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

Application

for

Authority to Construct, Launch and Operate the

Celestri Multimedia LEO System

A Global Network of Non-Geostationary Communications
Satellites Providing Broadband Services
in the Ka Band

Filed June 1997

Motorola Global Communications, Inc.
2501 S. Price Road
Chandler, Arizona 85248-2899

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

Philip L. Malet
James M. Talens
Pantelis Michalopoulos
Maury D. Shenk
Steptoe & Johnson LLP
1330 Connecticut Avenue, N. W.
Washington, D.C. 20036
(202) 429-3000

Executive Summary

Motorola Global Communications, Inc. ("Motorola"), a wholly-owned subsidiary of Motorola, Inc., hereby requests Commission authority to construct, launch and operate the Celestri Multimedia LEO System ("Celestri LEO System"), a non-geostationary orbit ("NGSO") global satellite system, offering a wide range of real-time broadband communication services in the Fixed-Satellite Service ("FSS"). The Celestri LEO System will comprise a total of 63 operational satellites in low-Earth orbit ("LEO") interconnected to virtually all of the populated land masses in the world. The Celestri LEO System will be an integral part of the Celestri System, whose other cornerstones are Motorola's Millennium System and M-Star System.

The service and gateway links of the Celestri LEO System will operate in the 18.8-19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth) and the 28.6-29.1 GHz and 29.5-30.0 GHz bands (Earth-to-space).[1] The TT&C high gain links will also operate in the service bands. The system will use optical inter-satellite links to interconnect the satellite network in space.

The Celestri LEO System comprises 63 satellites in 7 inclined orbital planes, up to 7 in-orbit spares, and the associated ground terminal equipment.[2] The satellites in each plane will rotate in circular orbits at an altitude of 1400 kilometers. The constellation is inclined at 48° with respect to the Equator.

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[1] Of these bands, the 18.8-19.3 GHz and 28.6-29.1 GHz bands have a primary domestic allocation for NGSO FSS. The 19.7-20.2 GHz and 29.5-30.0 GHz bands have a secondary domestic allocation for NGSO FSS. All bands have a worldwide primary FSS allocation. Motorola is cognizant of the obligations attendant upon system operators providing service pursuant to secondary allocations, and will comply with these obligations.

[2] Motorola is not requesting authorization for the ground segment facilities component of the system at this time.

The Celelstri Architecture will allow for the use of relatively small, low power and low cost earth terminals. It will also permit real-time communication capabilities: the delays experienced by end-users will be essentially equivalent to terrestrial communication systems for global real-time services.

Each satellite contains all of the hardware necessary to route communications traffic through the network, including Earth-to-space, space-to-Earth and space-to-space connections. With this architecture, a signal received by a satellite may be transponded directly back to Earth in the same or a different beam, or relayed by optical inter-satellite links through other satellites from which it is then transmitted to Earth. This architecture allows global interconnection for the provision of real-time multimedia, data, video and voice services.

The system is designed to avoid harmful interference with other service operators primarily through the use of space diversity. This technique will allow the Celestri LEO System to share the same spectrum with multiple NGSO and GSO systems, on a co-coverage and co-frequency basis. Implicit in the spectrum sharing approach is the assumption that all NGSO systems will participate in the spectrum sharing responsibility.

The system will utilize multi-beam phased arrays with fixed beams to provide ubiquitous coverage through the satellite footprint. Single or multiple earth terminals will provide access to the satellite constellation. The earth terminals will have equivalent antenna aperture sizes from 0.3 to 1 meter and will support bit rates from 2.048 to 155.52 Mbps.

The Celestri LEO System represents the third cornerstone in Motorola’s plan to create the Celestri System global wireless broadband communications infrastructure. It complements the recently licensed GSO FSS Millennium System and the proposed LEO FSS M-Star System. Each system is optimized for discrete types of broadband FSS offerings aimed at different, yet overlapping market segments.

Together, the three systems will offer an integrated, “total” FSS solution. The Celestri Architecture will comprise LEO and GSO satellites, satellite-to-satellite communications links, space-to-ground interfaces, terrestrial gateways and a family of customer premises equipment designed to deliver a full range of wireless multimedia and other bandwidth-on-demand applications to consumers, small businesses, multinational corporations and telecommunications service providers anywhere in the world.

Motorola believes that this unified and open architecture for the delivery of GSO, LEO and “hybrid” services is an advanced and highly flexible framework for meeting explosive worldwide demand for broadband services as well as an effective approach to spectrum conservation and sharing.

In the Ka-band, services delivered by the LEO system described in this Application and services delivered by the Millennium System will allow a single terminal to receive and send video, data and voice signals that offers the most efficient and cost-effective medium for each application. For applications that require exceptionally large bandwidth, Motorola’s proposed M-Star System leverages Ka-band user links into very high-capacity trunking and backhaul applications in the 40/50 GHz band.

Motorola has a proven record of developing and deploying new technologies that create new industries including two-way radio, paging, cellular mobile communications and, most recently, the IRIDIUM® global mobile communications system.[3] As the recognized worldwide leader in wireless

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[3] IRIDIUM® is a registered trademark and service mark of Iridium LLC.

communications systems, Motorola believes that the Celestri Architecture will define another new industry -- the global wireless delivery of broadband communications services.

The Celestri Architecture will allow integrated systems to support four classes of service for four segments of the marketplace. These types of service are:

- point-to-point, real-time symmetric connection services ranging from 64 kbps to 155 Mbps;
- point-to-point, bursty asymmetric services, in which each direction of communication uses varying amounts of bandwidth as needed, ranging up to 16 Mbps;
- broadcast and multicast services using variable service areas and communication rates;
- interactive and integrated broadcast and real-time response services.

Combinations of these services will be integrated with applications to serve the following market segments:

- residential consumers purchasing multimedia applications (data, video and voice) for work-at-home, personal productivity, entertainment, education, health care and security purposes;
- small businesses purchasing in the multimedia marketplace;
- large multinational corporations seeking strategic multimedia applications that improve their business processes and customer responsiveness to all corners of the world;
- telecommunications carriers and service providers world-wide seeking to extend their reach, control and service quality to areas not presently covered well by their current service offerings.

The Celestri System is ideally suited to rapidly fulfill the Global Information Infrastructure initiative recognized by Vice President Gore because it is capable of providing communications services virtually everywhere in the world without geographic or price discrimination. No other technology can more effectively help close the telecommunications gap between rich and poor countries, alleviating the distinction between information “haves” and “have nots.”

While the cost of constructing the Celestri LEO 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 be incurred to build out a terrestrial broadband network, whether nationwide or worldwide. The cost of a comparable terrestrial network infrastructure would be over a trillion dollars.

In addition, Motorola will achieve substantial cost savings through major design reuse of key space and ground-based components of the Millennium, M-Star and Celestri LEO Systems. This approach will dramatically reduce development time and costs, accelerate production of all elements of the architecture, and allow the start of service by the year 2002.

Motorola will operate the Celestri LEO System on a non-common carrier basis. Motorola does not anticipate selling services directly to end users. It intends to offer wholesale space segment capacity to carriers and service providers, who will, in turn, market a variety of services to their customers.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington D.C. 20554

In re Application of:	)	
MOTOROLA GLOBAL COMMUNICATIONS, INC.	)	**File No. _________________**
For Authority to Construct, Launch and Operate the Celestri Multimedia LEO System, a Global Non-Geostationary Orbit Satellite System in the Fixed-Satellite Service.	)	

APPLICATION OF
MOTOROLA GLOBAL COMMUNICATIONS, INC.

Pursuant to Sections 308, 309 and 319 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 308, 309, 319, Motorola Global Communications, Inc. ("Motorola"), a wholly-owned subsidiary of Motorola, Inc., hereby requests Commission authority to construct, launch and operate a non-geostationary orbit ("NGSO") global satellite system, offering a wide range of real-time multimedia, data and voice services in the Fixed-Satellite Service ("FSS"). The Celestri Multimedia LEO System ("Celestri LEO System") will comprise a total of 63 operational satellites. The corresponding earth segment will include a System Control Segment ("SCS") for constellation and network operations, and Customer Premises Equipment ("CPE") to provide access to the system for end users.[1]

The service and control links will operate in frequency bands that have a global allocation for the intended purpose. These links will operate in the 18.8-

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[1] Motorola is not at this time requesting authorization for ground segment facilities.

19.3 GHz and 19.7-20.2 GHz bands (space-to-Earth) and the 28.6-29.1 GHz and 29.5-30.0 GHz bands (Earth-to-space).[2] The TT&C high gain links will also operate in the service bands. The system will use optical inter-satellite links to interconnect the satellites in space.

I. INTRODUCTION

A. General

The Celestri LEO System will essentially complete Motorola's Celestri Architecture for broadband satellite communications. The other cornerstones of the architecture are the Millennium and M-Star Systems. Each of these systems is designed to offer distinct, yet complementary, types of services and to fill different consumer needs. The geostationary ("GSO") Millennium System will primarily provide less delay-sensitive, point-to-multipoint services to the Western Hemisphere; [3] M-Star, a non-geostationary NGSO system, will provide global, broadband backhaul and trunking services for wireless and other providers; the Celestri LEO System will provide primarily gobal point-to-point real-time end-user communications. Motorola will integrate these three systems into a seamless whole. Complete interoperability will allow customers to use the satellite infrastructure that most efficiently meets their bandwidth and service needs.

The Celestri LEO System comprises 63 satellites in 7 inclined orbital planes, up to 7 in-orbit spares, and the associated ground segment equipment. All of the satellites will revolve in circular orbits at an altitude of 1400 km. The constellation will be inclined at 48° with respect to the Equator.

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[2] Of these bands, the 18.8-19.3 GHz and 28.6-29.1 GHz bands have a primary domestic allocation for NGSO FSS. The 19.7-20.2 GHz and 29.5-30.0 GHz bands have a secondary domestic allocation for NGSO FSS. All bands have a worldwide primary FSS allocation.

The system's LEO architecture will allow the use of relatively small, low power and low cost earth terminals for real-time services. End-users will experience delays essentially equivalent to terrestrial communication systems providing global real-time services.

Each satellite contains all the hardware necessary to route communications traffic through the network, including Earth-to-space, space-to-Earth and space-to-space connections. With this architecture, a signal received by a satellite may be transponded directly back to the Earth in the same or a different beam, or relayed by optical inter-satellite links through other satellites from which it is then transmitted to the Earth. This architecture allows global interconnection for the transport of real-time multimedia, data and voice services.

The system is designed to avoid harmful interference with other service operators primarily through the use of space diversity. This technique will allow multiple NGSO and GSO systems to operate co-coverage and co-frequency with the Celestri LEO System. Implicit in the spectrum sharing approach reflected in this Application is the assumption that all NGSO systems, including the Teledesic System, will participate in the spectrum sharing responsibility.

The Celestri LEO System will offer two categories of services. First, through service providers, non-business and consumer end-users will use the system for accessing and retrieving content in real time. Particular applications will include Internet access, video-conferencing, financial transaction processing, home entertainment, distance learning and tele-medicine. This

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[3] Of the various service categories enumerated in the application for the Millennium System, Motorola has decided to place primary emphasis on the point-to-multipoint applications.

class of service will provide bandwidth-on-demand access to the network at data rates up to 10 Mbps. The second category of service will be interconnection services at up to 155.52 Mbps. This data rate will enable multinational corporations and terrestrial carriers to aggregate voice and data signals.

While the cost of constructing the Celestri LEO 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 worldwide. The cost of a comparable terrestrial network infrastructure would easily be over a trillion dollars.

The Celestri LEO System's ground segment will comprise a System Control Segment ("SCS"), consisting of two Operation Facilities and six antenna sites for constellation and network operations. Each Operation Facility will consist of a Satellite Operations Control Center and Network Operations Center, and will maintain communications with all six antenna sites.

Motorola will operate the Celestri LEO System on a non-common carrier basis. Motorola does not anticipate selling services directly to end users. It intends to offer wholesale space segment capacity to carriers and service providers who in turn, will 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] and Part 25 of the Commission's Rules and

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

Regulations to the extent applicable.[5] Motorola will amend or modify this Application, if necessary, after the Commission has adopted its policies and rules for satellite systems in the requested bands. In support of this Application, Motorola provides the following information:

1. Name, Address and Phone Number Of Applicant:

Motorola Global Communications, Inc.
Attn: Bary Bertiger, President
2501 South Price Road
Chandler, Arizona 85248-2899
602-732-3878

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

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

Philip L. Malet
James M. Talens
Pantelis Michalopoulos
Maury D. Shenk
Steptoe & Johnson LLP
1330 Connecticut Ave., N.W.
Washington, D.C. 20036
202-429-3000

3. Type Of Authorization Requested

Motorola requests authority to construct, launch and operate up to 63 non-geostationary orbit satellites, and up to 7 in-orbit spares, to establish a high-capacity broadband FSS system. The satellites will be distributed in 7 planes with 9 operational satellites in each plane. The planes will be inclined at

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[5] See Streamlining the Commission's Rules and Regulations for Satellite Application and Licensing Procedures, FCC 96-425, IB Dkt. No. 95-117 (Dec. 16, 1996).

48 degrees with respect to the Equator. Services will be provided on a non-common carrier basis.

II. PUBLIC INTEREST CONSIDERATIONS

The proposed Celestri LEO System worldwide broadband communications system will provide real-time, end-to-end broadband services to consumers' homes, businesses, schools and hospitals. It will facilitate the creation of a global community brought together by the exchange and communication of ideas, images and sounds in real time. It will also introduce competition with other terrestrial and satellite-based providers of broadband services.

The Celestri LEO System is an important component of Motorola's satellite communications vision. It will complement the other satellite systems for which Motorola has licenses from or pending applications with the Commission. Each of these systems -- IRIDIUM®, Millennium, M-Star and now the Celestri LEO System -- addresses a distinct segment of the global satellite communications market. The IRIDIUM® System, with five satellites already in orbit and the remaining constellation scheduled to be launched soon will provide narrowband Mobile-Satellite Services to a universe of mobile users. The Celestri Architecture, on the other hand, will provide broadband Fixed-Satellite Services ("FSS"). Each component of this architecture will target different markets. The Millennium System's four geostationary satellites will provide broadband and multicast services on a regional basis to customers in the Americas. The NGSO M-Star and Celestri LEO Systems will cover the globe. M-Star will be a backbone system, providing backhaul services for terrestrial wireless systems, including third-generation cellular services, and will serve as a conduit for other aggregated signals such as trunking on international private line services. The Celestri LEO System will provide primarily point-to-point broadband offerings for end users -- both businesses and homes -- including Internet access, video-conferencing, financial transaction processing, distance learning and tele-medicine.[6]

Motorola plans to integrate its three broadband FSS systems into a seamless whole. Customers with variable bandwidth and service needs will be able to shift seamlessly from one system to the other and use the infrastructure that most efficiently suits their particular needs. In the Ka-band, a single terminal will be able to receive and send data, video and voice signals over the Millennium or Celestri LEO Systems, depending on geography and efficiency. For applications that require exceptionally large bandwidth, the M-Star System will “leverage” Ka-Band user links into very high-capacity trunking and backhaul applications in the 40/50 GHz band.

The Celestri LEO System will provide a global broadband infrastructure at a much lower cost than would be possible through a terrestrial fiber optic network. Construction and launch of the Celestri LEO System and the first of four satellites of the Millenium System are estimated to cost $12.9 billion. By contrast, a global broadband fiber optic network to every location in the world would cost over a trillion dollars.[7]

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[6] Secondarily, the Celestri LEO System will also offer voice and data aggregation services for terrestrial carriers.

[7] The cost of planned fiber-optic backbone networks has been estimated at $550 billion in Japan alone, see Rob Guth, "Down But Not Out," Computerworld, at 9 (Sept. 9, 1996) and $58 billion in Korea, see "In Search of State-of-the-Art Technologies: Korea's Drive to the Information Superhighway," East Asian Executive Reports, at 8 (Sept. 15, 1996). New and upgraded fiber optic networks in the United States will cost several billion dollars per state. See Brian O'Reilly, "First Blood in the Telecom Wars," Fortune (Mar. 4, 1996); (Southern New England Telephone Co. network in Connecticut will cost $4.5 billion); "Pacific Bell's California Test Leaves Room for Marketers," Advertising Age, at 19 (Nov. 22, 1993) (upgrade to California network projected to cost $16 billion).

The Celestri LEO System also will provide global broadband services much earlier than comparable terrestrial broadband services will be globally available, particularly in view of the limited success and mixed prospects of current proposals for construction of fiber-based broadband networks providing direct service to end-users.[8] Decisions on whether and where to deploy a terrestrial network may leave populated remote and rural areas where deployment is prohibitively expensive on a per capita basis without broadband services. In contrast, by as early as the year 2002, the Celestri LEO System will be capable of providing economical broadband services to virtually any populated point on Earth through deployment of low-cost Celestri System earth terminals.[9]

The Celestri LEO System also will enhance competition in the broadband telecommunications marketplace. It will compete with terrestrial providers offering "last-mile" fiber or wireless connections, as well as with other announced and planned NGSO and GSO broadband fixed satellite service systems. The Celestri LEO System's innovative design will provide extensive double coverage and will allow co-frequency sharing between more than one NGSO system by means of interference mitigation techniques such as space

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[8] The Celestri LEO System will even be available before completion of backbone networks planned in industrialized countries. See Guth, "Down But Not Out" (Japanese fiber backbone network scheduled for completion in 2010); "In Search of State-of-the-Art Technologies" (Korean fiber backbone network scheduled for completion in 2010).

[9] See Judith J. Senkevitch Dietmar Wolfram, "Equalizing Access to Electronic Networked Resources: A Model for Rural Libraries in the United States," Library Trends (Mar. 22, 1994) ("satellite transmission could represent an economical way of reaching isolated communities because costs are less distance dependent than for enclose media [such as fiber optics]").

diversity.[10] To ensure that the Celestri LEO System is broadly usable, it will be accessible through open interfaces supporting a wide variety of communications protocols. The entry by the Celestri LEO System's use of the Ka-band will validate the Commission's long-standing efforts in the International Telecommunication Union and other international forums to facilitate the use of the Ka-band by multiple NGSO FSS systems.

The services that will be available through the Celestri LEO System will bring to reality virtual person-to-person contact and information exchange, which is now only possible by physical proximity. Communications across countries and between continents will, for the first time, become as effective as face-to-face communication.

The Celestri LEO System and the Celestri Architecture will also provide significant benefits for the U.S. and world economies. First, the widespread availability of broadband communications will increase global productivity.[11] Second, the Celestri LEO System will produce a direct infusion of capital into the United States and other countries. While Motorola will construct the space segment and will manufacture a large portion of the ground segment, Motorola expects that it will employ a multinational team of contractors and subcontractors to help design, build and launch the system and related components. Creations of this system will translate into millions of job person-

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[10] Space diversity will also facilitate sharing with GSO satellites using the Ka-band.

[11] 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).

hours, many of them involving specialized, highly compensated professional work. Third, the Celestri LEO System will promote rural development by providing real-time access to centralized databases, including finance, market, health and other information, not otherwise available locally. Moreover, implementation of the proposed system will add a significant number of jobs and money to the world economy through other direct and indirect economic benefits.

The Celestri LEO System will also play a significant role in global economic development, particularly in less developed countries. Vice President Gore recognized this role when he addressed the first ITU development conference in Buenos Aires on the Global Information Infrastructure ("GII"):

> We now can at last create a planetary information network that transmits messages and images with the speed of light from the largest city to the smallest village on every continent. . . . From these connections, we will derive robust and sustainable economic progress, strong democracies, better solutions to global and local environmental challenges, [and] improved health care . . . . Digital telecommunications technology, fiber optics, and new high-capacity satellite systems are transforming telecommunications.[12]

Global satellite networks like the Celestri LEO System are ideally suited to rapidly fulfilling the GII initiative because they are capable of providing communications services virtually everywhere in the world without geographic or price discrimination. No other telecommunications technology -- including

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[12] Remarks Prepared for Delivery by Vice President Al Gore, International Telecommunications Union (Mar. 21, 1994).

fiber optics -- can make that claim, and none can hope to achieve the promise of geographic universality as soon as global satellite networks.

Satellite services have the potential to help close the telecommunications gap between rich and poor countries is widely recognized.[13] By allowing easy accessibility to vast amounts of information, the Celestri LEO System will help close this gap by alleviating the distinction between information "haves" and "have nots". Its broadband capabilities will provide universal availability to the kinds of economic, telemedicine, distance learning, and teleconferencing services that the GII initiative mandates. With the Celestri LEO System, the promise of the GII and worldwide telecommunications access becomes a reality.

III. MARKET AND DEMAND FOR SERVICES

A. Overview

The future demand for broadband communications services, provided through a global information infrastructure, is presaged today by the enormous growth experienced in the number of Internet host addresses, Internet World Wide Web sites and commercial on-line service subscribers.

The Celestri Architecture will offer a full range of broadband services for transporting all forms of digital communications (including multimedia) and

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[13] See Mobile Satellite News, May 29, 1997, at 7 (quoting statement of ITU Deputy Secretary-General Henry Chasia that satellite-based Internet services can be used "to close . . . the telecommunications gap"); Communications Daily, May 29, 1997, at 10 (quoting statement of Prince Thumbumuzi Dlamini of Swaziland at AFCOM conference that "[u]niversal availability is no longer a dream and it will lead to the rapid acceleration of economic development which has historically been the product of modern telecommunications").

allocating only the needed portions of a communications channel to do it through bandwidth-on-demand. These broadband applications have the potential to save billions of dollars in health care delivery; enhance the quality and lower the cost of education by bringing remote instructors and new learning opportunities to students; improve the quality of life by fostering effective telecommuting (work at home) environments, place small businesses on a more “even playing field” with large corporations; increase the global competitiveness of all businesses and provide entertaining and personalized information to all consumers.

Providing these 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 systems and services. Currently, terrestrial systems offer bandwidth-on-demand services in a limited way and only in the densely populated areas of developed countries. The Celestri Architecture can provide global reach and cost-competitive communications to all regions in all countries, including hard-to-reach rural areas and remote locations.

B. Trends

1. Key Technology Trends

There are a number of technological and economic trends that create a demand for affordable broadband telecommunications services. The Celestri Architecture will satisfy that demand and enhance competition with the terrestrial and satellite providers targeting the same markets.

a. Digital Technology

Over the last few years, the implementation of digital compression techniques has led to widespread availability of video images in digital form. With the ability to handle all popular forms of media (data, video, text, still image and voice) in digital form for storage, transmission and delivery, a global broadband infrastructure becomes more realistic. The Celestri Architecture will not only provide the necessary long-haul transport, but supply “last-mile” connections, making available ubiquitous communicating devices (information appliances), easy-to-use collaborative applications and broadband communications transport, and placing these multimedia formats within everyone’s grasp.

b. Computers as Communication Devices

The need for a broadband infrastructure is a direct consequence of the recent revolution in the capabilities and functions of the personal computer. The personal computer has evolved from a sophisticated text processor and calculator to a true multimedia information appliance capable of processing all forms of multimedia, video, data and voice information. Increasingly complex operating systems and software that process images, voice, and video add to the volume of data. The “language” of these computers is broadband digital data, and it is the need to transport these data that generates demand for the services that will be provided by the Celestri System.

Computers are increasingly equipped with digital signal processors that can efficiently and rapidly handle multimedia signals. In 1970, a supercomputer could perform several million operations per second. Supercomputers today are many thousands of times faster, manipulating vastly larger volumes of data and storing information at levels not imagined in 1970. Desktop machines for the office and home have experienced corresponding increases in processing speed. Storage devices with capacities of over 3 gigabytes of data are available today for desktop computers for only a few hundred dollars, a fraction of the cost of much lower capacity storage systems only five years ago. These cost reductions make it affordable for a typical residential or business user to process and store large files associated with data, image and video. The new challenge is to transport this enormous volume of information quickly and efficiently.

c. Local Area Networks

As the ability of computers to process information has increased, the ability of local area networks ("LAN"s) to deliver that information among geographically distributed commercial environments has also increased. Today's Fiber Distributed Data Interface ("FDDI") networks and high speed Ethernet LANs can transport data at rates of up to 100 Mbps. Gigabit LANs are on the near horizon. Especially for businesses, these changes are alleviating the local area bottleneck that has slowed the development of "bandwidth-hungry" multimedia applications and services. These advanced networks have also promoted the development of bandwidth-on-demand technology, which allows a user to utilize only the bandwidth required for a particular application. For a satellite system, this technology providers the added advantage of spectral efficiency. Figure III-1 illustrates projected growth of LAN sites through the year 2002.

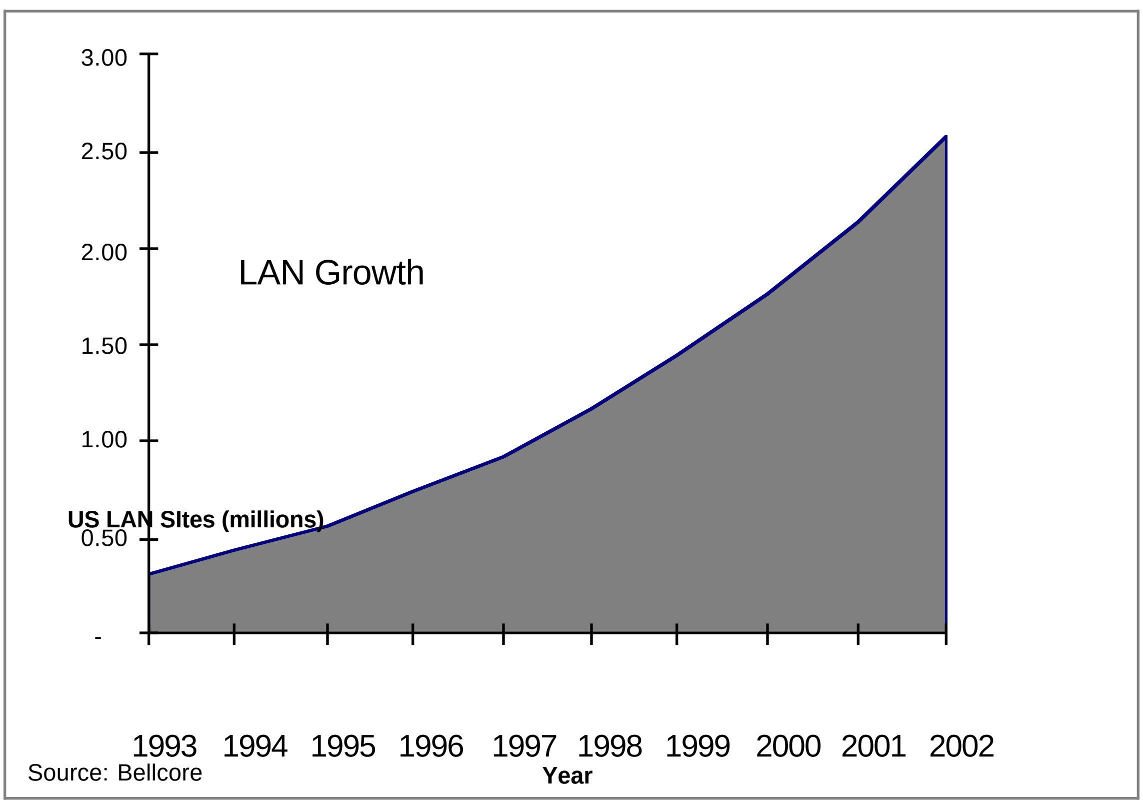

Figure III-1

d. Wide Area Networks

In the past, wide area networks have also been expensive bottlenecks that discouraged users from using high-bandwidth applications over wide geographic areas. However, both local exchange companies and cable operators are deploying high speed digital subscriber lines (“xDSL”) and fiber networks that promise to eliminate this bottleneck. By the year 2000, these changes will help spur the development and use of wide area multimedia communications.

In the U.S., the increasing deployment of ISDN by telephone companies will increase the bandwidth available to a typical home user from 33 kbps to 128 kbps (a four fold increase). Several local telephone companies and cable operators have announced plans to lay fiber to the home and provide truly broadband interactive services. Some of these plans appear to have been set back by the realization of the substantial cost and complexity of the enterprise. The progress made so far, as well as the impediments encountered, highlight both the demand for broadband communications and the difficulty of satisfying it in a cost-efficient way through terrestrial technologies.[14]

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[14] See "Fiber Use Continues as Strong as Cable TV Girds for Competition," Fiber Optic News, May 6, 1996 (The cable TV industry will likely surpass its 1995 growth in the deployment of fiber optic lines, as that industry is installing 163 miles of optical fiber every hour daily.); "New SONET Carries Voice, Video and Data," Video Technology News, Apr. 7, 1997 (GI and Fujitsu believe that cable operators are willing to invest in fiber technology enough to spur a booming market.); "TCI Suspends Large Portions of Fiber Upgrade," Fiber Optic News, Nov. 4, 1996 (TCI has decided to suspend large portions of its fiber upgrade, until further notice.). But see "Growth in HFC Seen Buoying Scientific-Atlanta Share Value," Fiber Optic News, Apr. 28, 1997 (One commentator suggests both that TCI will continue its fiber upgrade and that cable operator fiber buildout will be at a 20 percent annual expansion rate). Shira McCarthy, "A Full Meal, Cable Industry Tucks in its Bib for the Western Show," Telephony, Dec. 9, 1996 ("Cable operators have realized the cost

For business users, fast packet networks (e.g., frame relay) are rapidly growing in the U.S. Further increases will come from the expanding deployment of ATM networks (as illustrated in Figure III-2). These networks should enable businesses to extend their LANs over a wide area without sacrificing performance. While the U.S. is leading in the deployment of these high speed networks, European and Asian demand is also growing rapidly. This suggests that by the end of the decade, initial high speed networks should be a reality in many countries. However, these networks will not be ubiquitous for many decades, if ever.

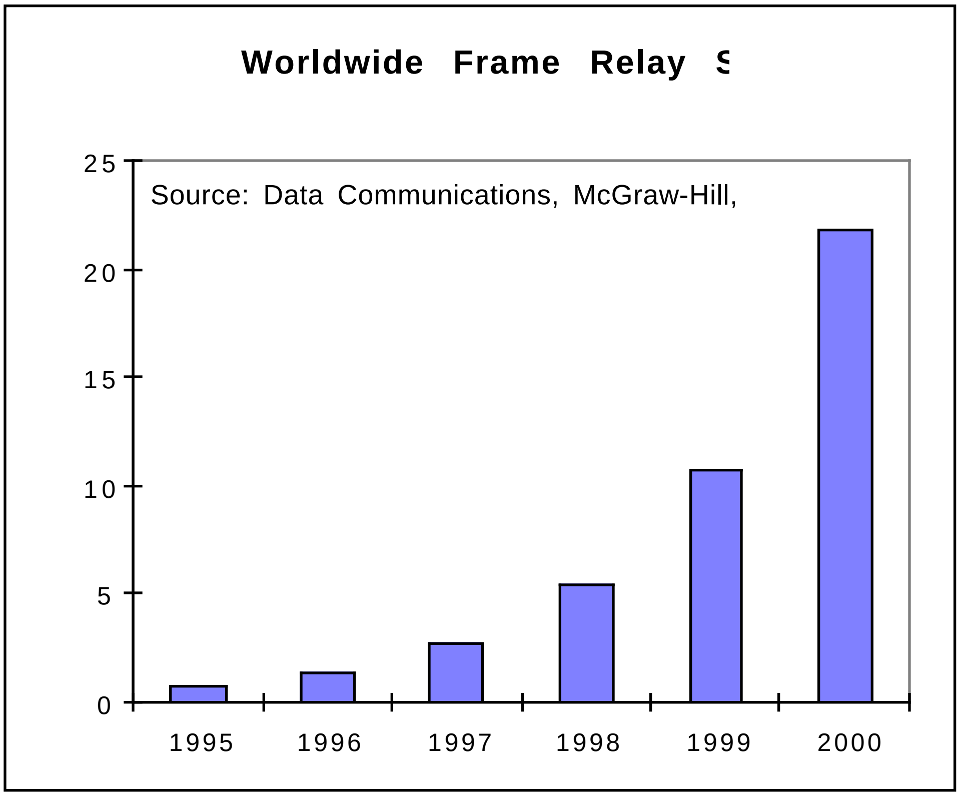

Figure III-2

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inherent in doing telephony over a hybrid fiber/coax architecture today is too great.").

2. Standards

In recent years, standards organizations and industry forums have defined key compression standards for digitizing images and video communications. By compressing communication streams that require hundreds of megabytes in their uncompressed form, these standards make it possible to store and transmit images and video using today's storage and communication technologies. The Celestri Architecture will be compatible with many world-wide data protocols and formats. Some examples are listed below:

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)

3. Economic and Regulatory Trends

A number of economic and regulatory trends are expected to enhance the market for many types of broadband digital communications services. These trends include:

- **Cost reduction pressures on all industry segments.** Businesses have come under increasing pressure to be globally cost competitive, to reduce the cost and improve the quality of education, to improve availability and to reduce overall costs of health care. The drive to efficiency has, in turn, increased the demand for applications such as telecommuting, distance learning and telemedicine.
- **Mobility and wider geographical distribution of work force.** This trend is associated with the increasing globalization of businesses as well as the environmental and quality-of-life pressures to increase the "work at home" population. It is estimated that 30 million households in the US currently have employees that work at home in some form (i.e., after-hours or telecommuting). This figure is expected to double by the year 2000**.**

- **Strategic importance of information access for large business*.*** For large business, information processing and communications are becoming a source of strategic advantage. They are used to increase efficiency and productivity as well as to propel expansion into the global marketplace.

- **Growth in number of small businesses*.*** Small businesses in the U.S. represent nearly 7 million establishments and are growing at 2% per year, according to estimates from IDC/Link Resources. They are using communications technology to “level the playing field” with large corporations. Information technologies such as interactive advertising on the World Wide Web allow them to inform vast audiences of their goods and services at a fraction of the cost of advertising through the traditional mass media.

- **Liberalization of international telecommunications*.*** Throughout the world, an increasing number of state-controlled public telephone companies are in the process of privatization. Access to the local network is gradually opening to support competition. It is expected that this liberalization will facilitate development of broadband applications and services. A significant milestone in the liberalization process is the February 15, 1997 agreement in the World Trade Organization Group on Basic Telecommunications. This agreement involved sixty-nine countries, most of which made significant commitments to open their markets for basic telecommunications services, including voice and data transmission by satellite, beginning as early as January 1, 1998.

- **Internet growth*.*** Internet continues to grow at a phenomenal rate is increasingly used for commercial transaction and interactive services. The Internet growth rate exceeds 25 to 50% per month, demonstrating a dramatic pent-up demand for information access in a personalized fashion. An Internet Society analysis shows that World Wide Web traffic currently constitutes about 30% of all Internet traffic, but is growing at more than 25% per month. Figure III-3 illustrates this growth in data volume.

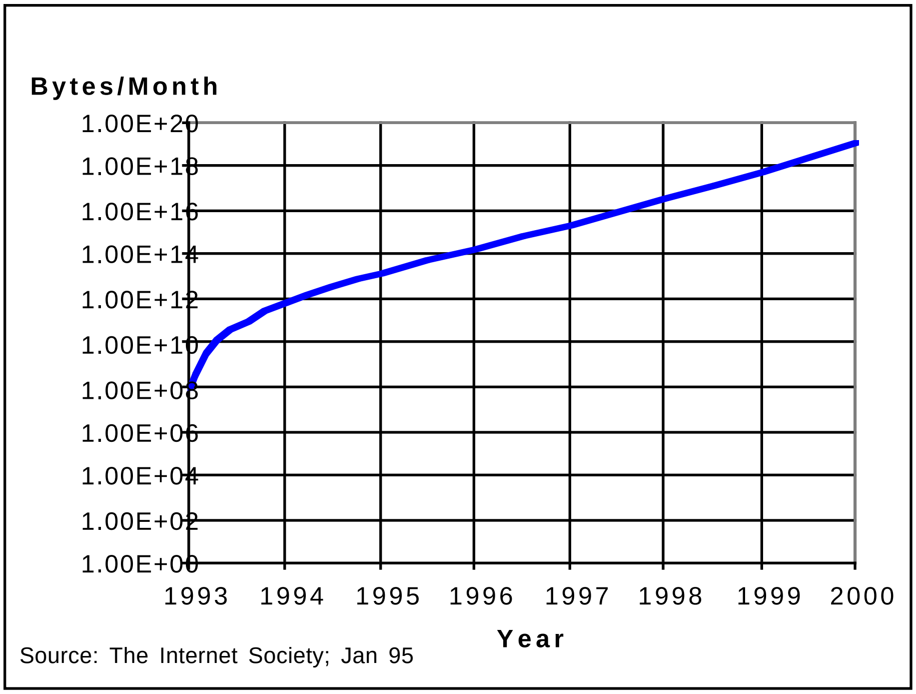

Figure III-3

- **Communications partnerships and alliances*.*** Communications and computer firms are forming alliances to offer end-to-end services by exploiting the synergies made possible by convergence of their industries.

- **Cost reductions in broadband equipment.** As equipment for broadband networks comes down in price and as a larger number of firms develop this equipment, it is becoming less difficult for new entrants to develop and offer broadband networks at affordable prices to consumers. For example, initial frame relay service networks in the U.S. use switches that cost less than 10%

of the price of a typical central office voice switch. ATM switch prices begin at under $50,000.[15]

C. Proposed Services

The broadband communications market includes consumer and business users of high and often variable bit rate data and media (voice, text, data, image and video). Typical data rates are in the 128 kbps to 51.84 Mbps range. In the case of voice-only transmission, data rates range from 16 kbps to 64 kbps. In cases where multiple sources of input are aggregated, the resultant bandwidth demands range from 51.84 Mbps to over 155.52 Mbps. The baseline design for the Celestri LEO System will serve the low (to 2.048 Mbps, E-1) and medium (to 155.5 Mbps, OC-3) data rate markets.

End users will access the system to retrieve information. Content can be user-created (as in the case of a video-conference or a home page on the World Wide Web) or can be more formally created (as in the case of film or magazines). The business plan for the Celestri LEO System focuses primarily on point-to-point applications. In some cases, content is multiplexed from many sources. Examples include LAN-to-LAN interconnections and access from local PCS service providers to a service collection point into the public switched telephone network ("PSTN").

Content users are coming to expect:

- Fast access to content;
- Low access and retrieval costs;
- Reliable retrieval of content;
- Support and ease of use in identifying and accessing the desired content;

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[15] Of course, the start-up costs for deploying a broadband network remain high, particularly for terrestrial technologies.

- Support for collaboration among several users in the access, viewing and interpretation of content;
- Sophisticated and pleasing displays of content involving the incorporation of multiple representations of media (voice, image, sound, video, etc.).

The Celestri System will meet these consumer demands.

1. Service and Application Characteristics

The Celestri LEO System will offer two categories of broadband services. The first category involves data and video services that enable residential and business customers to communicate at data rates ranging from 64 kbps to 10 Mbps on a bandwidth-on-demand basis. While voice may be part of the communication (as in the case of video-conferencing), it is not the primary ingredient of these services. It is assumed that *pure* voice communications will be served by a variety of wireless and wireline networks.

The second category of broadband services involves interconnection services that enable multinational corporations and terrestrial carriers to aggregate and transmit voice, data and video signals together. These services will primarily use the 51.84 Mbps (OC-1) and 155.52 Mbps (OC-3) data rates.

a. Residential and Business Broadband Services to End-Users

Internet Access. This service enables a personal computer to connect to the Internet. It may offer service to the user at home or to small businesses throughout the world. In the case of home usage, such access will comprise not only entertainment or news type services, but also cost effective data access for such services as self-care. The bulk of these services is handled by a relatively low speed uplink from the home or office (64 - 2048 kbps) and a fluctuating but fairly large downlink into the home or office (2.048 Mbps to more than 10 Mbps).

Video-conferencing. This service can be used in either business or residential environments through a personal computer. The video conference can be conducted between two computers or between several users at different locations. A higher-quality link can be used to establish a video conference with another person by linking a video-equipped computer or room to the satellite network. Such applications have characteristics similar to telephone calls but with higher bit rates. It is expected that such services will require symmetric links of 128 kbps to 1.544 Mbps.

Telecommuting. This service enables a telecommuting worker to connect to an office computer for the purpose of accessing work-in-progress, collaboration with co-workers, corporate information and databases, e-mail, etc. The capacity requirements are similar to those for Internet access.

Small Business Transaction Services. This service supports transaction data access for credit validation on credit/debit card sales as well as electronic data interchange access ("EDI") for order and invoicing by small businesses. Traffic demands are low for both uplink and downlink. The equivalent of a 64 kbps channel is adequate for this service.

Home Entertainment. This service includes satellite-delivered programming plus interactive services such as movies on demand, games, news and information services, and home shopping. The bulk of these services is handled by a relatively low speed uplink from the home (64 kbps or lower) and a bursty but fairly large downlink into the home (384 kbps up to 16.384 Mbps for some video services).

Telemedicine. This service uses the satellite system to transmit multimedia patient records (text records, high-quality images, video and voice annotations) between institutions. By using telemedicine, doctors and other care givers can consult with specialists thousands of miles away; continually upgrade their education and skills; and share medical records and x-rays. Telemedicine is projected to reduce health care costs while enhancing efficiency and accessibility to health care services. For example, in Texas, over 70 hospitals, primarily in rural areas, have been forced to close since 1984. Texas offers interactive video consultation to primary care physicians in rural hospitals as a way of alleviating the shortage of specialists in these areas. This trial is increasing the quality of care in rural areas and is providing at least 14 percent savings by cutting patient transfer costs and provider travel. Such services require symmetric links of 128 to 384 kpbs. Tele-radiology used for primary diagnosis requires data rates of 1.544 to 50 Mbps (for mammography images).

In addition to the telemedicine applications described above, the Celestri Architecture can achieve savings of several billions of dollars in U.S. health care expenditures by promoting self-care. The National Telecommunications & Information Administration ("NTIA") has identified a savings of $40 to $60 billion from use of personal health information systems, even if such systems were used only 25 to 35 percent of the time.[16]

Distance Learning and University Education. This service enables a student or teacher to connect to a school's computer for the purpose of accessing homework, reference materials, and/or communicating with other students or teachers. The bulk of these services is handled by a relatively low speed uplink from the home or school site (64 kbps or lower) and a bursty but fairly large downlink in return (64 kbps up to 16.384 Mbps for some video and image services). This service also allows live instruction provided between two or more classroom locations, using one or two-way video, video-conferencing, collaborative applications and/or multimedia. Characteristics of this service are

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[16] See NTIA, "The National Information Infrastructure: An Agenda for Action" (1993).

very similar to video-conferencing; such services require symmetric links of 128 to 384 kbps.

b. Aggregated Broadband Services

PCS Backhaul. This service will allow islands of PCS systems to interconnect with the rest of the world, even if they are remote to the global telephone network. In this application, the Celestri Architecture would provide communications services for use by the PCS service provider, not the end user. Estimates show that service cells of up to 5,000 subscribers can be handled with a symmetric uplink/downlink of from 128 to 384 kbps. This service would allow universal access to PCS service providers anywhere in the world.

LAN-to-LAN. This service enables a LAN-to-LAN communication by connecting routers at remote locations through a satellite channel. It would also allow remote branch locations access to corporate headquarters' data services. This service uses a symmetrical link running between 384 kbps and 51.84 Mbps. The bandwidth in use would be determined by the traffic demand at any point in time. Most LANs are expected to require up to 2.048 Mbps in service bandwidth.

Interexchange Carrier Backhaul. This service enables telecommunications carriers to aggregate voice long distance traffic for both domestic and international delivery. It takes advantage of the switching capabilities of the satellite to deliver data to numerous points from a single collection point. This service requires symmetric uplink and downlink channels that run from 51.84 Mbps to over 155.52 Mbps. The tremendous value of this service to carriers is the ability to reconfigure capacity to where it is needed, when it is needed.

2. Customer Premises Equipment

Motorola expects that the Celestri System will be accessed by end users through four categories of customer premises equipment ("CPE"): direct-to-home ("DTH") terminals that support information rates up to 2.048 Mbps, business terminals supporting information rates up to 10.0 Mbps, corporate terminals that support an information rate of 51.84 Mbps, and gateway terminals supporting an information rate of 155.52 Mbps.

D. Demand Analysis

1. Markets and Estimated Demand

Through the broadband offerings described above, the Celestri System will target several markets or market segments, including:

- Residential;
- Corporate customers (large businesses);
- Small businesses;
- Education;
- Terrestrial carriers;
- Government and Military;
- Health care.

The total size of the communication provider market in the first decade of the new millennium, as projected by Bellcore, is expected to approach $1.5 trillion in worldwide annual service revenue. This reflects end-user willingness to pay for delivery of, and access to, content; it does not include the value of content itself to the user. Motorola conservatively estimates that approximately 70-80% of this market will be served by terrestrial systems such as fiber and cable. This leaves an unserved global market of at least $300 billion. Rapid growth in demand is projected on the basis of data and estimates applicable to the discrete categories of broadband services described above. The following are some examples:

a. Video Demand

- Business Video-conferencing;
- University Education;
- Telemedicine;
- Telecommuting;
- Home Entertainment.

Frost & Sullivan, Inc.[17] project that equipment used for desktop and room-based video-conferencing is selling at a compound annual growth rate of 45%.

b. Data Demand

- Distance Learning;
- Internet Access;
- Telecommuting;
- Small Business Transaction Services;
- LAN-to-LAN.

Data growth rates are best represented by World Wide Web usage as shown in Figure III-3. This reflects a 25% increase per month. Additional indicators are LAN and WAN growth trends shown in Figures III-1 and III-2.

c. Voice Aggregated Demand

- PCS Access;
- Interexchange Carrier Backhaul.

International voice traffic is growing at over 12% per year. PCS growth projections from Bellcore[18] show a worldwide market of over 80 million subscribers by the year 2000.

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[17] Frost & Sullivan, Inc., "U.S. Desktop Video Product Market: The First Definitive Business and Technology Assessment" (1993).

[18] Private study prepared for Motorola (1995).

2. Geographic Coverage

As detailed below, the Celestri LEO System constellation will provide around-the-clock coverage of all points between 60° Northern and 60° Southern Latitudes at elevation angles that exceed or equal 16°. Coverage can be extended beyond 70° Latitude by mitigating the effects of low elevation angles. With respect to the United States, the system will be capable of continuous 24-hour-a-day service to any point in the contiguous United States ("CONUS"), Alaska, Hawaii, the Commonwealth of Puerto Rico, the U.S. Virgin Islands and all U.S. territories. It will also provide double coverage of all points in the 48 contiguous states (i.e. coverage by two satellites at elevation angles of at least

16° 99% of the time) as well as between 18° and 48° Northern and Southern Latitudes.[19] Further, all points in the contiguous U.S. will enjoy triple coverage for more than 50% of the time. Double and triple coverage will be important to allow for sharing spectrum with other systems by means of satellite diversity.

E. Key Advantages Over Terrestrial Services

In all cases, the services addressed by this analysis have counterparts in terrestrial networks. Delivery through NGSO satellite system, however, has several critical advantages. The primary advantage is global reach. While terrestrial broadband networks are typically restricted to a confined geographical area, the Celestri System can serve virtually any point in the world where people live or work. Moreover, terrestrial broadband networks are likely

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[19] Beyond CONUS, all points between 55° Northern and 55° Southern Latitudes will enjoy double coverage for 90% of the time.

to serve only large concentrations of customers such as those found in major metropolitan areas. In contrast, the Celestri 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, fewer than 5% of potential customers in parts of Asia and Africa have basic telephony service. Although terrestrial broadband services and technologies have been available for decades, they are expensive and cannot be readily obtained by consumers even in the United States and other highly developed countries.

A second 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 inter-operate. In contrast, the Celestri Architecture can link two or more locations anywhere in the world and offer the customer a single network with a common set of features and interfaces. Interoperability is guaranteed. Another key feature of the Celestri Architecture is its adherence to international standards and data formats.

A third advantage is speed of service activation. A customer who is not already connected to a terrestrial network may have to wait weeks (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.

F. Information Concerning Sales of Communications Services -- Regulatory Classification as Non-Common Carrier

Motorola intends to operate the Celestri LEO System as a non-common carrier with respect to all of the foregoing services. It will not provide services directly to the public. Rather, Motorola will market the Celestri LEO System's space segment capacity on a wholesale basis to a small number of service providers, each of which will offer the services to end-users. Motorola 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, neither Motorola nor the Celestri LEO System will hold itself out indiscriminately to serve the public, nor should there be any legal compulsion to regulate the space segment provider 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). In substantially the same circumstances, the Commission has held that the sale of FSS capacity on a wholesale basis does

not constitute common carriage. See Domestic Fixed-Satellite Transponder Sales, 90 F.C.C.2d 1238, 1256-57 (1982), aff'd, World Communications Inc. v. FCC, 735 F.2d 1465 (D.C. Cir. 1984), modified Martin Marietta Communications, Memorandum Opinion and Order, 60 Rad. Reg. (P&F) 2d 779 (1986). Therefore, in accordance with the Commission's DISCO I Report and Order, Motorola elects to offer services on a non-common carrier basis.[20]

[20] 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 1 Report and Order"). See also In the Matter of Teledesic Corporation Application for Authority to Construct, Launch, and Operate a Low Earth Orbit Satellite System in the Domestic and International Fixed Satellite Service, 12 FCC Rcd. 3154, ¶¶ 25-27 (International Bureau March 14, 1997).