reliance solely upon licensee certifications of compliance on the ground that the FCC uses similar certifications to ensure GSO compliance with FS sharing rules.[21]

The GSO FSS and FS services, however, have a long history of spectrum sharing, and the technical criteria used to ensure successful sharing are well understood and time tested. As a result, in the GSO/FS context, the Commission appropriately imposes on licensees the condition that they comply with frequency tolerance and emission limitations, rather than measuring or validating compliance prior to licensing.

The situation with respect to NGSO/GSO sharing is markedly different. NGSO systems are novel and never before have been operated. Neither the EPFD limits nor the methodologies NGSO operators will use to comply with those limits have ever been demonstrated, in operation, to be achievable or adequate. Indeed, the entire CPM compromise requires, to a significant extent, a leap of faith by GSO operators and the billions of users who rely on their services. In such an unsettled context, it would not be appropriate to rely on license conditions without also performing some assessment of whether a licensee actually can satisfy those conditions.

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[20] Boeing Comments at 6.
[21] SkyBridge Comments at 18.

D. The Commission Should Not Rely on The ITU To Develop Methods for Determining Compliance With the CPM Compromise Limits and Masks.

Loral proposes that the Commission defer to the ITU on the questions of how to determine compliance with the Additional Operational Limits.[22] PanAmSat opposes this proposal.

The ITU, while important, cannot replace the Commission in determining rules and processes that serve the specific needs of the United States. These needs should include the consideration that the United States has a large percentage of its land mass within low rain zone areas and those areas are more sensitive to NGSO interference. Although PanAmSat intends to participate in the ITU's process, it cannot be preordained that the results of this process will be sufficient. Accordingly, the Commission should - as it has in other situations - augment the ITU outputs with regulatory and technical performance criteria that expand upon the ITU recommendations.[23]

Moreover, there are no published ITU recommendations addressing the subject of the Additional Operational Limits and how to determine violations of these limits. Perhaps more importantly, there also is no schedule of when those recommendations might appear. On such a crucial matter, the FCC cannot reasonably exercise its rulemaking and enforcement authority simply by deferring to an uncertain and potentially open-ended process.

For all of the above reasons, the Commission should reject certain NGSO applicants' efforts to render the Additional Operational Limits toothless and

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[22] Loral Comments at 7. Loral makes a similar recommendation with respect to the Aggregate Limits, and both Loral and SkyBridge recommend reliance on the ITU for enforcement/measurement methodologies for the Operational Limits.

[23] The creators of ITU recommendations generally concentrate on technical issues while avoiding regulatory concerns. Although the ITU Study Groups, which are responsible for creating recommendations, do have the authority to address regulatory issues, regulatory considerations

should adopt PanAmSat's recommendations for a pre-licensing demonstration of compliance.

IV. THE OPERATIONAL LIMITS

The Operational Limits will be the sole ongoing means of enforcing NGSO sharing commitments. In order to give meaning to these limits, PanAmSat urged the Commission to develop and enforce a rapid, effective process for identifying NGSO systems that are exceeding the limits and for requiring those systems to reduce their emissions immediately to the proper levels.[24]

One necessary component of such a process is ensuring that GSO operators and users have available to them the information they need to identify the source of an interfering signal and to correlate sync loss problems with specific NGSO system satellites. Boeing, however, argues that these entities should be forced to rely on generic Air Force and NASA databases of all orbiting objects to determine the location of NGSO satellites.[25]

Boeing fails to explain why it would be an undue burden for NGSO licensees to perform the presumably simple task of identifying where their satellites are at any point in time. This, surely, is information they know, and with tools such as the Internet it would be a simple matter for it to be made readily accessible to affected parties.

Boeing also fails to justify forcing GSO operators and users to rely on third-party data. To the best of PanAmSat's knowledge, neither the Air Force nor NASA has an obligation to provide orbital data continuously, nor is either responsible for the accuracy of whatever data they do provide. As a result, the

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tend to be avoided due to the wide divergence of individual countries' domestic regulatory needs.

[24] PanAmSat does not propose any pre-licensing determination of compliance with the Operational Limits, as opposed to the Additional Operational Limits. See Boeing Comments at 5; Loral Comments at 5; SkyBridge Comments at 9, 16.

NGSO operators themselves are a much better source for securing this crucial information than are generalized NASA or Air Force databases.

SkyBridge's suggestion that the Commission rely on international dispute resolution mechanisms to ensure compliance with domestic requirements is similarly misguided.[26] Annex 8 of Chapter 3 of the CPM Report outlines a process that could be used by different Administrations to resolve cases of alleged NGSO interference. This process, however, is not up to the task of resolving disputes domestically between GSO operators or users, on the one hand, and domestic NGSO licensees or foreign NGSO licensees who have been granted access to the U.S. market, on the other. Unlike the ITU, the Commission can act rapidly and has the means to enforce its decisions. The Commission needs to use these powers to ensure that all disputes arising within the United States are resolved promptly and effectively. The ITU's dispute resolution process, therefore, is neither an appropriate model nor an adequate substitute for the Commission's enforcement procedures.

Moreover, SkyBridge's statement that the Commission has adequate authority to deal with "proven" non-compliance with the operational limits is disturbing.[27] As the CPM Report makes clear, violations of the Operational Limits must be resolved "as expeditiously as possible."[28] Consistent with this requirement, the Commission should not wait until a dispute has been fully resolved and non-compliance has been "proven" before requiring an NGSO operator to take corrective action.

Finally, for the reasons discussed in the previous section, the Commission should not defer to the ITU in developing a reliable means of measuring the

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[25] Boeing Comments at 7.

[26] SkyBridge Comments at 9-10.

[27] SkyBridge Comments at 16.

[28] CPM Report at § 3.1.2.4.7(iii).

actual $EPFD_{down}$ levels generated by an NGSO system into operational GSO earth stations.

V. THE AGGREGATE LIMITS

Individual limits were developed to promote regulatory certainty and to allocate burdens clearly among NGSO licensees. In the end, however, they are not what matters: the ability of GSO systems to operate co-frequency with NGSO systems will depend on the aggregate interference caused by all NGSO systems, not with any single licensee's compliance with its scaled limits.

It is crucial that the Commission maintain its focus on the issue of aggregate limits. There is a significant disconnect between the number of systems used to transform the aggregate limits into individual limits (3.5) and the number of Ku-band NGSO applications currently pending before the Commission (8). This disconnect is even more pronounced when one considers the likelihood of additional foreign systems seeking to operate in the United States. Simply stated, for the current single-system limits to have any meaning, the number of Ku-band NGSO systems cannot be allowed to go above 3.5 and the aggregate characteristics of all licensed systems cannot be allowed to deviate from the assumptions underlying the development of the single-system limits. Under these circumstances, suggestions by Boeing and SkyBridge that the Commission can ignore the problem of aggregate limits until 3 systems have been placed into operation[29] are divorced from reality and threaten the entire premise for the CPM compromise. For similar reasons, Loral's suggestion that the Commission can process the eight pending applications without first resolving the question of the aggregate limits should be rejected.[30]

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[29] Boeing Comments at 4-5; SkyBridge Comments at 22.
[30] Loral Comments at 8.

Indeed, SkyBridge goes so far as to suggest that the Commission should have no role in enforcing the aggregate limits, and that the international community instead should be responsible for seeing to it that there is compliance.[31] However, the reasons SkyBridge proffers for taking the Commission out of the equation – the difficulty of assessing compliance as different systems change their operating parameters over time, and the cumulative effects of systems licensed by different countries – actually underscore why effective Commission enforcement in the U.S. market is crucial. Without the FCC playing a role, GSO operators would be left to fend for themselves in an international regime that lacks effective enforcement tools, and in which any attempt to ensure compliance with the aggregate limits could quickly degenerate into finger-pointing among NGSO operators. This is not the intent of the CPM compromise, nor is it a reasonable outcome to the problems presented by NGSO use of GSO spectrum.

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[31] SkyBridge Comments at 22 and n. 49 (contending that the aggregate limits "have no meaning for individual systems and necessarily must be governed on an international level").

Finally, the Commission should bear in mind that, as with the single-entry limits, there is no reliable means for verifying NGSO compliance with aggregate limits once NGSO systems are operational. The only effective means for keeping NGSO systems within the aggregate limits, therefore, is software simulation. The aggregate limit compliance procedure proposed by PanAmSat is simple to implement and should ensure that GSO systems are protected to the extent intended by the aggregate limits. PanAmSat agrees with DirecTV, moreover, that, if future study demonstrates that the procedure used to go from aggregate to single-entry limits must be revised, or if $N_{effective}$ changes, then the single-entry limits must be revised accordingly.

Respectfully submitted,

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January 14, 2000

PanAmSat®

ENGINEERING AFFIDAVIT

I, Philip A. Rubin, Chief Scientist of PanAmSat Corp., hereby certify that I am the technically qualified person responsible for the preparation of the technical information contained in these Reply Comments and that I am familiar with Part 25 of the Commission's Rules and Regulations. My experience is documented in many engineering filings with the Commission.

I have reviewed all technical materials provided herein and certify that they were either prepared by me or under my direction. I further certify that the technical information submitted in this amendment is complete and accurate to the best of my knowledge.

By: ____________________
Philip A. Rubin
Chief Scientist
PanAmSat Corp.

Date: 1/14/2000

Exhibit S

US006871045B2

(12) United States Patent
Rubin et al.

(10) **Patent No.: US 6,871,045 B2**
(45) **Date of Patent: Mar. 22, 2005**

(54) **IN-ORBIT RECONFIGURABLE COMMUNICATIONS SATELLITE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 603 days.

(21) Appl. No.: **09/907,507**

(22) Filed: **Jul. 18, 2001**

(65) **Prior Publication Data**

US 2003/0017803 A1 Jan. 23, 2003

(51) **Int. Cl.**^{7} **H04B 7/185**

(52) **U.S. Cl.** **455/12.1**; 455/13.3; 455/427; 455/430

(58) **Field of Search** 455/12.1, 13.3, 455/427, 430, 428, 429, 13.1, 278.1, 8; 342/354, 352

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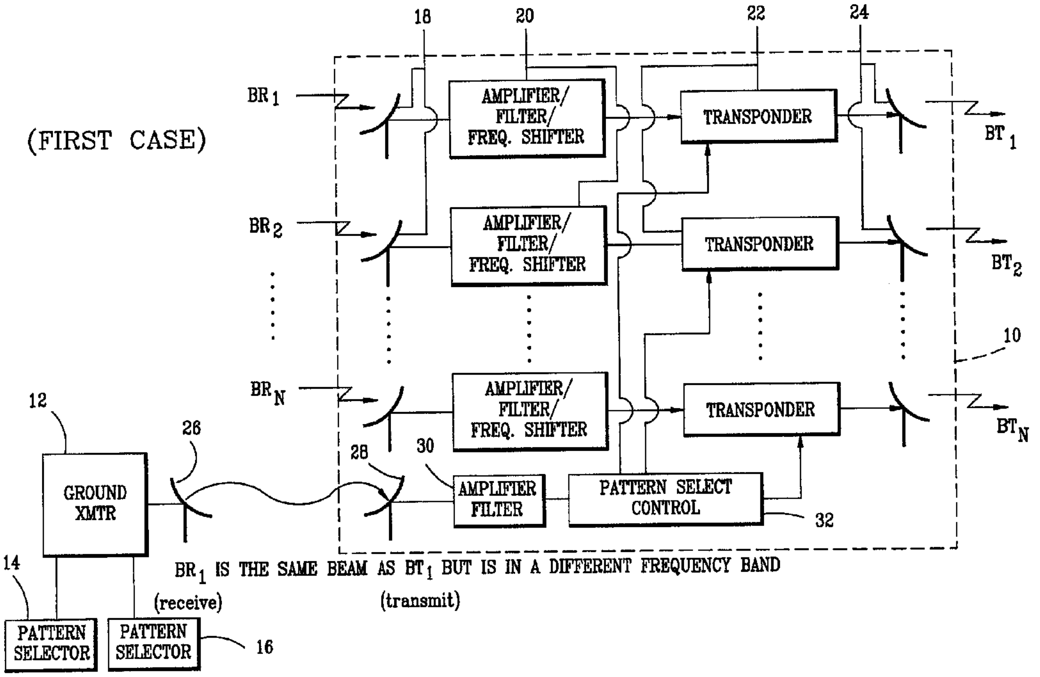
(57) **ABSTRACT**

The footprint of a first satellite is reconfigurable in orbit by ground control to switch on and off different transponders. Each transponder is connected to a corresponding downlink antenna feed, each of which transmits a downlink beam independent of the others. The satellite can be moved into different orbits or otherwise changed to service new geographic areas by using different combinations of the transponders. In one embodiment, the satellite includes an antenna and components for an uplink beam corresponding to each downlink beam. Various subsets of the downlink antenna feeds are mechanically linked to move in unison using gimbals, each subset using a corresponding gimbal and mechanical driver. The first satellite is sufficiently reconfigurable that it may serve as a back up satellite to a plurality of other satellites in a constellation of satellites.

18 Claims, 4 Drawing Sheets



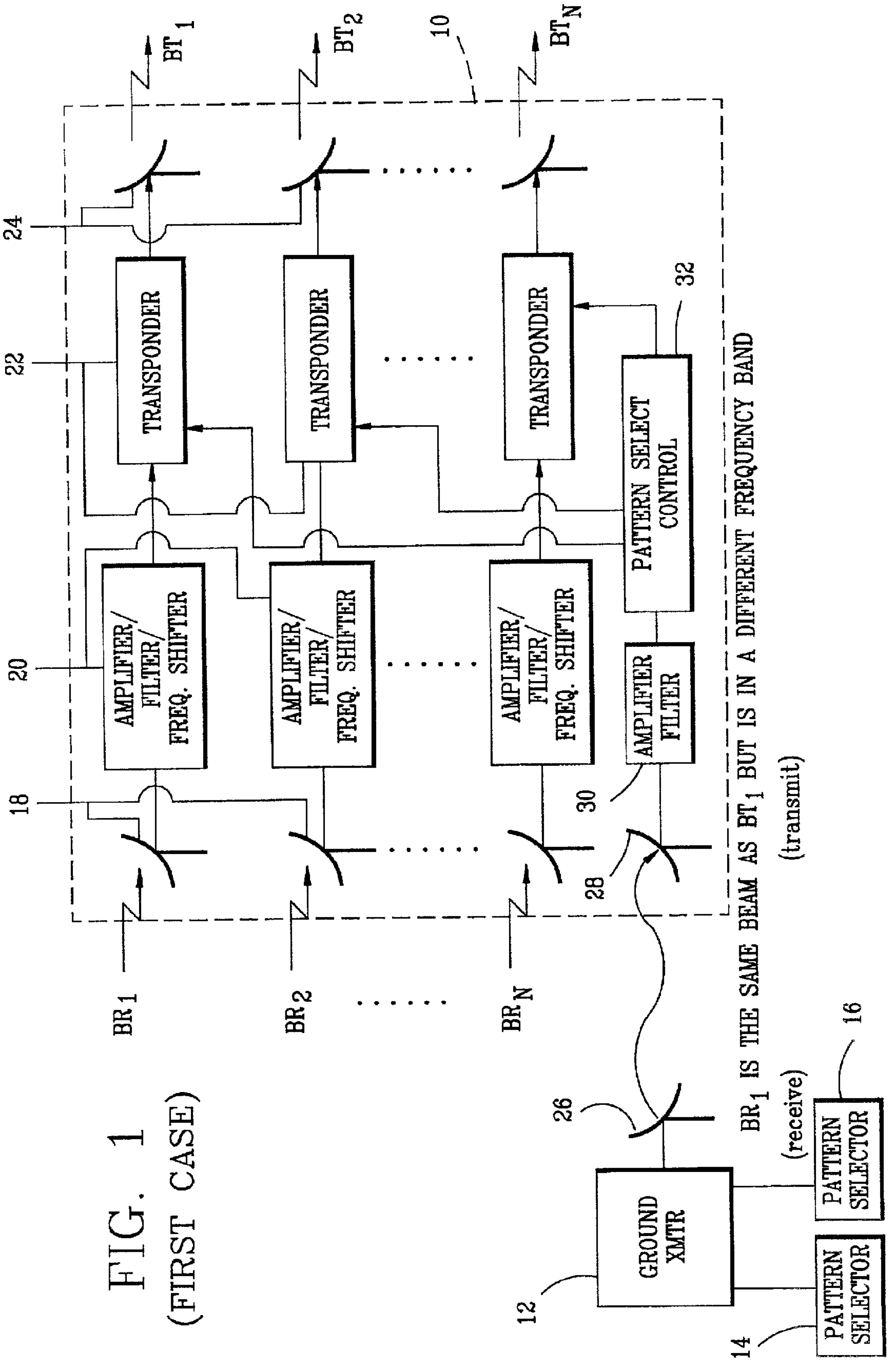


FIG. 1
(FIRST CASE)

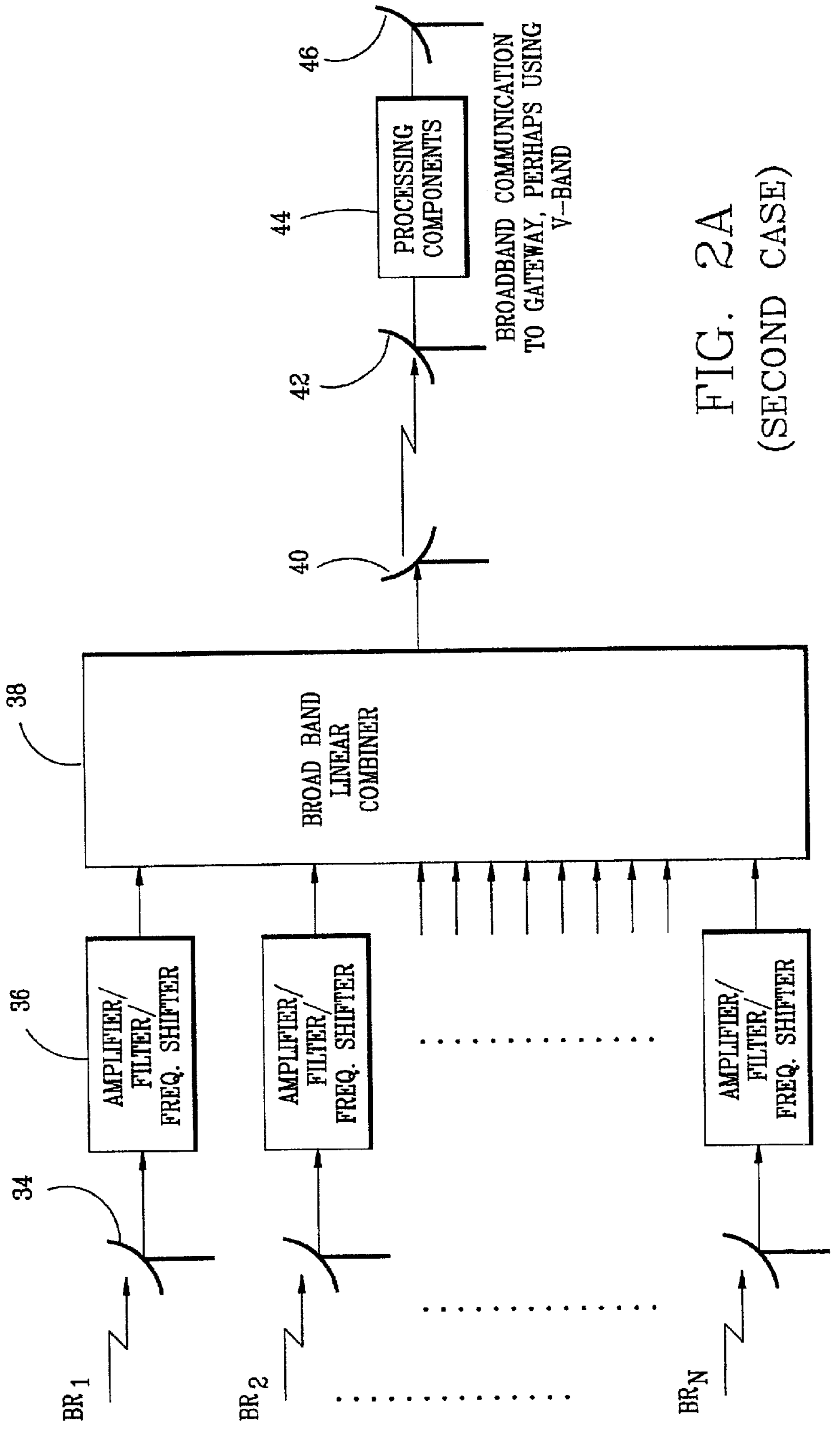


FIG. 2A
(SECOND CASE)

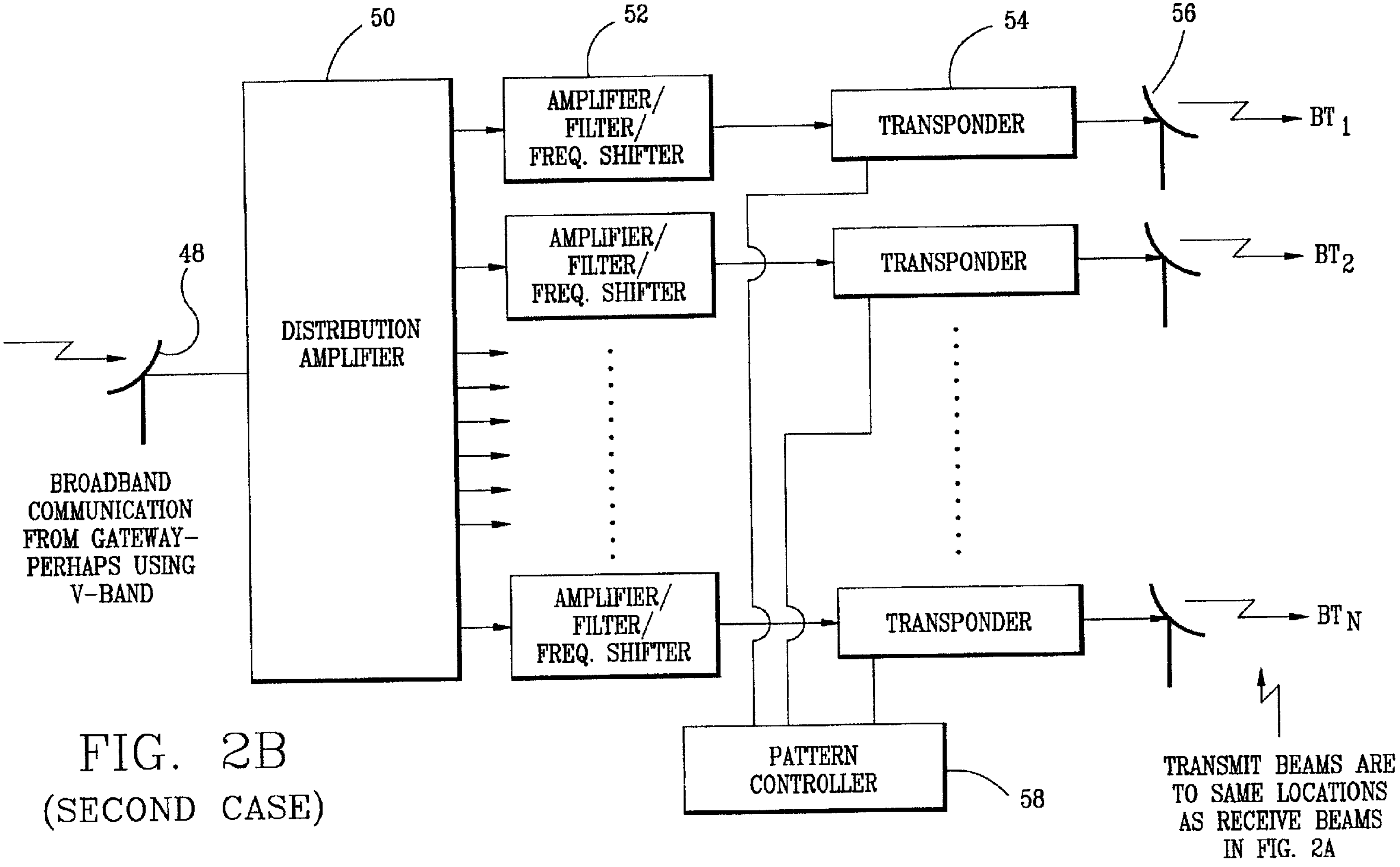


FIG. 2B
(SECOND CASE)

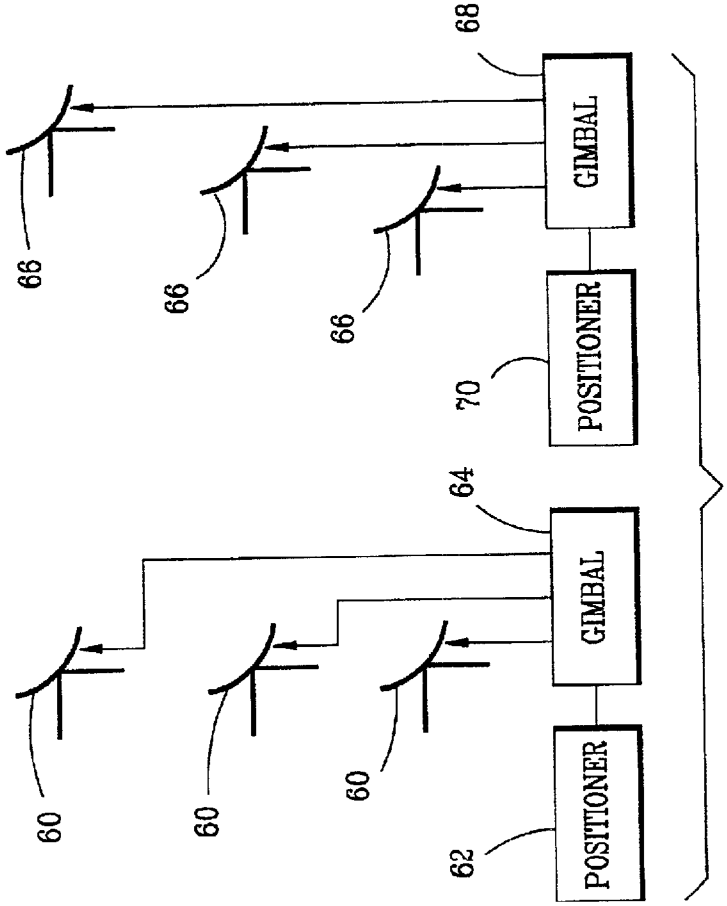


FIG. 3

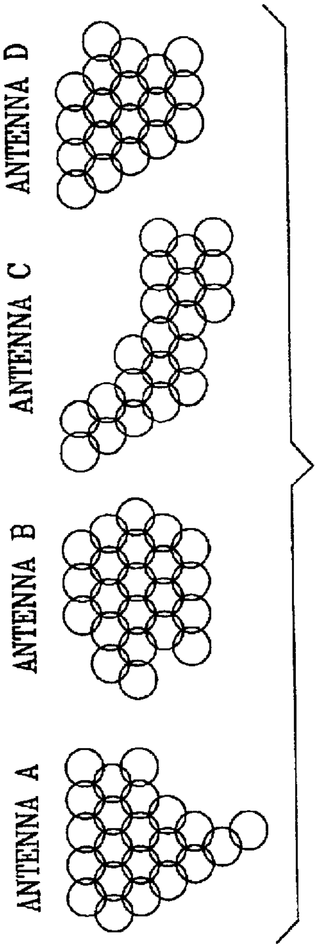


FIG. 4

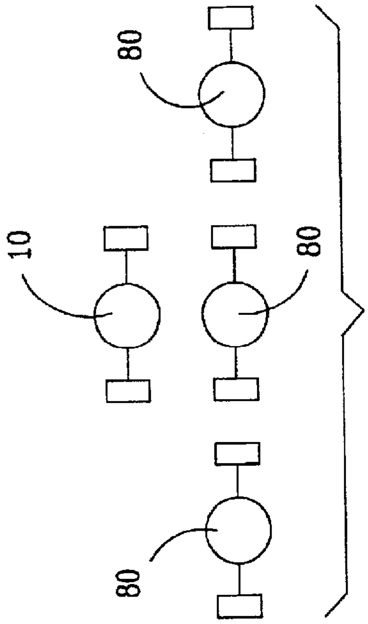


FIG. 5

IN-ORBIT RECONFIGURABLE COMMUNICATIONS SATELLITE

BACKGROUND OF THE INVENTION

The present invention relates to communication satellites. More specifically, it relates to satellites having communications footprints (i.e., spatial pattern of signals) that can be reconfigured when the satellite is in space.

When using a satellite to provide communications with or to a land mass or other limited geographic area, it is known to try to match the footprint of the signals with the area being served. That is, the satellite should concentrate its signal energy in the area being served.

The present invention relates to systems which use very high frequency bands (Ka-Band and above) where the preferable coverage of an area to be serviced consists of small independent beams, each using a portion of the available frequency band in a frequency reuse pattern. This reuse pattern requires subdivision of the available frequency band in a small number of bands, typically four to seven, where beams of different frequencies overlap slightly in a close knit pattern but adjacent re-use of the same pattern produces insignificant overlap of beams using the same sub-band. For the same size satellite antenna, higher frequencies produce smaller beams on the earth. This use of small beams, on the order of 0.5 to 0.9 degrees, can be implemented with a reflector using a large number of separate feeds, with each feed connected to one or more amplifiers (transponders). The feeds are not phased together in a network to form beams but are each independent, and each produces a single beam. Formation of small beams on the satellite is practical at the Ka-Band.

When the satellite is in space at a particular orbital slot, it may be desirable to move the satellite to a different orbital slot to replace a satellite that is malfunctioning or for contractual or other reasons. However, when the satellite is moved to a different orbital slot with a corresponding second geographic area different from the original service area, the satellite has a footprint matching the boundaries of the original geographic area being serviced, not the new or second geographic area. Depending on the differences in shape(s) and size(s) of the first and second geographic areas, the signal footprint of the satellite may make it impractical to move the satellite to service an area different from the first area.

This problem of matching the satellite to its intended footprint hindering its flexibility in use (i.e., making it unfeasible or at least less effective in use upon changing the service area once the satellite is in space) is especially significant when dealing with small beams.

Various U.S. patents relating to communications techniques will be discussed.

Metzger U.S. Pat. No. 4,144,495 shows a satellite with a reconfigurable beam switching system.

Assal U.S. Pat. No. 4,868,886 shows a reconfigurable beam satellite including a series of switches to select elements in an antenna array to produce a spot beam pattern.

Smith U.S. Pat. No. 5,949,370 shows a reconfigurable beam satellite where a reflector antenna is moved relative to elements in the feed array.

Jones U.S. Pat. No. 5,929,804 shows a phase shift arrangement where a beam is directed by a phased array.

Although many of the prior designs have been generally useful, they have often been subject to one or more of several disadvantages.

Those techniques that rely on phased array arrangements are usually quite complex.

Many techniques use a plurality of feed elements to produce an overall pattern at a given frequency. However, the pattern uses all the elements as part of an array as opposed to independent beams. Therefore, the bandwidth may be limited compared with arrangements using independent beams on different frequencies where each frequency is used repeatedly with geographic spacing between the beams using the same frequency.

Various communications satellites are relatively inflexible in use. If optimized for use at a particular orbital position and/or for a particular service area (geographic area in which service is provided), they often are not able to effectively adjust to a new orbital position and/or new service area.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a new and improved technique for reconfiguring a satellite footprint after it is in orbit.

A more specific object of the present invention is to provide satellite in orbit reconfiguration in a relatively simple manner.

The above and other features of the present invention which will be more readily understood when the following detailed description is considered in conjunction with the accompanying drawings are realized by a method of matching a communications satellite footprint to an area to be served, the steps comprising: providing a first satellite with a plurality of transponders and a plurality of downlink antenna feeds, each transponder connected to a corresponding downlink antenna feed to provide a downlink beam independent of other downlink beams; and providing a pattern controller within the satellite to select, based on signals from a ground station, a transmission footprint corresponding to a pattern for the downlinks by selectively turning on and off transponders. The method further includes turning on a first set of less than all of the transponders to provide a first transmission footprint corresponding to a first geographic area to be served. A pattern control signal is sent from a ground station. The pattern control signal is received in the satellite. The pattern controller is used to change, based on the pattern control signal, to a second transmission footprint corresponding to a second geographic area to be served, the change to the second transmission footprint accomplished by selectively turning on and off transponders such that a second set of less than all of the transponders remains on, the second set being different than the first set.

The method preferably further comprises the step of moving the first satellite to a new orbital position, the second transmission footprint being used in the new orbital position, whereas the first transmission footprint having been used in an old orbital position of the first satellite.

Before changing to the second transmission footprint, the method includes moving the first satellite to a new orbital position.

A plurality of reception routes are provided on the first satellite, each reception route with a corresponding uplink antenna feed and a corresponding electronic component; and wherein each reception route being used at a given time corresponds to one of the transponders at the given time.

The method includes the steps of mechanically linking a first plurality of the antenna downlink feeds for movement in unison relative to the first satellite, mechanically linking a second plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and changing the transmission footprint by moving the first plurality of the antenna downlink feeds in unison and moving the second plurality of the antenna downlink feeds in unison.

An output of each reception route is provided as an input to the corresponding transponder.

The first satellite is a back up satellite that is operable to replace any one of a plurality of other satellites upon malfunctioning or damage to the one of the plurality of other satellites.

The communicating step includes communicating an output of each reception route to the corresponding transponder via the gateway.

The method further comprises the steps of mechanically linking a third plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and wherein the step of changing the transmission footprint by moving the first and second pluralities also includes moving the third plurality of the antenna downlink feeds in unison. The method further comprises the steps of mechanically linking a fourth plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and wherein the step of changing the transmission footprint by moving the first, second, and third pluralities also includes moving the fourth plurality of the antenna downlink feeds in unison.

The present invention may alternately be described as a communications satellite with a plurality of transponders and a plurality of downlink antenna feeds, each transponder connected to a corresponding downlink antenna feed to provide a downlink beam independent of other downlink beams. A pattern controller is within the satellite to select, based on signals from a ground station, a transmission footprint corresponding to a pattern for the downlinks by selectively turning on and off transponders. A receiver is within the satellite for receiving a pattern control signal from a ground station in the satellite. The pattern controller is operable to change, based on the pattern control signal, a transmission footprint corresponding to a geographic area to be served by selectively turning on and off transponders such that a set of less than all of the transponders remains on.

Preferably, the pattern controller is operable to adjust the transmission footprint depending on any changes in an orbital slot of the satellite.

The communications satellite has a plurality of reception routes on the satellite, each reception route with a corresponding uplink antenna feed and a corresponding processing component; and wherein each reception route being used at a given time corresponds to one of the transponders at the given time. An output of each reception route is supplied as an input to the corresponding transponder. The output of each reception route is directly provided to the corresponding transponder.

The communications satellite further includes a first mechanical driver connected to a first plurality of the antenna downlink feeds for movement in unison relative to the satellite, a second mechanical driver connected to a second plurality of the antenna downlink feeds for movement in unison relative to the satellite and wherein the first and second mechanical drivers are operative to change the transmission footprint by moving the first plurality of the antenna downlink feeds in unison and moving the second plurality of the antenna downlink feeds in unison. A third mechanical driver is connected to a third plurality of the antenna downlink feeds for movement in unison relative to the satellite, and wherein the third mechanical driver is operative to change the transmission footprint by moving the third plurality of the antenna downlink feeds in unison. A fourth mechanical driver is connected to a fourth plurality of the antenna downlink feeds for movement in unison relative to the satellite, and wherein the fourth mechanical driver is operative to change the transmission footprint by moving the fourth plurality of the antenna downlink feeds in unison.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will be more readily understood when the following detailed description is considered in conjunction with the accompanying drawings wherein like characters represent like parts throughout the several views and in which:

FIG. **1** is a simplified illustration of the present invention showing a satellite and ground station;

FIGS. **2**A and **2**B show two satellites in an alternate technique of the present invention;

FIG. **3** is simplified illustration of a gimbal pattern control technique;

FIG. **4** is an illustration of four different antenna patterns, each pattern of which may be combined with others and each pattern having a plurality of beams and controlled by a corresponding gimbal; and

FIG. **5** is a simplified showing of various satellites illustrating that the present invention allows one satellite to back up (i.e., replace in event of malfunction) any one of a constellation of other satellites with different geographic coverage areas.

DETAILED DESCRIPTION

FIG. **1** shows a satellite configuration using the present invention. The satellite **10** is controlled by a ground station with transmitter **12** connected to a pattern selector **14** which controls the footprint of the satellite and position selector **16** which controls the position of the satellite.

By building the spacecraft antenna with a large number of feeds, more than necessary to cover most service areas, the satellite **10** may be moved to any orbital slot where geographic areas such as land masses are to be covered, and only the groups of beams covering the desired service areas are energized. This is facilitated by the same worldwide allocations of the Ka-Band and higher bands. Ku-Band for example does not have the same allocations worldwide. Thus, if it is desirable to have a satellite in a different orbital location from where one presently exists, the satellite may be moved elsewhere and the lay-down of the beams can be adjusted to again cover the desired service area. This would entail energizing some beams not used in the previous location and de-energizing other beams not needed in the new location.

Each beam consists of an up-link portion in one frequency band and a downlink portion in a second independent frequency band. The satellite **10** is built in the “bent pipe” mode such that the content of an up-link beam is frequency-converted and sent back down the companion downlink beam. In this way traffic within a particular city, or each geographic area within a beam pair is served.

The uplink portion includes an uplink antenna **18** and electronic components **20** (such as a switch, amplifier, filter and frequency shifter). The output of each component **20** is supplied directly to a corresponding transponder **22** which feeds a corresponding downlink antenna feed **24**. There are N sets of the components **18** to **22**, each set in parallel to the other sets.

A pattern control signal determined by pattern selector **14** is transmitted by transmitter **12** via antenna **26** to satellite antenna **28**. The signal received is processed via filter/amplifier **30** and supplied to pattern controller **32**. Pattern controller **32** turns on and off various of the transponders **22** such that the transmission footprint corresponds to the desired footprint from the position selected for the satellite by position selector **16**. Alternatively, the pattern controller can switch capacity between beams. In other words, the uplink from any given area can be switched to different ones of the various downlink antennas.

Another satellite implementation provides service between a gateway and many customers. The satellite has the same pairing of up-link and downlink beams as before but the up-link beam is no longer connected directly to the downlink beam. Rather, the up-link beam in the satellite is connected to a downlink beam, which is received by the gateway. The gateway in turn has a companion up-link beam, which is connected to the companion downlink beam of customer up-link beam. In this way a bi-directional link is available to a customer outside of his geographical region by means of the gateway.

Turning now to FIG. **2**A, a parallel arrangement of uplink antenna feeds **34** connect to processing components **36** (amplifier, filter, frequency shifter) supply a broadband linear combiner **38** which in turn feeds downlink antenna feed **40**.

The signal from antenna **40** goes to a ground gateway having antenna feed **42**, processing components **44** (receivers, signal processing, transmitters, etc.), and antenna feed **46**.

Turning now to FIG. **2**B, the signal from feed **46** of FIG. **2**A goes to a satellite having antenna element **48**. Element **48** in turn supplies the signals to distribution amplifier **50** which processes the signals and directs them to the appropriate downlink portion. Each of the parallel downlink portions has a electronic processing component **52** (switch, amplifier, filter, frequency shifter), transponder **54**, and downlink antenna feed **56**.

The transmission footprint of the satellite is controlled by a pattern controller **58** which is operable like pattern controller **32** of FIG. **1**. For ease of illustration, the feed and processing components associated with supplying pattern controller **58** are not shown in FIG. **2**B.

There are multiple implementations of the system that includes a gateway. First, the gateway would use the same frequency bands as the customer frequency bands. In this case the gateway and the customers must share the bands such that the customer capacity would be smaller than without a gateway.

A second implementation of a system with a gateway would use gateway links, which are not in the customer link bands. Such a system might employ the much higher V-Band for gateway links. Although this band is even more adversely effected by rain attenuation the gateway could be strategically located in an arid region where rain outages are remote. Since the bandwidth available at V-Band is much greater than at Ka-Band a great many customer links could be multiplexed prior to transmission from and to the satellite. A mechanical steering mechanism on board the spacecraft would point its beams toward the location of the gateway on the earth.

FIG. **3** shows a further technique, beyond the selective turning on and off of the transponders, to control the transmission footprint. This technique, which preferably would be used with the techniques of FIG. **1** or FIGS. **2**A and **2**B, has downlink feeds **60** positionable (i.e., relative to the satellite) in unison by a positioner **62** acting through gimbal **64**. A second set of downlink feeds **66** are positionable by operation of gimbal **68** and positioner **70**. A third and fourth set of downlink feeds positionable by a corresponding gimbal and positioner are not shown for ease of illustration. It should be understood that the downlink feeds **60** and **66** would be different subsets of the downlink feeds **24** of FIG. **1** or feeds **56** of FIG. **2**B. Although not shown, each positioner is controller from the ground by a signal received from the ground and supplied to the positioner.

Turning now to FIG. **4**, the four subsets of downlink feeds controlled by the four positioners may supply corresponding transmission patterns A, B, C, and D. By combining them in various arrangements and by turning off some of the beams (i.e., shown as circles in the patterns) as discussed above, the footprint can be readily adjusted to match a desired service area. The transmission pattern can either be continuous as shown in FIG. **4** or discontinuous (i.e., there could be a discontinuity between adjacent beams such as the circles). If the beams from the antennas are discontinuous, one could have beams from antenna A for example interleaved with beams from antenna B such that the gaps in coverage of the antenna A beam are filled in by the coverage of antenna B and gaps in coverage of the antenna B beam are filled in by the coverage of antenna A. The possible downlink beams are a super set of all geographic regions to be served. That is, all possible downlink beams form a set larger than the set of beams shown in FIG. **4**. However, by switching using the pattern select control and/or otherwise turning transponders on and off, the beam set at a given time is smaller than the superset of all possible beams.

Turning now to FIG. **5**, the flexibility in configuring satellite **10** in space allows it to serve as a back up satellite for a plurality of other satellites **80** in a satellite constellation. Maximum flexibility would be provided by having each of the satellites **80** constructed like satellite **10**. However, the satellites **80** could alternately be designed to only serve limited, different geographic regions, with only satellite **10** being reconfigurable and having the flexibility to replace any damaged or malfunctioning satellite **80**.

Although specific constructions have been presented, it is to be understood that these are for illustrative purposes only. Various modifications and adaptations will be apparent to those of skill in the art. Therefore, the scope of the present invention should be determined by reference to the claims.

What is claimed is:

1. A method of matching a communications satellite footprint to an area to be served, the steps comprising:

providing a first satellite with a plurality of transponders and a plurality of downlink antenna feeds, each transponder connected to a corresponding downlink antenna feed to provide a downlink beam independent of other downlink beams;

providing a pattern controller within the satellite to select, based on signals from a ground station, a transmission footprint corresponding to a pattern for the downlinks by selectively turning on and off transponders;

turning on a first set of less than all of the transponders to provide a first transmission footprint corresponding to a first geographic area to be served;

sending a pattern control signal from a ground station;

receiving the pattern control signal in the satellite; and

using the pattern controller to change, based on the pattern control signal, to a second transmission footprint corresponding to a second geographic area to be served, the change to the second transmission footprint accomplished by selectively turning on and off transponders such that a second set of less than all of the transponders remains on, the second set being different than the first set.

2. The method of claim **1** further comprising the step of moving the first satellite to a new orbital position, the second transmission footprint being used in the new orbital position, whereas the first transmission footprint having been used in an old orbital position of the first satellite.

3. The method of claim **1** further comprising the step of; before changing to the second transmission footprint, moving the first satellite to a new orbital position.

4. The method of claim **1** further comprising the step of: providing a plurality of reception routes on the first a satellite, each reception route with a corresponding uplink antenna feed and a corresponding electronic processing component; and wherein each reception route being used at a given time corresponds to one of the transponders at the given time.

5. The method of claim **4** wherein the plurality of reception routes is provided on the first satellite.

6. The method of claim **5** further comprising the step of: providing an output of each reception route as an input to the corresponding transponder.

7. The method of claim **6** wherein the output of each reception route is directly provided to the corresponding transponder.

8. The method of claim **4** wherein the first satellite is a back up satellite that is operable to replace any one of a plurality of other satellites upon malfunctioning or damage to the one of the plurality of other satellites.

9. The method of claim **8** wherein the communicating step includes communicating an output of each reception route to the corresponding transponder via the gateway.

10. The method of claim **1** further comprising the steps of mechanically linking a first plurality of the antenna downlink feeds for movement in unison relative to the first satellite, mechanically linking a second plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and changing the transmission footprint by moving the first plurality of the antenna downlink feeds in unison and moving the second plurality of the antenna downlink feeds in unison.

11. The method of claim **10** further comprising the steps of mechanically linking a third plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and wherein the step of changing the transmission footprint by moving the first and second pluralities also includes moving the third plurality of the antenna downlink feeds in unison.

12. The method of claim **11** further comprising the steps of mechanically linking a fourth plurality of the antenna downlink feeds for movement in unison relative to the first satellite, and wherein the step of changing the transmission footprint by moving the first, second, and third pluralities also includes moving the fourth plurality of the antenna downlink feeds in unison.

13. A communications satellite comprising:

a plurality of transponders and a plurality of downlink antenna feeds, each transponder connected to a corresponding downlink antenna feed to provide a downlink beam independent of other downlink beams;

a pattern controller within the satellite to select, based on signals from a ground station, a transmission footprint corresponding to a pattern for the downlinks by selectively turning on and off transponders;

a receiver for receiving a pattern control signal from a ground station in the satellite;

a plurality of reception routes on the satellite, each reception route with a corresponding uplink antenna feed and a corresponding processing component; and wherein each reception route being used at a given time corresponds to one of the transponders at the given time;

wherein the pattern controller is operable to change, based on the pattern control signal, a transmission footprint corresponding to a geographic area to be served by selectively turning on and off transponders such that a set of less than all of the transponders remains on; and

wherein the pattern controller is operable to adjust the transmission footprint depending on any changes in an orbital slot of the satellite.

14. The communications satellite of claim **13** wherein an output of each reception route is supplied as an input to the corresponding transponder.

15. The communications satellite of claim **14** wherein the output of each reception route is directly provided to the corresponding transponder.

16. A communications satellite comprising:

a plurality of transponders and a plurality of downlink antenna feeds, each transponder connected to a corresponding downlink antenna feed to provide a downlink beam independent of other downlink beams;

a pattern controller within the satellite to select, based on signals from a ground station, a transmission footprint corresponding to a pattern for the downlinks by selectively turning on and off transponders;

a receiver for receiving a pattern control signal from a ground station in the satellite;

a first mechanical driver connected to a first plurality of the antenna downlink feeds for movement in unison relative to the satellite, a second mechanical driver connected to a second plurality of the antenna downlink feeds for movement in unison relative to the satellite and wherein the first and second mechanical drivers are operative to change the transmission footprint by moving the first plurality of the antenna downlink feeds in unison and moving the second plurality of the antenna downlink feeds in unison; and

wherein the pattern controller is operable to chance, based on the pattern control signal, a transmission footprint corresponding to a geographic area to be served by selectively turning on and off transponders such that a set of less than all of the transponders remains on.

17. The communications satellite of claim **16** further comprising a third mechanical driver connected to a third plurality of the antenna downlink feeds for movement in unison relative to the satellite, and wherein the third mechanical driver is operative to change the transmission footprint by moving the third plurality of the antenna downlink feeds in unison.

18. The communications satellite of claim **17** further comprising a fourth mechanical driver connected to a fourth plurality of the antenna downlink feeds for movement in unison relative to the satellite, and wherein the fourth mechanical driver is operative to change the transmission footprint by moving the fourth plurality of the antenna downlink feeds in unison.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,871,045 B2
DATED : March 22, 2005
INVENTOR(S) : Philip A. Rubin et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 8,
Line 47, please delete "chance" and replace with -- change --.

Signed and Sealed this

Ninth Day of August, 2005

Jon W. Dudas

JON W. DUDAS
Director of the United States Patent and Trademark Office