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ORIGINAL

September 4, 1996

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

RE: Motorola Satellite Systems, Inc. Application to Construct, Launch and Operate the M-Star System of Low Earth Orbit Satellites

Dear Mr. Caton:

Enclosed please find for filing on behalf of Motorola Satellite Systems,. Inc. an original and nine (9) copies of its Application for Authority to Construct, Launch and Operate the M-Star System, a global Low Earth Orbit Satellite System of 72 satellites to operate in the 40 GHz Band.

Please date stamp and return a copy of this Application to our messenger. I ask that you forward these applications to the Satellite and Radiocommunications Division of the International Bureau for their consideration.

Due to the bulk of these applications, copies of these applications were filed in a box with a copy of this letter attached thereto. The documents and box are marked as "Original" and "Copy" to avoid confusion.

If there are any questions concerning this Application, please do not hesitate to contact me.

Respectfully submitted,

Brent Weingardt
Counsel for Motorola Satellite
Systems, Inc.

Enclosures

FEDERAL COMMUNICATIONS COMMISSION

FCC REMITTANCE ADVICE

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

PAGE NO. 1 OF ____

(RESERVED)

SPECIAL USE
FCC/MELLON SEP 04 1996

157-SAT-P/LA-96
S2240

(Read instructions carefully BEFORE proceeding.)

PAYOR INFORMATION

(1) FCC ACCOUNT NUMBER: 0 5 2 1 3 4 9 7 9 0

Did you have a number prior to this? Enter it.

(2) TOTAL AMOUNT PAID (dollars and cents): $ 247,970.00

Received
SEP 23 1996
Satellite Policy Branch

(3) PAYOR NAME (If paying by credit card, enter name exactly as it appears on your card): STEPTOE & JOHNSON, LLP

(4) STREET ADDRESS LINE NO. 1: Attn: Phil Malet

(5) STREET ADDRESS LINE NO. 2: 1330 Connecticut Avenue, N.W.

(6) CITY: Washington

(7) STATE: DC

(8) ZIP CODE: 20036

(9) DAYTIME TELEPHONE NUMBER (Include area code): 202/429-6239

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

ITEM #1 INFORMATION

FCC USE ONLY

(11A) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR: MOTOROLA SATELLITE SYSTEMS, INC.

(12A) FCC CALL SIGN/OTHER ID:

(13A) ZIP CODE: 85248-2899

(14A) PAYMENT TYPE CODE: C Z W

(15A) QUANTITY: 1

(16A) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14: $ 6,890

(17A) FCC CODE 1:

(18A) FCC CODE 2:

(19A) ADDRESS LINE NO. 1: Attn: Durrell H. Hills

(20A) ADDRESS LINE NO. 2): 2501 South Price Road

(21A) CITY/STATE OR COUNTRY CODE: Chandler, AZ

ITEM #2 INFORMATION

FCC USE ONLY

(11B) NAME OF APPLICANT, LICENSEE, REGULATEE, OR DEBTOR: MOTOROLA SATELLITE SYSTEMS, INC.

(12B) FCC CALL SIGN/OTHER ID:

(13B) ZIP CODE: 85248-2899

(14B) PAYMENT TYPE CODE: C L W

(15B) QUANTITY: 1

(16B) FEE DUE FOR PAYMENT TYPE CODE IN BLOCK 14: $ 241,080

(17B) FCC CODE 1:

(18B) FCC CODE 2:

(19B) ADDRESS LINE NO. 1: Attn: Durrell H. Hills

(20B) ADDRESS LINE NO. 2: 2501 South Price Road

(21B) CITY/STATE OR COUNTRY CODE: Chandler, AZ

CREDIT CARD PAYMENT INFORMATION

(22) MASTERCARD/VISA ACCOUNT NUMBER:

☐ Mastercard

☐ Visa

EXPIRATION DATE: Month Year

AUTHORIZED SIGNATURE DATE

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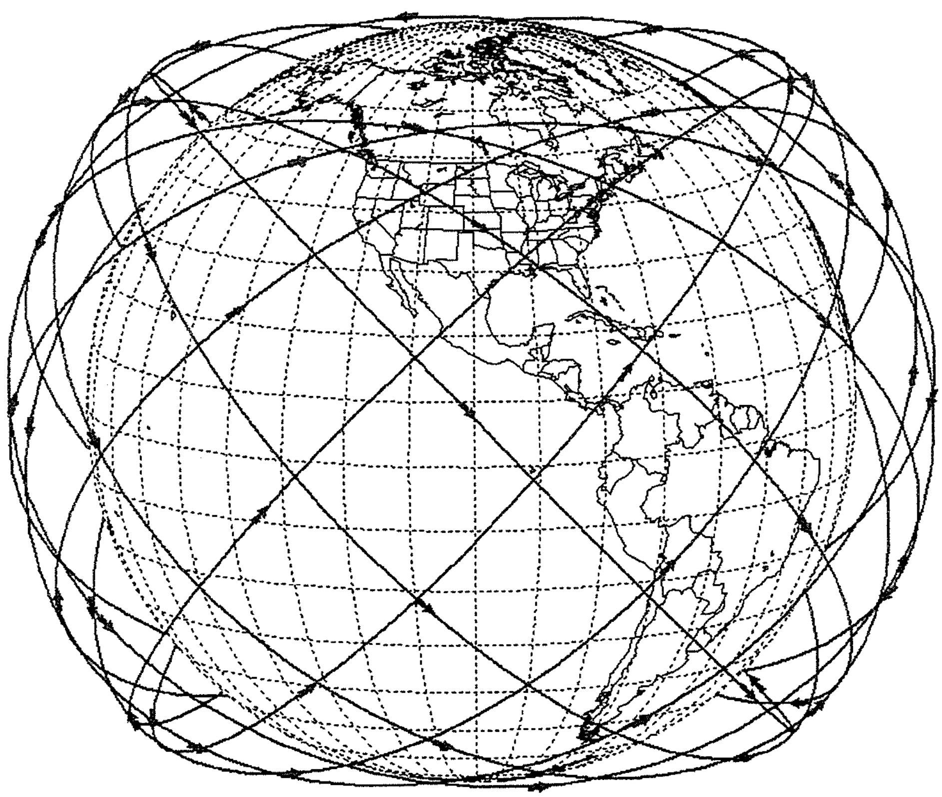
...ate on reverse.

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

ORIGINAL

Application of Motorola Satellite Systems, Inc. for Authority to Construct, Launch and Operate The M-Star System

A Global Network of Non-Geostationary Communications Satellites Providing Broadband Services In The 40 GHz Band



Motorola Satellite Systems, Inc.
2501 S. Price Road
Chandler, Arizona 85248-2899

Philip L. Malet
Pantelis Michalopoulos
Steptoe & Johnson LLP
1330 Connecticut Avenue, N.W.
Washington, D.C. 20036
202-429-3000

September 4, 1996

157-SAT-P/LA-96
S2240

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

Application of

Motorola Satellite Systems, Inc.

for

Authority to Construct, Launch and Operate

The M-Star System

A Global Network of Non-Geostationary Communications
Satellites Providing Broadband Services
In The 40 GHz Band

Motorola Satellite Systems, Inc.

2501 S. Price Road

Chandler, Arizona 85248-2899

Philip L. Malet
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Steptoe & Johnson LLP
1330 Connecticut Avenue, N.W.
Washington, D.C. 20036
202-429-3000

September 4, 1996

EXECUTIVE SUMMARY

Motorola Satellite Systems, Inc. ("MSS Inc." or "Motorola"), a wholly-owned subsidiary of Motorola, Inc., hereby requests Commission authority to construct, launch and operate the M-Star System,[1] a non-geostationary orbit (NGSO) global satellite system, offering a wide range of real-time voice and data transport services in the Fixed-Satellite Service (FSS). The M-Star System will comprise a total of 72 operational satellites interconnected in low-Earth orbit to virtually all of the populated land masses in the world.

MSS Inc. requests authorization to construct the system's satellites with three types of radio links: service links, intersatellite links, and telemetry, tracking and command (TT&C) links. Each of these links must operate in a frequency band that has a global allocation for the intended purpose. The service links will operate in the Fixed-Satellite Service (FSS) in the 37.5-40.5 GHz band (space-to-Earth) and the 47.2-50.2 GHz band (Earth-to-space).[2] The intersatellite links will operate in the Intersatellite Service band allocation at 59.0-64.0 GHz. The TT&C high gain links will operate in the

---

[1] "M-Star" is a temporary working name used to describe the instant project for internal purposes and is not intended for use as a trade name, trade mark or service mark.

[2] The 37.5-40.5 GHz and 47.2-50.2 GHz band segments have a worldwide primary FSS allocation. However, the 37.5-38.6 GHz segment is not allocated to the FSS in the United States. An affiliate of MSS Inc. has previously petitioned the Commission to conform the U.S. Table of Allocations with this worldwide primary FSS allocation. In the Matter of Amendment of Parts 2.106 and 25 of the Commission's Rules to Allocate the 37.5-38.6 GHz Band to the Fixed-Satellite Service and to Establish Technical Rules for the 37.5-38.6 GHz Band, RM No. 8811 (filed March 4, 1996). See Public Notice, Report No. 2132 (May 21, 1996). Pending this revision, MSS Inc. is hereby requesting a limited waiver of the domestic Table of Allocations.

37.5-40.5 GHz band (space-to-Earth) and the 47.2-50.2 GHz band (Earth-to-space). A suitable FSS band below 18 GHz will be used for TT&C links during launch and emergency operations for communications to an omni-directional antenna on the satellites. The exact frequency band for this link has yet to be determined.

The M-Star System comprises a constellation of interconnected low-earth orbit (LEO) satellites in an inclined orbit, along with the associated ground terminal equipment. The 72 satellite constellation will consist of 12 planes with 6 satellites in each plane. The constellation is inclined at 47° with respect to the equator and is in circular orbits at an altitude of 1350 km. Each satellite contains multiple "bent pipe" transponders, spot beam antennas pointed toward the Earth, and intersatellite link antennas pointed toward each of four adjacent satellites. With this architecture, a signal received by a satellite may be transponded directly back to the Earth in the same or a different spot beam, or relayed by intersatellite links through other satellites from which it is then transmitted to the Earth. This architecture allows global interconnection for the transport of real-time voice and data services. A LEO, rather than a GEO, constellation has been selected to allow for the use of relatively small, low-power and low-cost ground terminals and to ensure that the delays experienced by end-users are essentially equivalent to domestic transport systems for global real-time services. For interference avoidance this system employs space diversity. This technique would allow multiple NGSO systems to operate co-coverage and co-frequency in the FSS bands.

Specific locations on the surface of the Earth will be served by spot beams from the satellite constellation. At these locations, single or multiple ground terminals will provide access to the satellite constellation. The ground terminals will have antenna aperture sizes from 0.66 to 1.5 meters and will support bit rates from 2.048 to 51.84 Mbps.

The M-Star System will offer two categories of services. The first category will include voice and data transport to service providers and business customers. This class of service will provide 2.048 Mbps to and from multiple remote sites which can be backhauled to a hub at 51.84 Mbps. This service category can be used to provide a two-way backhaul service or to provide one-way point-to-multipoint or multipoint-to-point service. The second category of service will include interconnection services at up to 51.84 Mbps. This data rate will enable terrestrial carriers to aggregate voice or data signals.

The proposed worldwide broadband communication satellite system promises to become an important component of the U.S. National Information Infrastructure and the Global Information Infrastructure. The M-Star System will provide a competitively priced global communications infrastructure for the interconnection of real-time voice and data services.

As early as the year 2000, the M-Star System will ensure a ready-to-use broadband infrastructure at a much lower cost and in less time than necessary to build out a terrestrial worldwide fiber optic network. While the cost of constructing the M-Star System will be high in absolute terms, the system's global reach makes it possible to spread that cost over a large number of potential users, resulting in a fraction of the per-user cost that would need to be incurred to build out a terrestrial broadband network, whether nationwide or international. The cost of a comparable terrestrial network structure would easily be several trillion dollars.

The M-Star System will also enhance competition in the telecommunications marketplace through open interfaces. This openness will ensure that the system is broadly usable by carriers with divergent technologies.

This system will usher in several important technological innovations, including the first commercial satellite use of the millimeter waves, as its design makes it possible to overcome the propagation losses and other technical problems that have hitherto inhibited satellite use of these bands. The system's innovative design will also provide extensive double or triple coverage and will allow co-frequency sharing between more than one NGSO system by means of satellite-based space diversity, subject only to moderate constraints.

MSS Inc. proposes to operate the M-Star System on a non-common carrier basis. It intends to offer wholesale space segment capacity to carriers, who will, in turn, market a variety of services to their customers.

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of the Application of	)	
	)	
Motorola Satellite Systems, Inc.	)	
	)	File No. ________________
For Authority to Construct, Launch and Operate a Non-Geostationary Orbit Satellite System in the Fixed- Satellite Service Service	)	

APPLICATION OF

MOTOROLA SATELLITE SYSTEMS, INC.

Pursuant to Sections 308, 309 and 319 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 308, 309, 319 (1995), Motorola Satellite Systems, Inc. ("MSS Inc." or "Motorola"), a wholly-owned subsidiary of Motorola, Inc., hereby requests Commission authority to construct, launch and operate the M-Star System,[1] a non-geostationary orbit (NGSO) global satellite system, offering a wide range of real-time voice and data transport services in the Fixed-Satellite Service (FSS). The M-Star System will comprise a total of 72 operational satellites. The corresponding ground segment will include a System Control Segment for constellation and

---

[1] "M-Star" is a temporary working name used to describe the instant project for internal purposes and is not intended for use as a trade name, trade mark or service mark.

network operations, and Customer Premises Equipment to provide access to the system for service providers and carriers.[2]

MSS Inc. requests authorization to construct the system's satellites with three types of radio links: service links, intersatellite links, and telemetry, tracking and command (TT&C) links. Each of these links must operate in a frequency band that has a global allocation for the intended purpose. The service links will operate in the Fixed-Satellite Service (FSS) in the 37.5-40.5 GHz band (space-to-Earth) and the 47.2-50.2 GHz band (Earth-to-space).[3] The intersatellite links will operate in the Intersatellite Service band allocation at 59.0-64.0 GHz. The TT&C high gain links will operate in the 37.5-40.5 GHz band (space-to-Earth) and the 47.2-50.2 GHz band (Earth-to-space). A suitable FSS band below 18 GHz will be used for TT&C links during launch and emergency operations for communications to an omni-directional antenna on the satellites. The exact frequency bands for this link have yet to be determined.

---

[2] MSS Inc. is not submitting at this time an application for any ground segment facilities. It is filing, however, a request, pursuant to Section 319(d) of the Communications Act, to begin immediately the construction of the M-Star System at its own risk. MSS Inc. is also submitting a pioneer's preference request, incorporated herein, for the M-Star System's innovative use of the 40 GHz bands for commercial satellite services.

[3] The 37.5-40.5 GHz and 47.2-50.2 GHz band segments have a worldwide primary FSS allocation. However, the 37.5-38.6 GHz segment is not allocated to the FSS in the United States. An affiliate of MSS Inc. has previously petitioned the Commission to conform the U.S. Table of Allocations with this worldwide primary FSS allocation. In the Matter of Amendment of Parts 2.106 and 25 of the Commission's Rules to Allocate the 37.5-38.6 GHz Band to the Fixed-Satellite Service and to Establish Technical Rules for the 37.5-38.6 GHz Band, RM No. 8811 (filed March 4, 1996). See Public Notice, Report No. 2132 (May 21, 1996). Pending this revision, MSS Inc. is hereby requesting a limited waiver of the domestic Table of Allocations.

I. INTRODUCTION

A. General

The M-Star System comprises a constellation of interconnected low-earth orbit (LEO) satellites in inclined orbits, along with the associated ground terminal equipment. The 72 operational satellite constellation consists of 12 planes with 6 satellites in each plane. The orbits of the constellation are inclined 47° and are circular at an altitude of 1,350 km. Each satellite contains multiple "bent pipe" transponders, spot beam antennas pointed toward the Earth, and intersatellite link antennas pointed toward each of four adjacent satellites. With this architecture, a signal received by a satellite may be transponded directly back to the Earth in the same or a different spot beam, or relayed by intersatellite links through other satellites from which it is then transmitted to the Earth. This architecture allows global interconnection for the transport of real-time voice and data services. A LEO, rather than GEO, constellation has been selected to allow the use of relatively small, low-power and low-cost ground terminals and to ensure that the delays experienced by end-users are essentially equivalent to domestic transport systems for global real-time services. By means of satellite-based space diversity, multiple NGSO systems could be deployed and share in the same 40/50 GHz bands or in any other FSS bands.

User locations on the surface of the Earth will be served by spot beams from the satellite constellation. At these locations, single or multiple ground terminals will provide access to the satellite constellation. The ground terminals will have antenna aperture sizes from 0.66 to 1.5 meters and will support bit rates from 2.048 to 51.84 Mbps.

The M-Star System will offer two categories of services. The first category will include voice and data transport to service providers and business customers. This class of service will provide 2.048 Mbps to and from multiple remote sites which can be backhauled to a hub at 51.84 Mbps. This service category can be used to provide two-way backhaul services. The second category of service will include interconnection services at up to 51.84 Mbps. This data rate will enable terrestrial carriers to aggregate voice or data signals.

MSS Inc. proposes to operate the M-Star System on a non-common carrier basis. It intends to offer wholesale space segment capacity to carriers, who will, in turn, market a variety of services to their customers.

B. Information Contained In This Application

This Application contains all of the required information for an FSS application as specified in Appendix B of the Commission's 1983 Space Station Filing Procedures decision,[4] to the extent applicable, and Part 25 of the Commission's Rules and Regulations. MSS Inc. understands that it will have an opportunity to amend or modify this Application after the Commission has adopted its policies and rules for satellite systems in the requested bands. In support of this Application, MSS Inc. provides the following information:

1. Name, Address and Phone Number Of Applicant

Motorola Satellite Systems, Inc.
Attn.: Mr. Durrell W. Hillis, President
2501 South Price Road
Chandler, Arizona 85248-2899
602-441-3122

---

[4] Filing of Applications for New Space Stations in the Domestic Fixed-Satellite Service, Memorandum Opinion and Order, 93 FCC 2d 1265 (1983).

2. Names, Addresses and Phone Numbers of Persons To Be Contacted

Motorola, Inc.
Michael D. Kennedy
Vice President & Director
Regulatory Relations
Barry Lambergman,
Mgr., Satellite Regulatory Affairs
1350 I Street, N.W, Suite 400
Washington, D.C. 20005
202-371-6900

Steptoe & Johnson LLP
Philip L. Malet
Pantelis Michalopoulos
Brent H. Weingardt
1330 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202) 429-3000

3. Type Of Authorization Requested

MSS Inc. requests authority to construct, launch, and operate approximately 72 non-geostationary orbit satellites for a high-capacity broadband FSS system. The satellites will be distributed in 12 planes, initially with 6 satellites per plane. The planes will be inclined at 47 degrees with respect to the equator. The corresponding ground segment will comprise a System Control Segment, consisting of two Operation Facilities and six antenna sites for constellation and network operations. Each Operation Facility will consist of a Satellite Operations Center and Network Operations Center, and will maintain communications with all six antenna sites.

II. PUBLIC INTEREST CONSIDERATIONS

The proposed worldwide broadband communication satellite system promises to become an important component of the U.S. National Information Infrastructure and the Global Information Infrastructure. The M-Star System will provide a competitively priced global communications infrastructure for the interconnection of real-time voice and data services.

As early as the year 2000, the M-Star System will ensure a ready-to-use broadband infrastructure at a much lower cost and in less time than necessary to build out a terrestrial worldwide fiber optic network. While the cost of constructing the system will be high in absolute terms, the system's global reach makes it possible to spread that cost over a large number of potential users, resulting in a fraction of the per-user cost that would need to be incurred to build out a terrestrial broadband network, whether nationwide or international. The cost of a comparable terrestrial network infrastructure would easily be several trillion dollars.[5]

The M-Star System will also enhance competition in the telecommunications market place. The system will be accessible through open interfaces. This openness will ensure that the system is broadly usable by carriers with divergent technologies.

The system will usher in several important technological innovations, including the first commercial satellite use of the millimeter waves, as its design makes it possible to overcome the propagation losses and other technical problems that have heretofore inhibited satellite use of

---

[5] See "No Less than 11 Pilot Projects Were Expected to Be Rubber Stamped During the G-7 Ministerial Conference on the Information Society," European Report, European Information Service (Feb. 25, 1995) (The estimated cost of a planned nationwide fiber optic network in Japan alone is $980 billion). See also "Pacific Bell's California Test Leaves Room for Marketers," Advertising Age (Nov. 22, 1993), p. 19 (company announces plan to build and upgrade fiber-optic network in California to allow the delivery of video and data services at a cost of $16 billion).

these bands. The system's innovative design will also provide extensive double or triple coverage and thereby allow co-frequency sharing between more than one NGSO system by means of satellite diversity, subject only to moderate constraints.

The M-Star System will provide significant benefits for the U.S. economy. First, the widespread availability of broadband communications, along with the ability to incorporate instant transport infrastructure, will increase U.S. productivity.[6] Second, the M-Star System will result in the direct infusion of substantial amounts of capital into the United States. MSS Inc. intends to construct much of the system in the United States. Motorola will construct the space segment, will manufacture a large part of the terrestrial equipment infrastructure, as well as related Customer Premises Equipment (CPE). This activity will translate into millions of U.S. person-hours, many of them involving specialized, highly compensated professional work.

The system will also add a significant number of jobs and income to the world economy through construction-related activities and other direct and indirect economic benefits.

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[6] See, e.g., Stephen R. Rivkin and Jeremy D. Rosner, Shortcut to the Information Superhighway: A Progressive Plan to Speed the Telecommunications Revolution, Progressive Policy Institute (July 1992) at 1 (a nationwide fiber optic network would substantially improve the nation's quality of work and life; according to one study, it could boost U.S. annual productivity growth by 0.4% and add $321 billion to the nation's wealth over 16 years, not including energy and environmental savings) (citing Robert B. Cohen, The Impact of Broadband Communications on the U.S. Economy and on Competitiveness, Economic Strategy Institute (1992)).

III. MARKET AND DEMAND FOR SERVICES

A. Overview

With the completion of the licensing in the United States for broadband Personal Communication Services (PCS), the wireless communications industry has come to a crossroads. While cellular technology is still in a high-growth mode, customers around the world are beginning to think in broader terms of "wireless" communications, as the potential of PCS fuels exciting opportunities. The success foreseen for PCS stems from expectations that it will prove to be the next generation of cellular radio with varied service offerings, lower costs and better quality than that of existing services.

The M-Star System will provide a competitive alternative for the interconnection of wireless cell sites. The M-Star System will enable the vision of lightweight devices that provide varied forms of communications including voice, data, images and even video, to become a reality by reducing the required infrastructure investment and enhancing competition among wireless services providers. The public will benefit from an increased variety of services, expanded choices among service providers, improved quality, reduced cost and improved utilization of spectrum by facilitating diverse cell sites.

Fulfilling this potential effectively and providing such benefits to all members of the global community will require the innovative and creative application of satellite technology to complement and extend the reach of terrestrial wireless systems and services. The M-Star System can help provide global reach and cost-competitive communications to all regions of the world.

B. Trends

1. Key Technology Trends

The paradigm of wireless communications comprising primarily voice telephony is rapidly giving way to telecommunications that are "more than just voice." There are a number of technological and economic trends that create a demand for feasible and affordable wireless telecommunications services.

a) Personal Communication Services

Today's society requires mobility. Cellular, paging and portable computing are all moving beyond the very high end of the market toward becoming mass market products. With an expanding variety of services and service providers and continued reductions in service costs, cellular, paging and portable computing are moving toward becoming mass market products for communications.

Early PCS services for individuals and businesses will include several advanced forms of voice and data communications transmitted from pocket-size telephones, wireless facsimile machines and other portable devices.

In order to provide these expanded wireless communication services, a range of innovative solutions will be required. New frequency bands are being made available. Digital communications are being used in conjunction with advanced voice compression techniques to provide more capacity and increased services from existing and future frequency bands. Wireless coverage areas are being subdivided into smaller and smaller geographical coverage areas migrating from "micro" cells to "pico" cells. The migration toward smaller and smaller cell sizes increases the demand for interconnection capabilities.

Growth of Wireless Subscribers

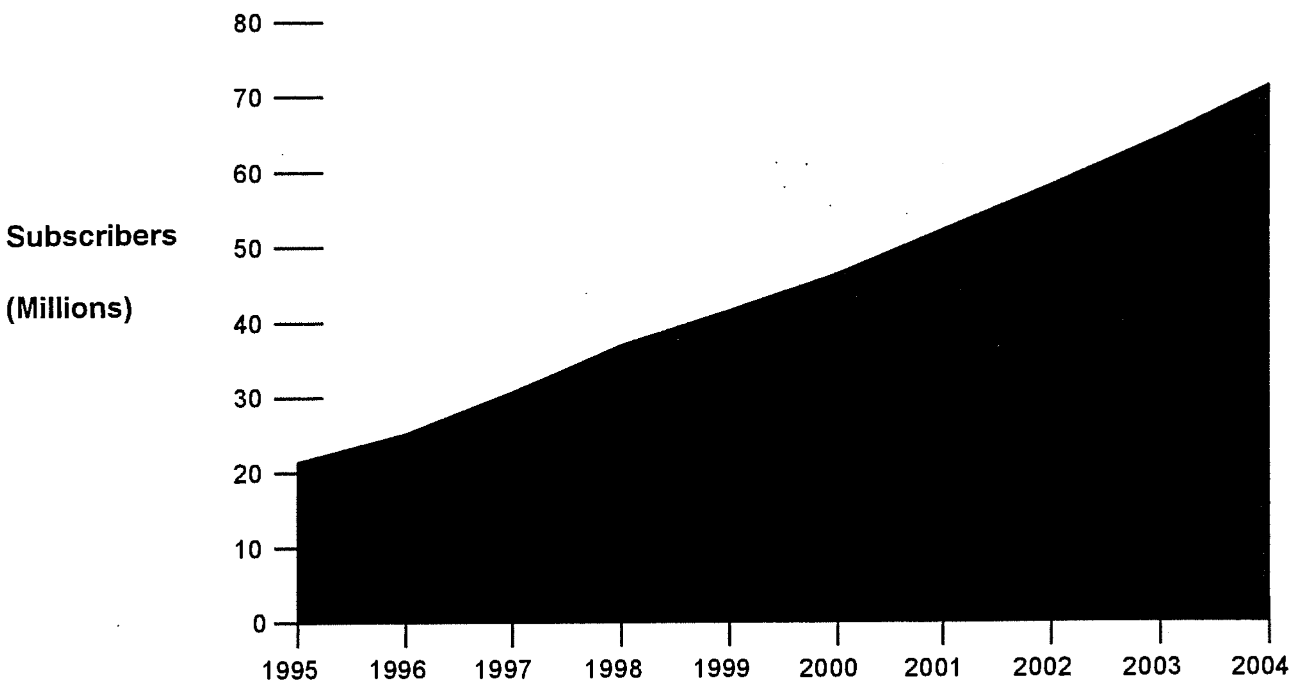

Figure III-1

Figure III-1 shows the growth of wireless subscribers forecasted by The Yankee Group (Reference: "PCS: The Implementation Phase", the Yankee Group, February 1995).

b) Digital Technology

In the middle to late 1960s, digital encoding and switching of voice communications were introduced, making possible the transmission of voice in binary format similar to the text and data formats used by computers of the day. In the late 1970s and throughout the 1980s, image and graphics advances added still image to the binary format family in an affordable way. Currently, the implementation of digital compression techniques is adding video images to the list of binary formatted media. With the ability to handle all popular forms of media (voice, data, audio, image and video) in a single binary representation for storage, transmission and delivery, the ability to communicate and collaborate among individuals is at a new threshold. Transcending this threshold requires a global network that would help make available ubiquitous broadband communications. The M-Star System's wireless backhaul capability can provide the required connectivity between multiple remote sites to help make this possible.

c) Computers as Communication Devices

Technology changes are transforming personal computer and computer-based products from a sophisticated text processor and calculator into true multimedia information appliances capable of processing the data, voice, image and audio information that are the basis of the services described in this Application. Operating systems and software are being optimized to process images, voice, and video.

Computers are increasingly equipped with digital signal processors that can efficiently and rapidly handle multimedia signals. In 1970, a supercomputer could perform 1 million instructions per second; supercomputers today perform several billion instructions per second. There have been corresponding increases in the desktop machines for the office and home.

The advances in computer technology are enabling individuals access to powerful mobile computing capabilities, further satisfying society's needs for mobility. The M-Star System will help provide the interconnection of mobile computing capabilities of the future.

d) Local Area Networks

As the ability of computers to process information has increased, the ability of local area networks (LANs) to deliver that information has also increased. While a capacity of 10-16 Mbps was state-of-the-art 10 years ago, today's Fiber Distributed Data Interface (FDDI) networks and high speed Ethernet LANs can deliver 100 Mbps. With the advent of ATM and Ethernet switches, LANs are also evolving from shared networks where many users contend for the same bandwidth to switched networks where large amounts of bandwidth can be allocated to an individual user.[7] These changes are eliminating the local area bottleneck that has slowed the development of "bandwidth-hungry" multimedia applications and services. The M-Star System's private trunking capability will provide a flexible alternative to interconnecting remote LANs for an organization with geographically dispersed facilities.

2. Standards

The M-Star System is designed to be compatible with many world-wide voice protocols and formats. In recent years, standards organizations and industry have defined key standards for mobile voice communications. The new digital cellular standards compress voice communication streams, making it possible to increase the number of voice channels that can be carried in an equivalent frequency band. Some examples are listed below:

a) Technical Standards/Formats

<u>Existing standards</u>:

- IS-95 is the U.S. CDMA Digital Cellular Standard approved by the Telecommunications Industry Association (TIA).
- IS-54 is the U.S. Digital Cellular standard based on TDMA, and adopted by the TIA.

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[7] Switched Ethernets can deliver 10 Mbps to each user while ATM switches can deliver 25 or more Mbps to each user.

- IS-136 is an evolutionary enhancement to IS-54 with major new enhancements of a new DCCH, which will support additional services.
- GSM (General System for Mobile Telecommunications) is the pan-European Digital Cellular Radio standard.
- AMPS (Advanced Mobile Phone System) is an analog cellular FDMA system.
- NAMPS (Narrowband Advanced Mobile Phone System) is an analog cellular FDMA system.
- NMT450 is the Nordic Mobile Telephone system.
- DECT (Digital European Cordless Telecommunications) is an ETSI standard intended for in-building wireless voice services.
- iDEN (Integrated Dispatch Enhanced Network) is a digital ESMR radio system.
- PHS (Personal Handy Phone System) is a low-tier PCS Japanese standard which uses TDMA and TDD.

<u>Future standards</u>:

- UMTS (Universal Mobile Telecommunications) is a next generation mobile and personal wireless access system.
- FPLMTS (Future Public Land Mobile Telecommunications System) is a next generation mobile and personal wireless access system.

The M-Star System will also inter-operate with other prevailing sub-networks via protocol adapters such as:

- ISDN (Integrated Service Digital Network)
- Frame Relay
- X.25
- TCP/IP (Transmission Control Protocol/Internet Protocol)

- ATM (Asynchronous Transfer Mode)
- FDDI (Fiber Distributed Data Interface)
- SONET (Synchronous Optical Network)
- SDH (Synchronous Digital Hierarchy)
- OC-X (Optical Carrier Level X)

C. Proposed M-Star Services

The wireless interconnection market will include wireless service providers and business users that require two-way interconnection from a Mobile Telephone Switching Office (MTSO) or Base Station Controller to remote cell sites. These interconnects are used to backhaul voice/data signals to and from remote sites and their central facilities. The required access rates to these remote sites can vary. Typical rates are in the 1.5 Mbps to 2.0 Mbps range. The baseline design for the M-Star System will provide 2.048 Mbps rates to remote facilities and 51.84 Mbps to central facilities. A high rate interconnect service will also be provided at 51.84 Mbps to interconnect central facilities for service providers or business customers.

1. Service and Application Characteristics

The M-Star System will offer two categories of services. The first category includes voice and data backhaul to service providers and business customers. This class of service will provide 2.048 Mbps (E1) to and from multiple remote sites which can be backhauled to a hub at 51.84 Mbps (OC-1). This service category can be used to provide a two-way backhaul service or to provide one-way point-to-multipoint or multipoint-to-point service.

The second category of services will be interconnection services at up to 51.84 Mbps. This service will enable terrestrial carriers to aggregate voice and data signals.

The following is a list of the voice and data services that could be provided over the M-Star System.

a) Backhaul Services

Wireless Backhaul would allow even remote islands of wireless services to interconnect to the global telephone network. In this application, the M-Star System would interconnect with the wireless service provider, not with an end user. This service would enable universal access to wireless services through isolated service providers anywhere in the world and could also be used for disaster recovery and emergency services.

One-Way communications can be utilized for point-to-multipoint services. Point-to-multipoint services will provide businesses and service providers the ability to access the satellite network with a 51.84 Mbps channel which can be downloaded to separate remote sites at 2.048 Mbps. The one-way multipoint-to-point services will permit remote sites to uplink at 2.048 Mbps to the satellite network where the signal will be concentrated and linked down to a central point at 51.84 Mbps, for such applications as financial transactions, retail and remote data collection.

b) Aggregated Voice/Data Services

LAN-to-LAN interconnection will allow for routing at remote locations through a satellite channel. It would also allow remote branch locations access to corporate headquarters' data services. This service would use a symmetrical link running at up to 51.84 Mbps. Most LAN-to-LAN connections are expected to require over 1.5 Mbps in service data rates.

Interexchange Carrier Backhaul Services aggregate domestic and international voice and data long distance traffic. The M-Star System will facilitate the delivery of voice and other traffic to numerous points from a single collection point.

A summary of applications and data rates supported by the M-Star System is shown in Table III-1.

	E1 To/From Remote 2.048 Mbps	**OC-1 To/From HUB 51.84 Mbps**	**OC-1 Point-To-Point 51.84 Mbps**
Wireless Backhaul	**X**	**X**	
Point-to-Multipoint	**X**	**X**	
Multipoint-to-Point	**X**	**X**	
LAN-to-LAN			**X**
Interexchange Carrier			**X**

Table III-1

D. Demand Analysis

1. Markets and Estimated Demand

The following markets could be served by the M-Star System. Some services can be targeted to multiple markets. For example, the wireless backhaul service could be sold directly to a business user or to a wireless network operator who would utilize the service in its terrestrial network.

Target Markets:

- Wireless service providers
- Corporate customers (large businesses)
- Terrestrial carriers, who need to link their networks to other carriers' networks, or to isolated customers. These customers include traditional telephony providers and value added networks.

The M-Star System will affect the lives of millions of households and businesses world-wide. Fast demand growth is projected on the basis of data and estimates applicable to the discrete categories of services described above. The following are some examples:

a) Backhaul Service Demand

According to The Yankee Group ("PCS: The Implementation Phase", the Yankee Group, February 1995), within the United States alone the total number of PCS/Cellular/ESMR subscribers will grow to 58.1 million by the year 2002. PCS growth projections from Bellcore similarly show a worldwide market of over 80 million subscribers by the year 2000. The services to be provided by the M-Star System will include:

- Cellular Backhaul Service
- PCS Backhaul Service
- Wireless Local Loop Backhaul Service
- Retail Point of Sale Backhaul Service
- Corporate Private Broadcast
- Corporate Private Data Distribution Service

b) Voice/Data Aggregated Demand

International voice traffic is growing at over 12% per year. The services to be provided will include:

- Interexchange Transport Service
- Private Line Networks
- Backup and Disaster Recovery

2. Geographic Coverage

As detailed below, the M-Star System constellation will provide around-the-clock coverage of major urban centers between 57° Northern and 57° Southern latitudes at elevation angles of at least 22 degrees. In other words, the system will be capable of providing service to and from virtually any point between these two latitude boundaries, 24 hours a day. With respect to the United States, the system will provide continuous 24-hour-a-day service to any point in the contiguous United States, Hawaii, the Commonwealth of Puerto Rico, the U.S. Virgin Islands and all U.S. territories. The population centers of Alaska will also be served by this system. Indeed, the M-Star System will provide nearly continuous double coverage (i.e., coverage by two satellites) of all points in the 48 contiguous states. Such coverage can facilitate the sharing of spectrum and provide for peaking capacity.

E. Key Advantages Over Terrestrial Services

In all cases, the services addressed by this Application have counterparts in terrestrial networks. Satellite delivery, however, has several critical advantages. The primary advantage is speed of service activation. A customer who is not already connected to a terrestrial network may have to wait months (possibly years in some areas of the world) to obtain service. In contrast, that customer can receive satellite based service as soon as a satellite terminal can be delivered.

The secondary advantage of a global satellite system is its reach. While terrestrial networks are typically restricted to a confined geographical area, the M-Star System can serve most points in the world. Moreover, terrestrial networks are likely to serve only large concentrations of customers, such as those found in major metropolitan areas. In contrast, the M-Star System can serve virtually any customer no matter how geographically isolated the customer may be. To appreciate this point, it is instructive to consider that although telephony services are over 100 years old, less than 5% of potential customers in large parts of Asia and Africa have basic telephony service. In sum, the M-Star System can help facilitate ubiquitous services that terrestrial networks will not be able to provide for decades to come, if at all.

A third advantage is interoperability. A communication solution over a large geographic area (e.g., multiple countries) will often involve multiple terrestrial carriers. Each carrier will offer different service features, and the services of the carriers may not interoperate. In contrast, a satellite system can link two or more locations around the world and offer customers a single network with a common set of features and interfaces, thereby guaranteeing interoperability.

F. Information Concerning Sales of Communications Services Regulatory Classification

MSS Inc. intends to operate the M-Star System as a non-common carrier with respect to all of the foregoing services. It will not provide services directly to the public. Rather, MSS Inc. will market the M-Star space segment capacity on a wholesale basis to other providers, each of which will offer their services to end users in a particular territory. MSS Inc. will make individualized decisions with respect to the choice of each provider and the terms of its relationship with each such provider, and will enter into long-term relationships with those providers. Consequently, MSS Inc. will not hold itself out indiscriminately to serve the public, nor should there be any legal compulsion to regulate it as a common carrier. See National Association of Regulatory Utility Commissioners v. FCC, 525 F.2d 630, 642 (D.C. Cir.), cert. denied, 425 U.S. 999 (1976) (NARUC I). Therefore, in accordance with the Commission's DISCO I Report and Order, MSS Inc. elects to offer services on a non-common carrier basis.[8]

[8] Amendment to the Commission's Regulatory Policies Governing Domestic Fixed Satellites and Separate International Satellite Systems, Report and Order, 11 FCC Rcd. 2429, 2436 (1996) (DISCO I Report and Order).

IV. SYSTEM DESCRIPTION

A. General Overview of the System

The M-Star System is a low earth orbit (LEO) satellite communications network designed to provide broadband transport services around the world. It will facilitate the growth of existing and anticipated wireless communications infrastructures, such as PCS, GSM, UMTS, DCS-1900 and CDMA cellular by providing wireless service operators a readily available means for the interconnection of cell sites, mobile telephone switching offices (MTSOs),[9] and system control facilities. It also will provide high capacity global transport services for enterprise networking and other private data services.

The system will comprise a space constellation of 72 LEO satellites, a System Control Segment (SCS) consisting of two Operations Facilities and four remote antenna sites for constellation and network operations, and Customer Premises Equipment (CPE) to provide access to the system for wireless service providers and other system users.

The network architecture for the system is based on a constellation of interconnected transponding satellites, along with the associated ground equipment. Approximately one half of the transponder channels on each satellite are especially designed to provide backhaul services for a wireless access group. The wireless access group transponders will

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[9] For the purpose of this filing, the term Mobile Telephone Switching Office (or MTSO) is used generically to refer to the central controller for a group of remotely located cell transceivers. For example, in a GSM or DCS-1800/1900 system, the M-Star system would provide the interconnection between the Base Station Controller (BSC) and a group of Base Transceiver Stations (BTS). Other cellular wireless communication systems use somewhat different architectural elements and interfaces, but they all require the backhaul function between cell sites and a central controller.

provide local data link connections between a set of cell sites in a wireless communications system and the associated MTSO. These transponders are also suitable for other local backhaul services where a central control point must communicate with a number of remote sites. The remaining transponder channels will be connected via a flexible switching and intersatellite link structure to provide high capacity (OC-1) data links for intra-system and inter-system wireless network connections and global enterprise networking.

A LEO constellation has been selected for M-Star to ensure that the transmission delays experienced by end users are essentially equivalent to domestic transport systems for global real-time voice and data services. Typical intercontinental delays for information traffic between two end users via M-Star will be 80 milliseconds. Geostationary orbit (GSO) systems encounter difficulties supporting real-time services in a comparable manner, experiencing substantially greater delays between ground equipment and satellite nodes, and between satellite nodes as signals traverse the geostationary arc through intersatellite links or multiple hops to intercontinental gateways.

Another reason for selecting a LEO constellation is to provide a very large overall system capacity with relatively modest individual satellite complexity. Each M-Star satellite is capable of supporting up to 1,800 cell sites (assuming an E-1 rate cell site-to-MTSO connection) along with 64 point-to-point OC-1 links. The aggregate realizable capacity for the system, however, is continuous support for about 43,000 cell sites and 1,500 full duplex OC-1 connections. Since these LEO satellites will primarily provide Earth-to-space and space-to-earth connections over populated land areas, they enjoy the additional advantage of long opportunities for recharging their energy supplies. This allows for further simplification of the satellite power subsystems.

Orbits for the 72 satellites comprising the M-Star constellation have been chosen to provide double or triple instantaneous satellite coverage for over 99% of the major urban centers where existing cellular and wireless systems are expected to be deployed. This geometric diversity is employed to maintain the desired quality-of-service under changing atmospheric conditions (e.g. rain fade), and to increase the capacity that can be realized in a particular geographic location. Equally important, the geometric diversity provided by multiple satellites in view facilitates coordination with other satellite-based systems utilizing the same bandwidth, provided the designs of such systems permit cooperation in a like manner.

The requested spectrum for the M-Star System is 38/48 GHz for service links and in the 59/64 GHz bands for intersatellite links.[10] The distribution of end users, which is correlated to the population distribution throughout the global coverage area, will naturally create high peak demands on the system, a key driver in the overall spectrum requirements for the system. The LEO constellation geometry, in conjunction with a versatile satellite payload design, creates a number of relatively small service areas in the coverage footprint, which is instrumental in supporting the highly peaked traffic demands. In terms of capacity density (i.e., capacity per unit of bandwidth per unit area) in a service area, M-Star achieves nearly 5 times that of GSO systems proposed for similar applications.

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[10] An additional allocation in a suitable FSS band below 18 GHz will be used for TT&C launch operations and during failure recovery operations.

The M-Star infrastructure includes two basic types of customer ground systems with their associated Customer Premises Equipment (CPE). The first type of customer ground system is a wireless backhaul interface system for a Wireless Access Group (WAG). A WAG ground system includes two types of CPE. The first is a high capacity MTSO interface unit which controls the group and processes the data from remote sites. The second type of CPE in a WAG is a set of low cost remote cell site interface units which operates in MTSO-directed mode. The second type of customer ground system for the M-Star System uses variations of one fundamental type of CPE, a High Bit Rate Terminal (HBRT) that supports information rates up to 51.84 Mbps (OC-1).

The WAG CPE architecture (Figure IV-1) allows the MTSO interface unit to communicate with the remote cell site interface units via a FDMA/TDMA format. The MTSO interface CPE provides the centralized timing and control for the WAG. This control manages the FDMA/TDMA multiplexing for the remote site interface CPEs and directs other radio link functions such as uplink power control. A WAG is nominally sized to support 25 cell sites, each communicating with the MTSO at a data rate of 2.048 Mbps (E-1). The wireless system operator, however, has the option to redistribute this backhaul capacity by modifying the FDMA/TDMA frame.

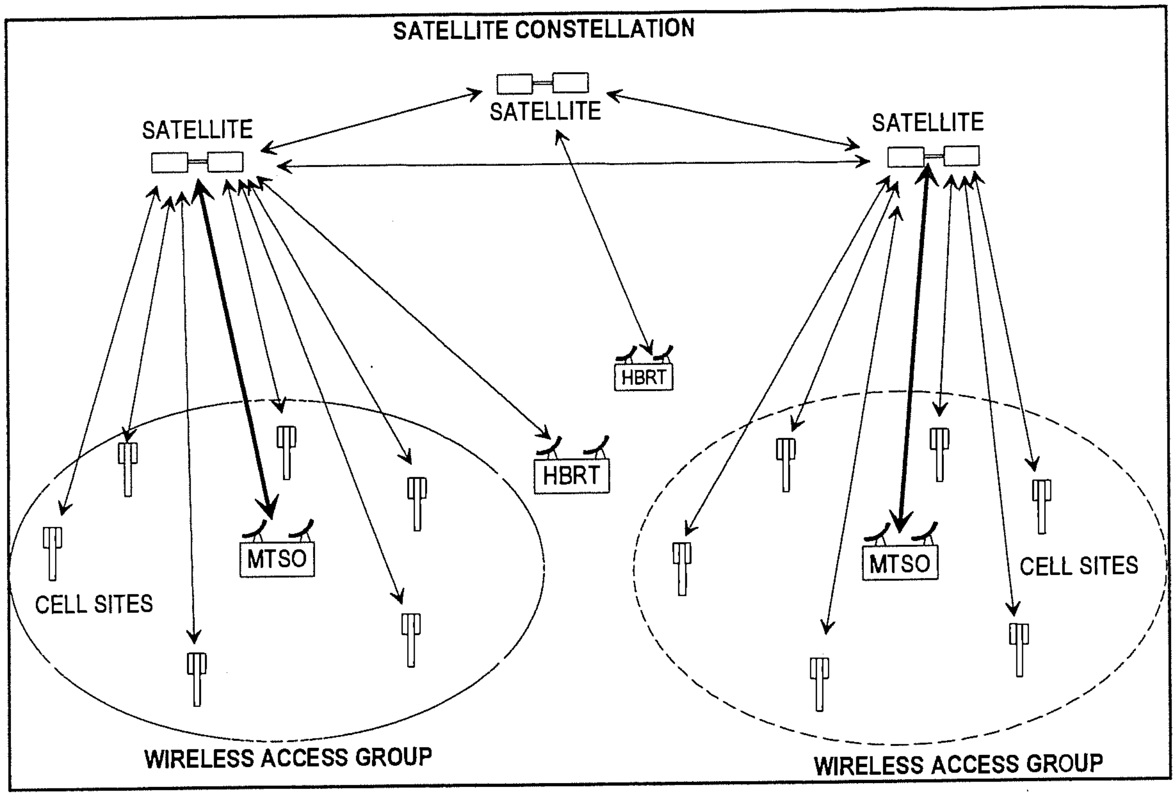

FIGURE IV-1: Wireless Access Group Architecture

The HBRT CPE (Figure IV-2) is designed to be compatible with various equipment normally supported by OC-1 physical networks. The fundamental CPE provides a standard OC-1 interface with SONET/SDH framing and formatting that allows manufacturers and their customers a broad range of options in developing CPE installations. In addition to this basic unit, it is anticipated that manufacturers will offer CPE configurations to support the variety of standard electrical and optical interconnects used in existing telecommunications systems. For example, the CPE shown in Figure IV-2 can be configured by selection of protocol adapters to support E-1, T-1, OC-1, T-3, Ethernet, FDDI, and other standard physical interfaces as well as the vast assortment of network interconnection standards, such as ATM, ISDN, X.25, Frame Relay, TCP/IP, and others.

All CPE terminals use directional antennas to maintain contact with the space constellation, with at least two independent antenna beams per terminal to support make-before-break handoffs. The CPE antennas planned for use with M-Star range in aperture size from 0.66 meters for the individual cell site interface antennas to 1.5 meters for the MTSO interface and OC-1 link antennas.

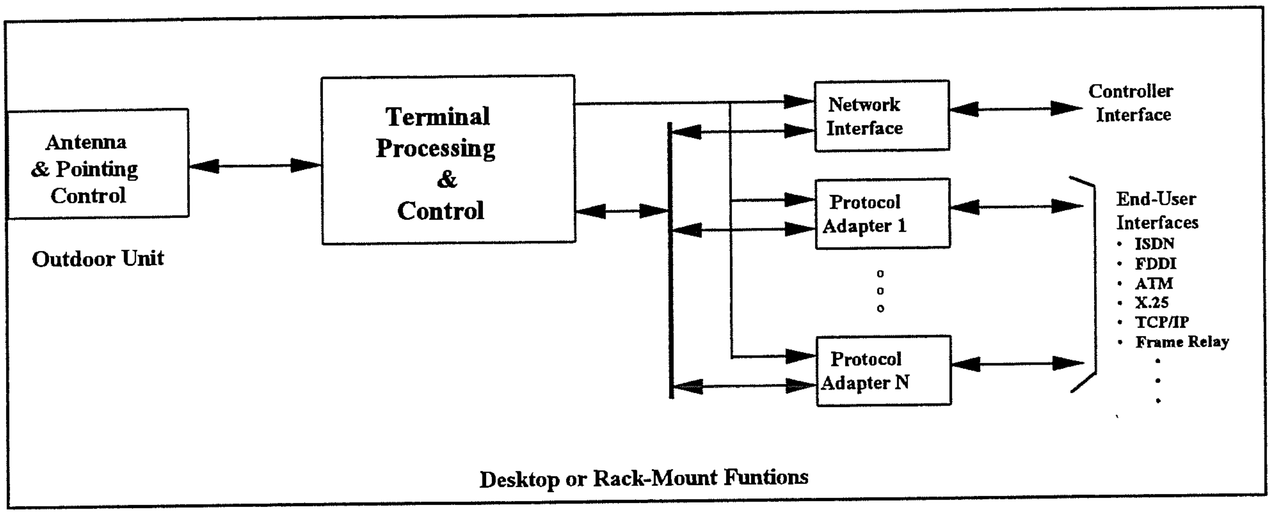

Figure IV-2: High Bit Rate Terminal Customer Premises Equipment Block Diagram

The payload design for M-Star (Figure IV-3) includes uplink and downlink antennas to form service beams that project cells on the Earth's surface, transponders connected to the beams via switch matrices and a control processor. Interconnections to other satellite nodes -- which form the satellite network -- utilize four intersatellite links operating in the 59.0 - 64.0 GHz band (described in Table IV-4).

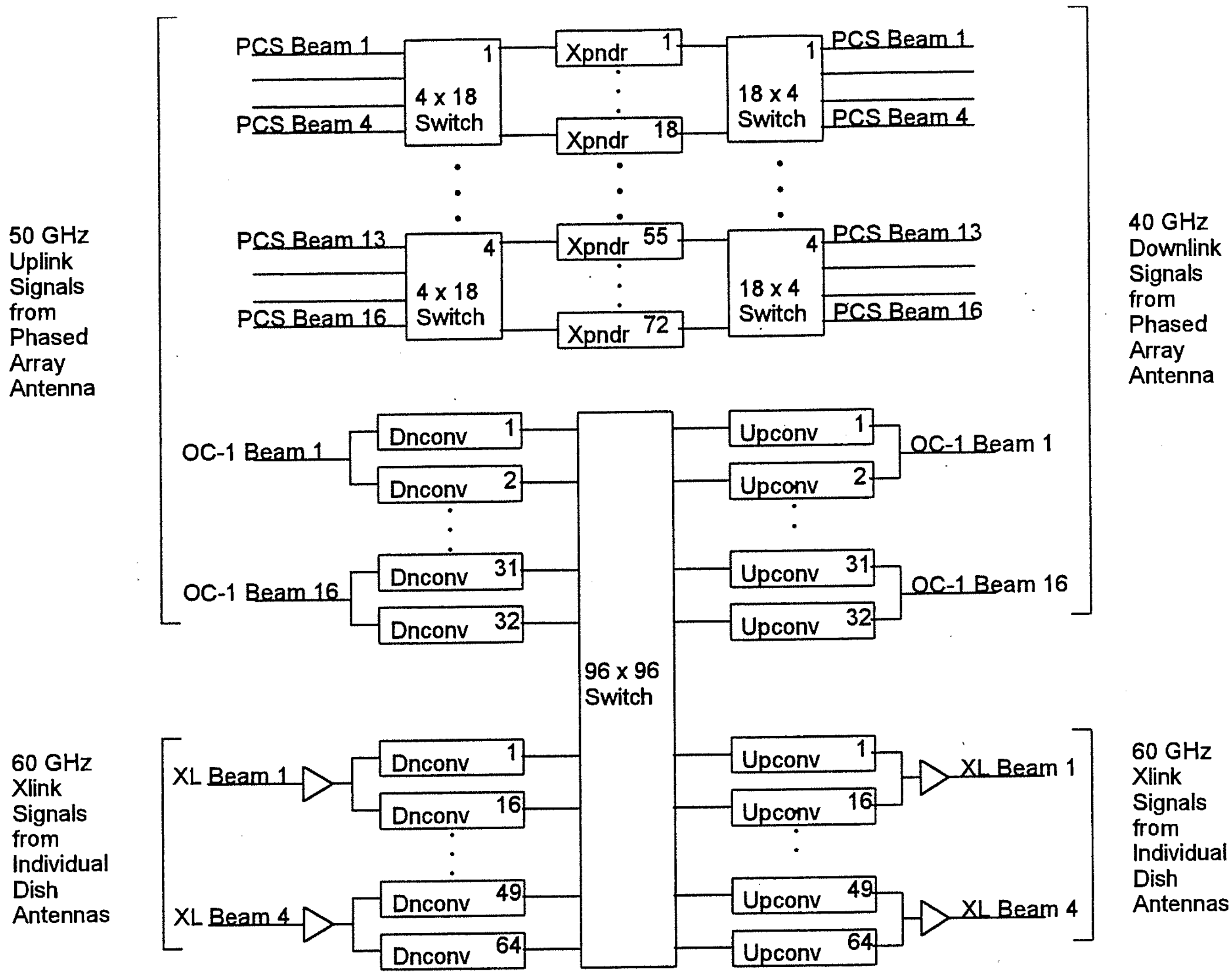

Figure IV-3: Satellite Payload Block Diagram

Network and constellation operations for M-Star are accomplished from one of two Operations Facilities. Each of the facilities is linked with all of the antenna sites, which will be strategically located in the coverage area to maintain contact with the constellation for line-of-sight communications. This mode of communications supports launch operations, operations in parking and sparing orbits, orbit transfer operations, on-station operations to recover from anomalies, and satellite decommissioning. When a satellite is on-station and operational, constellation and network operations utilize the M-Star network to move control and telemetry packets between nodes.

B. Orbit Considerations

The constellation's orbital parameters were selected after careful consideration of many criteria. **First**, the constellation must provide the ability to share spectrum with other satellite systems. This criterion places a requirement on the constellation to have multiple satellites in view of subscribers a large percentage of the time to permit the Network Operations Control Center (NOCC) in the Operations Facility to assign a serving satellite to the subscriber which will not interfere with external systems' service beams also being used in the same region. **Second**, to maximize the available power to the user in the desired coverage area, while maintaining compliance with Section 25.208(c) of the Commission's Rules and ITU RR.2581, the system must maintain greater than a 22 degree minimum elevation angle with respect to the subscriber's viewing geometry. **Third**, the system must provide coverage of the major populated areas of the Earth. **Fourth**, consideration was given to the chosen orbits of systems which have already filed applications for any type of service with the FCC. **Fifth**, the system must be cost-effective and minimize the total number of satellites required. **Sixth**, the capacity of each individual satellite and the ability of the system to deliver that capacity to a specific region of the Earth (such as CONUS) must be in concert with the business plan.

Upon analyzing each of these criteria, a 72-satellite constellation was selected and designed that consists of 12 planes each having 6 satellites per plane (Figure IV-4). The technical details of the constellation are given in Table IV-1.

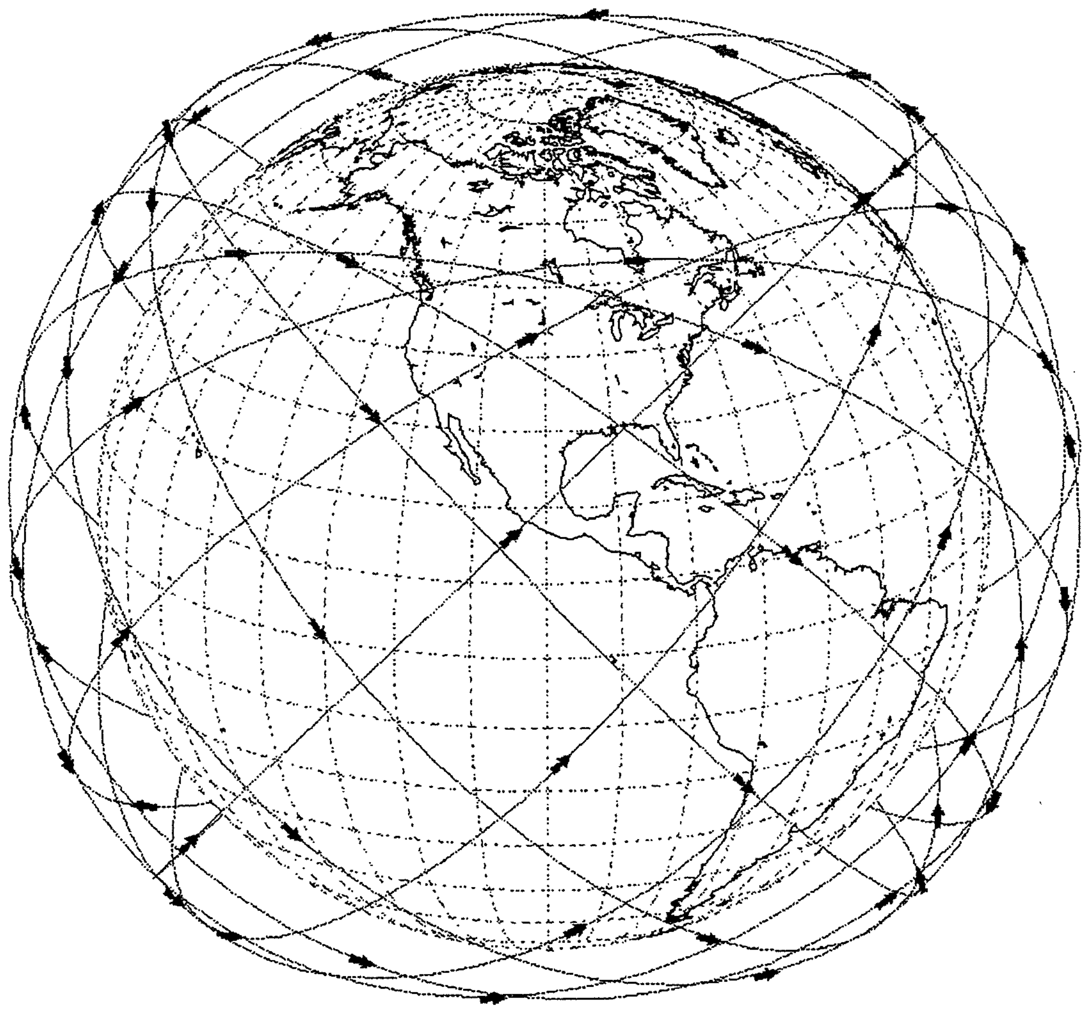

Figure IV-4: Constellation Configuration

The orbits in the constellation are inclined at 47 degrees providing multiple levels of coverage (Figure IV-5). The multiple levels of coverage ensure that population areas which lie between 55 degrees north latitude and 55 degrees south latitude will have greater than a 50% probability that at least two satellites will be in view simultaneously. For the latitudes between 26 degrees and 49 degrees (roughly equivalent to the north and south extremes of CONUS), double coverage is provided more than 80% of the time. Three satellites are in view of subscribers within these latitudes at least 20% of the time and for most of the region it is above 40% of the time.

With only a 1% of the time exception at around 15 degrees latitude, continuous single coverage is provided between 57 degrees north and south latitudes.

Number of Planes	12
Satellites per Plane	6
Inclination	47°
Altitude	1,350 km
Argument Of Perigee	90°
Eccentricity	0.0013
Plane Spacing At Equator	30°
Plane Phasing	+25°
Minimum Elevation Angle	22°
Orbit Period	6761 seconds

Table IV-1: Constellation Technical Parameters

The M-Star network will utilize other orbital altitudes in the vicinity of the mission orbit defined above. The booster types being considered will be capable of placing multiple satellites into a 200 km circular orbit. On-orbit spares will be maintained in a 1,300 km orbit just below the 1,350 km mission orbit and moved into the mission orbit when required. The separation of parking, sparing and mission orbits has been selected to eliminate the probability of collision by satellites in different orbits.

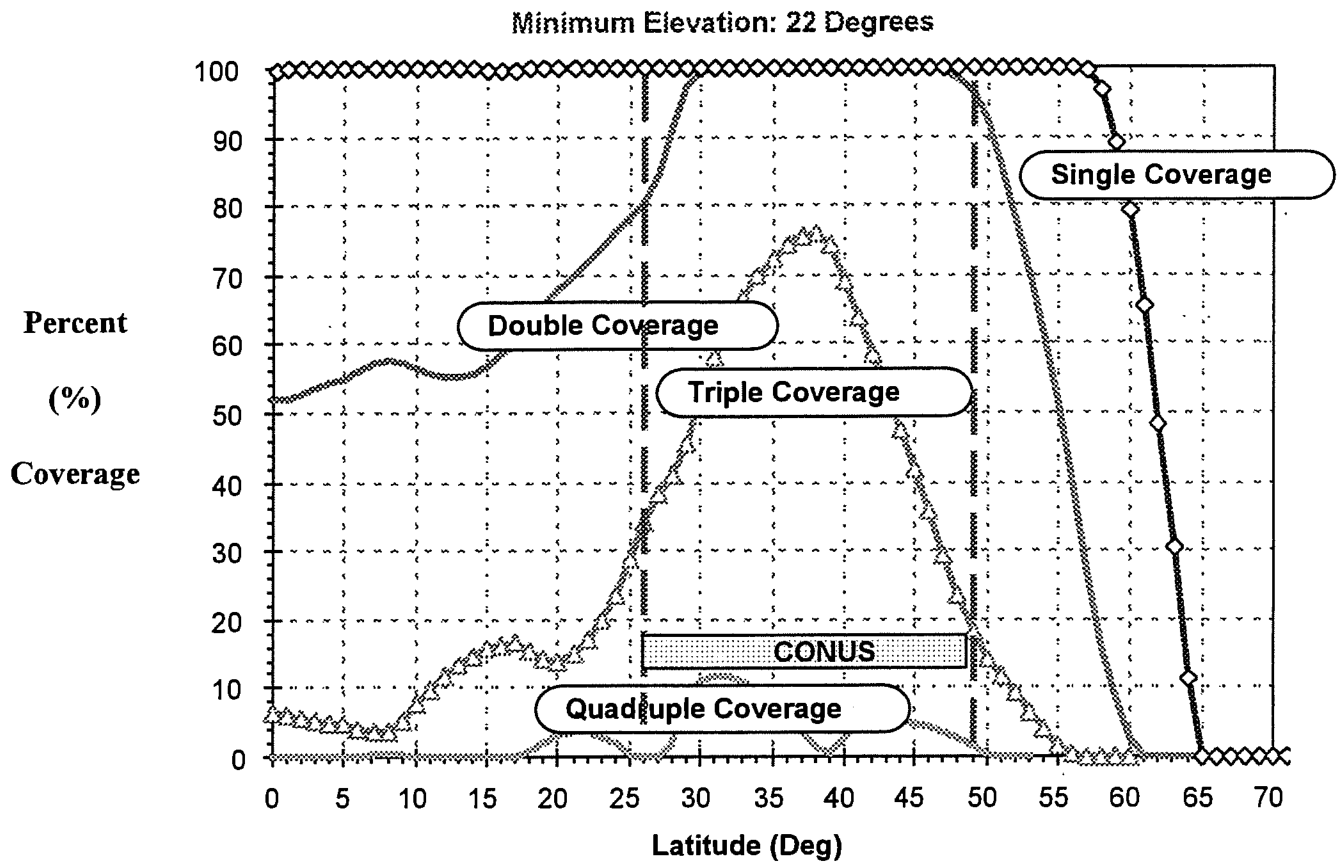

Figure IV-5: Constellation Coverage Performance

C. Space Segment - Overview

Figure IV-6 is a conceptual drawing to illustrate the on-orbit configuration for the M-Star satellite design. Key objectives in the design are to minimize interfaces and deployment mechanisms to enhance manufacturability and mitigate the risk of faulty deployment.

The drawing depicts candidate mounting locations for the 60 GHz crosslink antennas. These locations provide the necessary degrees of azimuth and elevation pointing.

The large flat surface on the nadir end of the satellite satisfies two objectives. First, it provides a mounting surface for the service link antennas. In satisfying this purpose, the location on the nadir panel provides an efficient means of interfacing to the payload electronics above the panel. The second objective for the nadir surface is to provide sufficient surface area to distribute and radiate some of the heat generated in the small antenna apertures.

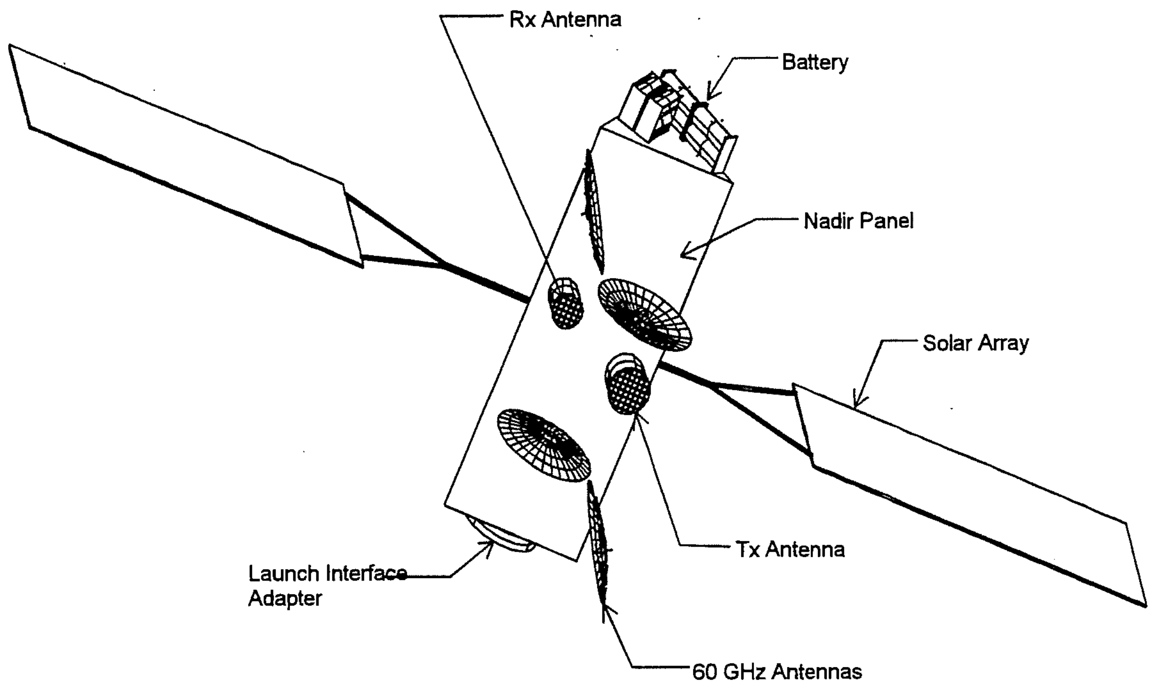

Figure IV-6: M-Star System Satellite Concept

The figure depicts the triangular shape that, in a stowed configuration, permits several satellites to be "stacked", or placed side-by-side, in a launch configuration. The primary requirements for the initial deployment of the satellites, once they have separated from the launch vehicle, are to deploy the solar arrays and attain a stable attitude.

The following table contains a list of key characteristics of the M-Star satellites:

Table IV-2 General Satellite Characteristics

Peak DC Power	3,100 W @ End-of-Life
Average DC Power	1,530 W @ End-of-Life
Mission Life	8 Yrs (Operational Capability) 10 Yrs (Expendables & Decommissioning Functions)
Stabilization	3 Axis Stabilized, Momentum Bias with gyros, Earth and star sensors
Positioning Sensor	GPS
Stationkeeping	8 km
Deployed Length (Overall)	43 feet
Total Satellite Wet Weight	2,535 lbs
Satellite Dry Weight	2,210 lbs
Propellant	323 lbs (Transfer & Stationkeeping)
Tracking, Telemetry and Command (Primary TT&C)	
Normal Operations	8 TT&C Channels
Frequencies	Service link frequencies (38/48 GHz)
Command Link Rate	56 kbps; 2.5 MHz total BW
Telemetry Link Rate	100 kbps; 2.5 MHz total BW
Satellite Antenna (Cmd & Tlm)	High gain

Tracking, Telemetry and Command (Secondary TT&C)

Deployment, Transfer, Abnormal Ops	8 TT&C Channels
Frequencies	A suitable FSS band below 18 GHz
Command Link Rate	56 kbps; 2.5 MHz total BW
Telemetry Link Rate	100 kbps; 2.5 MHz total BW
Satellite Antenna (Cmd & Tlm)	Omnidirectional

Communications Overview

Communication Beams per Satellite	
- User Service Links	32
- Crosslinks	4
Antenna Pointing	
- User Service Links	Electronically steered, nadir pointing
- Crosslinks	Mechanically steered
Frequencies of Operation	
- User Uplink	47.20 to 50.20 GHz bands
- User Downlink	37.50 to 40.50 GHz bands
- Intersatellite Link	59.00 to 61.35 & 61.65 to 64.00 GHz bands
Communication Beam Bandwidth	90 MHz For User Links
Polarization (Uplink/Downlink)	Circular, Right- or Left-hand
Peak Receive Flux Density	< -105 dBW/m2/MHz at 25° Elevation Angle (Edge of Coverage)

1. Radio Frequency and Polarization Plan

a) Uplink and Downlink User Service Links

The system design requires 3 GHz for uplink communications at 47.2 GHz to 50.2 GHz and 3 GHz for downlink communications at 37.5 GHz to 40.5 GHz. The demand for transport services is expected to grow significantly in the next few years, imposing new requirements for higher data rate links. Providing backhaul transport via a satellite network, will require a flexible allocation of several of these higher data rate links, within a single satellite footprint. This flexibility requires significant bandwidth not readily available in other frequency bands. Accordingly, operation in the 38/48 GHz bands is integral to the M-Star System's ability to support higher transmission rates.

Table IV-3 provides the frequency plan for the proposed uplinks and downlinks operating in the 38/48 GHz bands.

	Requested Frequency Band	**Polarization**
User Uplink	47.2 - 50.2 GHz	RHCP
User Downlink	37.5 - 40.5 GHz	LHCP

Table IV-3: Uplink/Downlink Frequency Plan

The system architecture for the M-Star System permits considerable flexibility in the channelization within the uplink and downlink bands. In addition to supporting several information rates on both uplink and downlink directions, the architecture permits subbands to be designated for various data rates and channel types. For example, bandwidth allocated for an OC-1 channel can alternatively be used for 25 E-1 channels.

b) Intersatellite Links

The system design includes intersatellite links to provide connectivity between wireless MTSOs with different serving satellites as well as for other services. The crosslink band plan is described in Table IV-4. The bands are used in pairs as indicated in this table. Polarization of the bands can be RHCP or LHCP, and each frequency band in a pair of bands can be used either in the transmit or receive mode. The precise assignment of polarization and transmit/receive pairings is dependent upon the specific location of the satellites in the constellation.

Frequency Band	Paired Band	Polarization
59 - 61.35 GHz	61.65 - 64 GHz	RHCP/LHCP, LHCP/RHCP

Table IV-4: RF Crosslinks Frequency Plan

c) Satellite Footprint and Antenna Contours

Figure IV-7 depicts a satellite coverage footprint with 22° minimum elevation angles at ground terminal sites. Also shown in Figure IV-7 are three example beams which are expanded in the views of Figures IV-8 through IV-10. Figure IV-8 shows the antenna pattern contour plot for a beam pointed directly under the satellite, to the nadir point. Figure IV-9 shows the antenna pattern contour plot for a beam pointed midway between nadir and the edge of the satellite footprint. Figure IV-10 shows the antenna pattern contour plot for a beam pointed to the edge of the satellite footprint

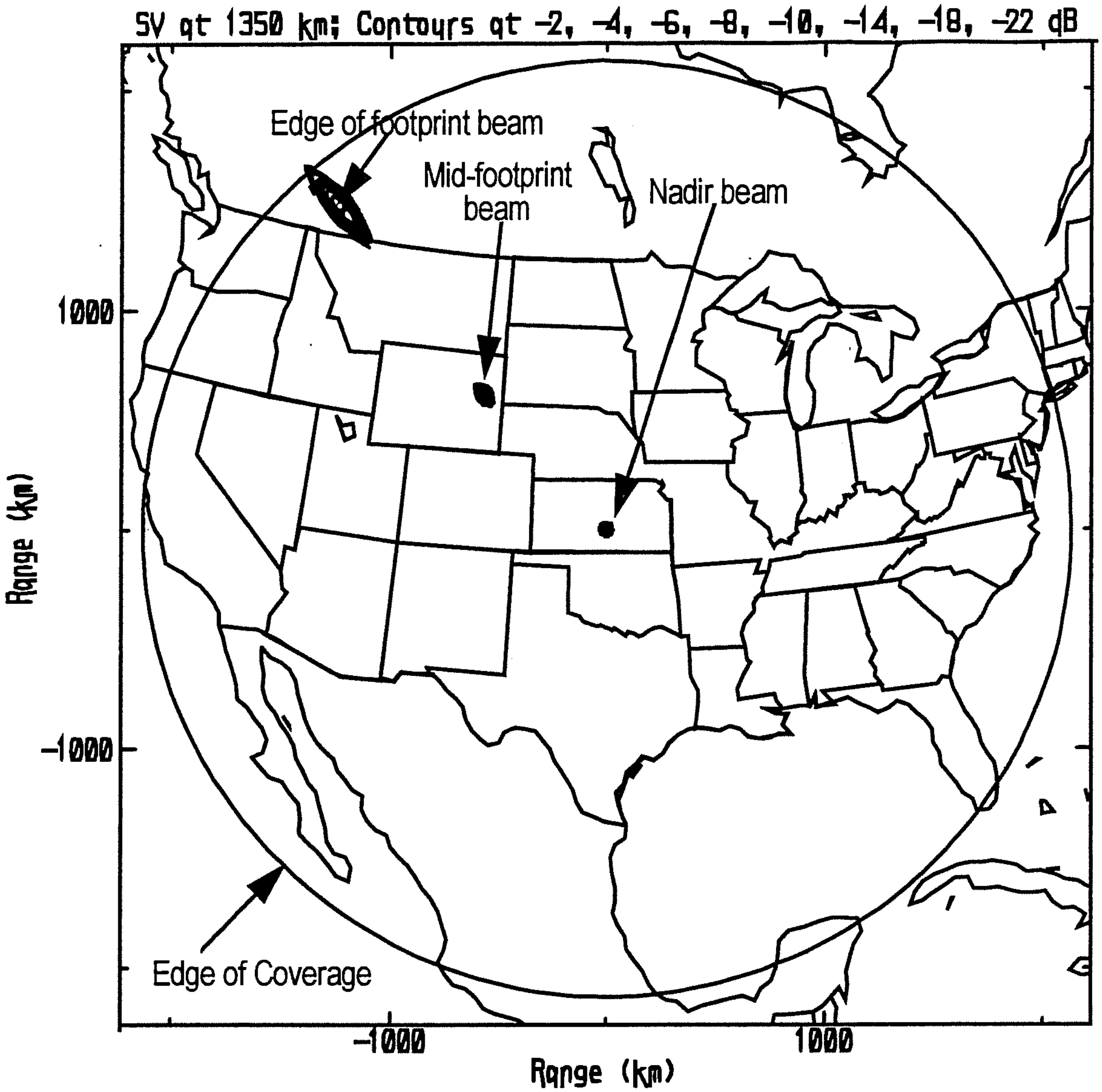

Figure IV-7: Satellite Footprint Plot

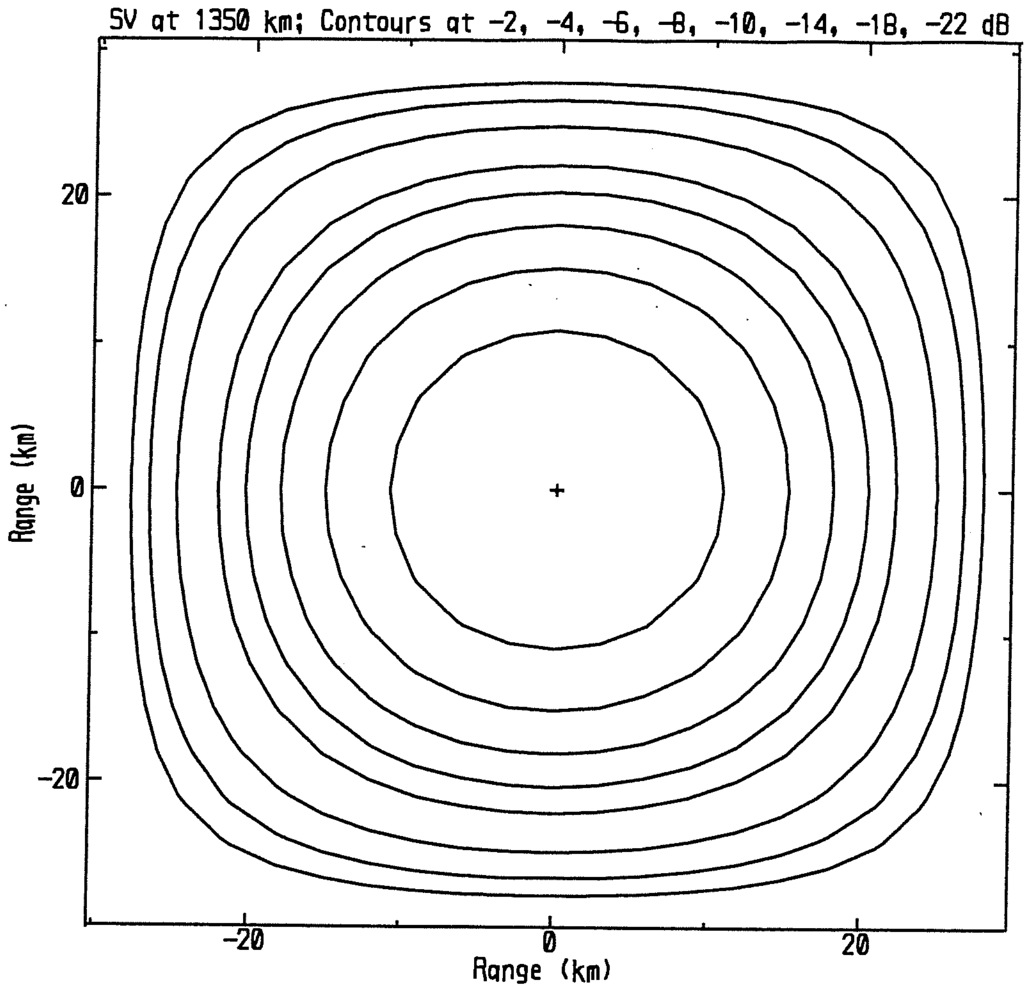

Figure IV-8: Example Nadir Beam Contour Plot
(Levels are at -2, -4, -6, -8, -10, -14, -18 and -22 dB relative to peak gain)

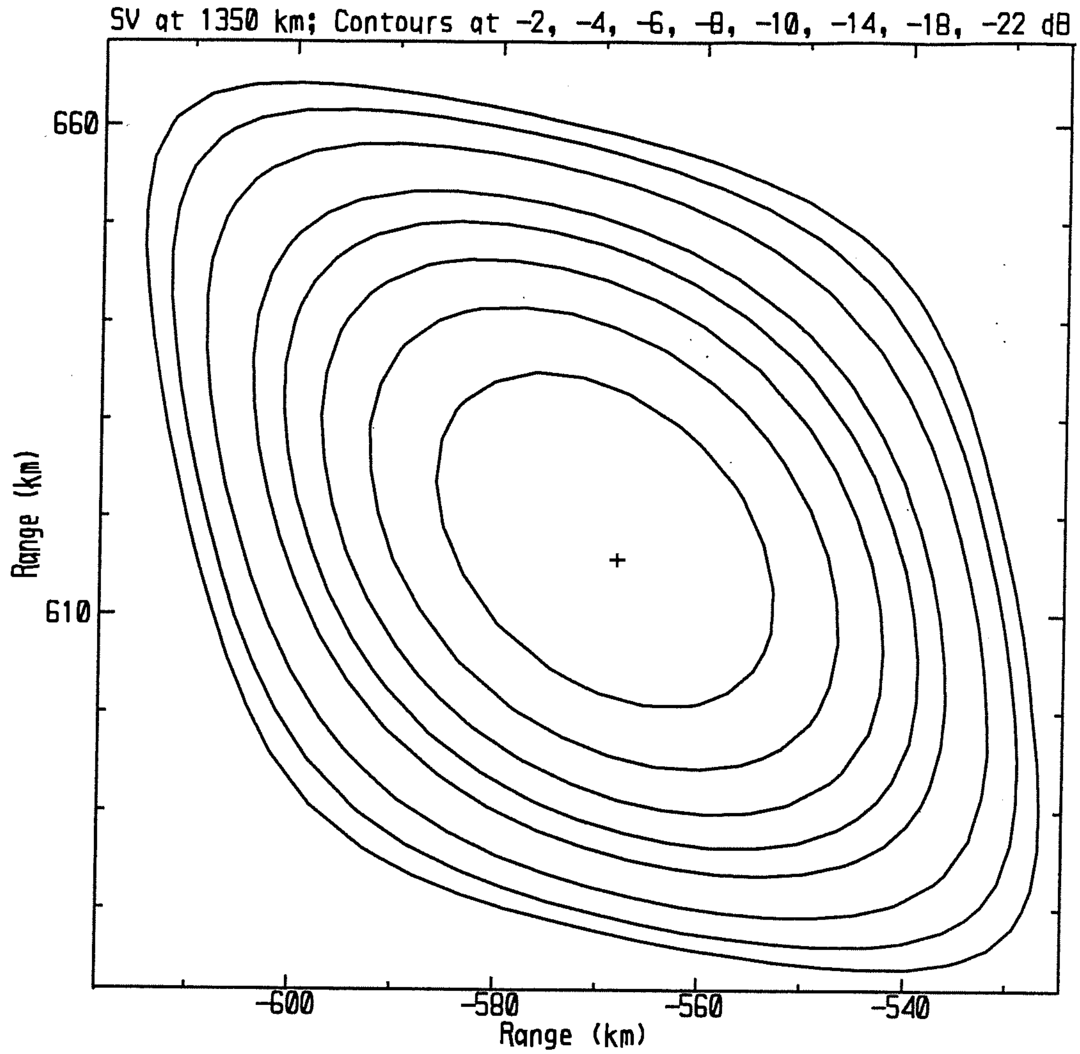

Figure IV-9: Example Mid-Field-of-View Beam Contour Plot
(Levels are at -2, -4, -6, -8, -10, -14, -18 and -22 dB relative to peak gain)

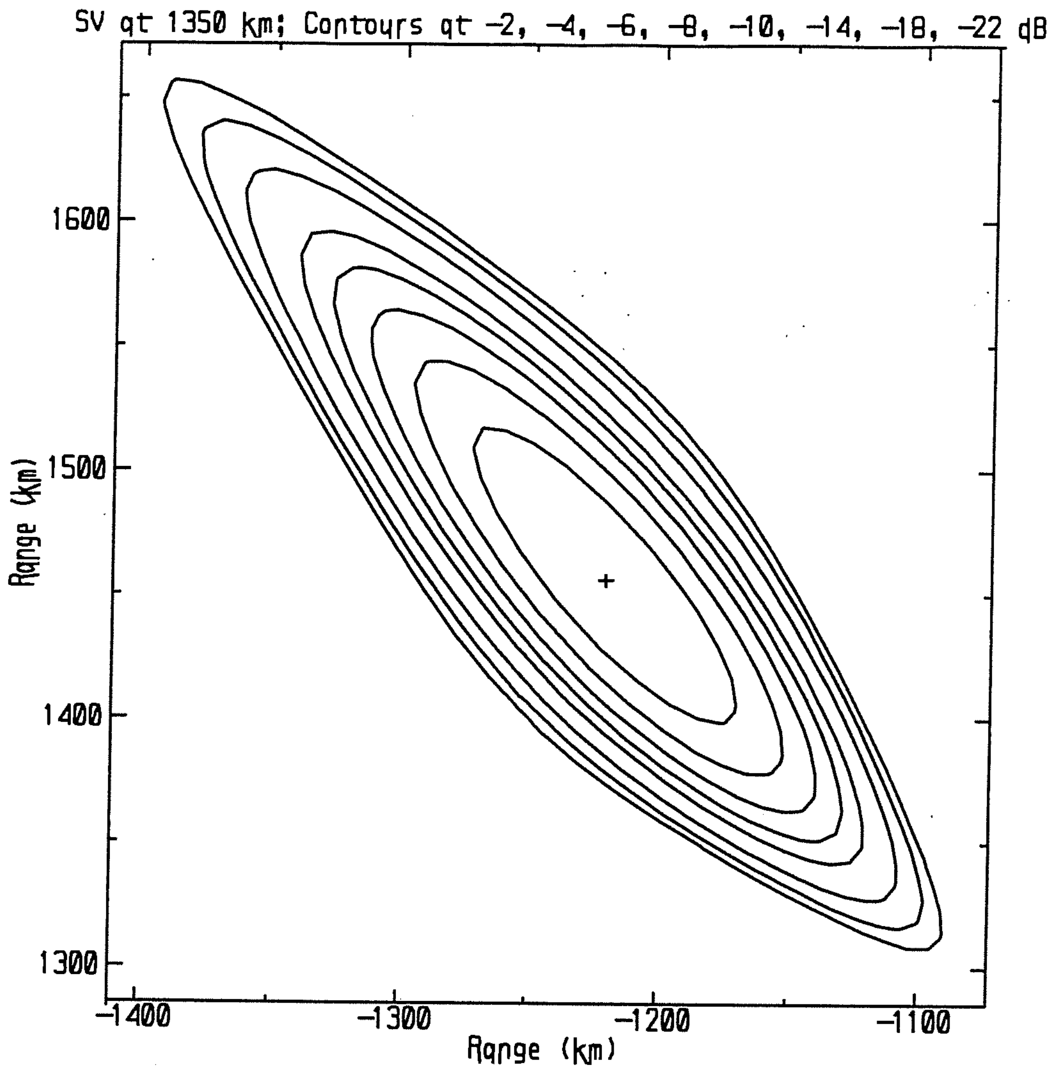

Figure IV-10: Example Edge-of-Footprint Beam Contour Plot
(Levels are at -2, -4, -6, -8, -10, -14, -18 and -22 dB relative to peak gain)

d) Emissions

The emission designators for the M-Star System's communications links, including all uplinks and downlinks as well as intersatellite links, are defined in Table IV-5. Table IV-6 provides a summary of transmitter output power and maximum EIRP for each of the links. Table IV-7 defines the satellite receiver parameters for each of the links. Table IV-8 provides the anticipated out-of-band emission performance for the uplinks and downlinks. For a more in-depth tabulation of the characteristics of the M-Star System's satellite links, refer to Appendix A.

Transmission Description	Emission Designator
E-1 Downlink	18M0G7W
E-1 Uplink	18M0G7W
HBR Downlink	90M0G7W
HBR Uplink	90M0G7W
Multicarrier Secondary Command Link	2M5G7D
Secondary Telemetry Downlink	2M5G7D
60 GHz RF Intersatellite Link	90MG7W

Table IV-5: Emission Designators

Satellite Link	Transmit Power Per Carrier, W	EIRP, dBW
Satellite To MTSO	0.02 to 0.13	19.9 to 29.1
Satellite To Cell Site/E-1	0.23 to 2.91	31.6 to 42.7
Satellite To HBR Terminal	0.1 to 2	51.49 to 56.02
Intersatellite Link	0.235	47.9
Normal TT&C	0.001 to 0.6	9.1 to 36.7

Table IV-6: Satellite Transmitter Output Power and EIRP[11]

[11] Terminal link numbers reflect performance with power control to compensate for rain conditions and range variations over the satellite footprint. Intersatellite link numbers reflect the maximum output power required to maintain the link at the maximum range.

Satellite Link	G/T, dB/K
User Uplink	10.5
Intersatellite Link	27
Normal TT&C Command Uplink	11.3

Table IV-7: Satellite Receiver Parameters[12]

Percent of Authorized Bandwidth From Carrier Frequency	Spurious Emissions Below Transmit Carrier Power, dBc
50 - 100	-25
100 - 250	-35
> 250	-65

Table IV-8: Emission Performance

2. Communications Subsystem

The satellites will use the latest developments in phased-array antenna technologies and switching technologies to achieve a high degree of spectrum efficiency and system flexibility. Spatial isolation will permit reusing the available spectrum within a footprint up to 32 times. In order to utilize on-board resources more efficiently, minimize interference, and provide protection against rain, dynamic power control will be used.

The antennas to be used on board the spacecraft will generate 32 beams to cover service areas within a satellite footprint. In addition, the use of phased-array antennas will obviate

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[12] G/T numbers for the uplinks vary over the satellite footprint.