PR 92-28

PAPERS FOR CHINESE PUBLICATION

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The IRIDIUM™ system brings a new meaning to the word "communications." The possibility of

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Low-Earth Orbit Satellite System above 1 GHz
Request for Pioneer's Preference
ET Docket No. 92-28, PP-32

The Chief Engineer today accepted as a late-filed comment information filed by Motorola Satellite Communications, Inc. (Motorola) in ET Docket No. 92-28, PP-32, on April 10, 1992; and established May 28, 1992 as the deadline for reply comments to the material. The material accepted consists of a "Supplement to Request for Pioneer's Preference", and information titled "Papers for Chinese Publication" that originally was submitted as part of material subject to a Request for Confidential Treatment but which counsel for Motorola has stated may be released and placed in the public record.[1]

These documents are available for inspection in the ET Docket No. 92-28, PP-32 file at the FCC public reference room (Room 239), 1919 M Street N.W., Washington, DC 20554. Copies of these requests also may be obtained from Downtown Copy Center, (202) 452-1422. For further information, contact Ray La Forge, Office of Engineering and Technology, (202) 653-8117.

The IRIDIUM™ system brings a new meaning to the word "communications." The possibility of communicating via a network of Low-Earth-Orbit satellites using affordable hand-held units anywhere in the world opens a new chapter in world communications.

Imagine the possibilities...government officials on travel can be in constant contact with their office. Land and sea mining and oil operations can have continuous worldwide communications service. A businessman travelling in a remote area will be able to communicate with his co-workers. And telephone booths can be placed in remote areas to allow residents to speak with relatives in other villages and people across the globe.

We at Motorola are convinced that the IRIDIUM™ system can be of significant benefit to your country. We are providing some business and technical articles for this monthly issue of your journal as an introduction to our system. We invite your questions and suggestions, and we hope these articles will be just the first exchange in an ongoing association between your country and the IRIDIUM™ system .

Motorola, Inc.

Durrell Hillis
Corporate Vice President
and General Manager,
Satellite Communications

MOTOROLA INC. OVERVIEW

GENERAL INFORMATION

Motorola Inc. is one of the world's leading providers of electronic equipment, systems, components and services for worldwide markets. Products include two-way radios, pagers, cellular telephones and systems, semiconductors, defense and aerospace electronics, automotive and industrial electronics, data communications and information processing and handling equipment. Motorola has 105,000 employees worldwide and is among the United States' 50 largest industrial companies ranked by total sales.

Motorola's fundamental objective is total customer satisfaction. The company was a winner of the first Malcolm Baldrige National Quality Award in 1988, in recognition of its superior companywide management of quality processes.

1990 Net Sales by Business Segment

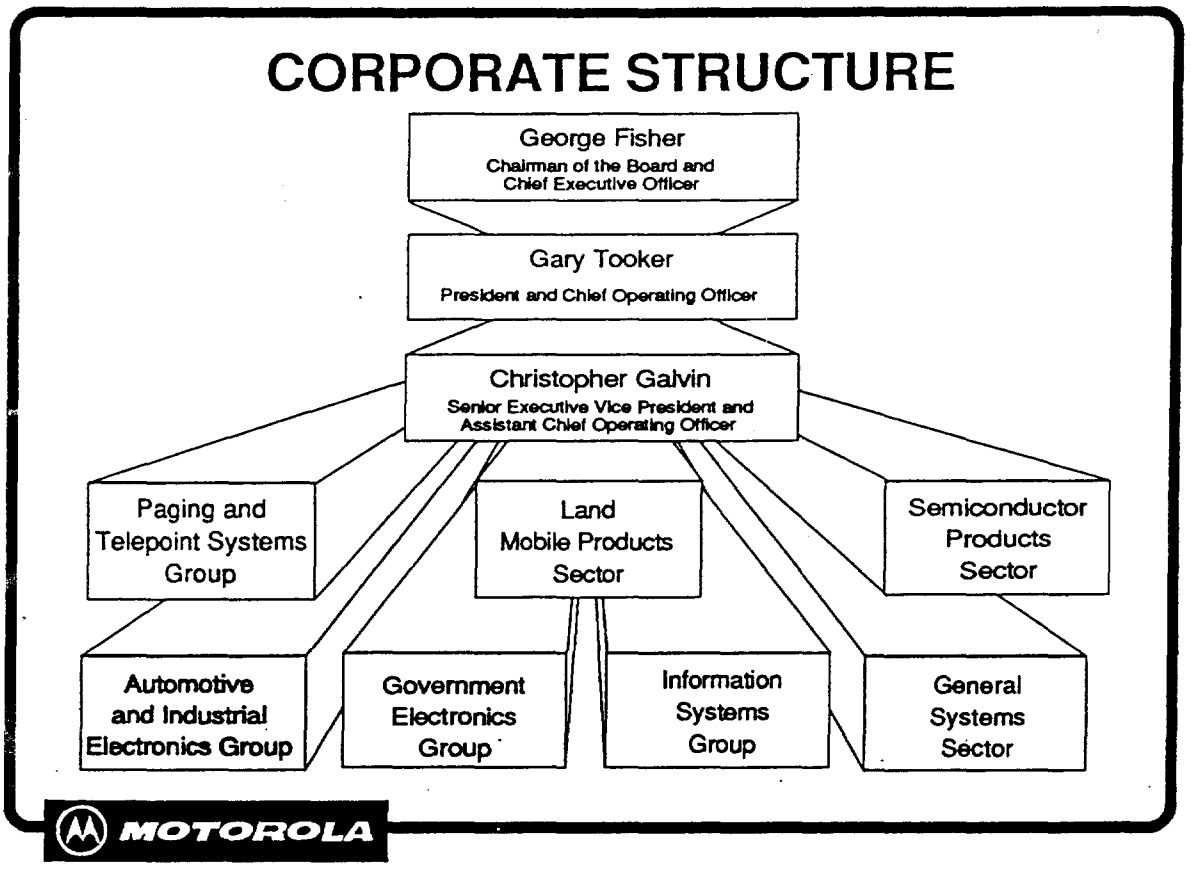
32% Communications Products	$3.6 Billion
30% Semiconductor Products	$3.4 Billion
23% General Systems Products	$2.6 Billion
5% Information Systems Products	$599 Million
6% Government Electronics Products	$685 Million
4% Other Products	$436 Million

FINANCIAL RESULTS

Motorola's sales increased 13 percent in 1990 to $10.88 billion from $9.62 billion in 1989. Earnings were $499 million, or $3.80 per share, compared with $498 million, or $3.83 per share, a year earlier. Research and development expenditures rose to more than $1 billion in 1990, while fixed asset expenditures continued at a high level, totalling $1.26 billion for the year.

Motorola's customer base has become more global, and the company is expanding accordingly. As a result, electronic products from Motorola are bringing the world closer together. Non-U.S. revenues as a percentage of the total reached 44% in 1990, on an international market basis.

Motorola places particular emphasis on product quality, total customer satisfaction, short cycle manufacturing, and training and education of employees at all levels to improve manufacturing, marketing and technical skills.



MAJOR BUSINESSES

Motorola is divided into eight major businesses which include:

Land Mobile Products Sector

The Land Mobile Products Sector designs, manufactures and distributes two-way radios and other forms of electronic communications systems for a wide range of customers including agriculture, commercial, construction, education, state, local and federal government and health care markets, as well as for industrial, mining, petroleum, and transportation companies and utilities.

Major Products

Automatic Vehicle Location Systems
Communications System Installation and Maintenance
FM Two-Way Radio Products
HF Single Sideband Communications Systems
Signaling and Remote Control Systems
Communications Control Centers
Emergency Medical Communications Systems
FM Two-Way Radio Systems
Integrated Security Systems
Mobile Data Systems

Paging and Telepoint Systems Group

The Paging and Telepoint Systems Group designs, manufactures and distributes products for paging and CT2 (telepoint) systems worldwide.

Major Products

Components
CT2 (telepoint systems)
Second Generation Cordless Phones
Pagers
Radio Paging Systems

Semiconductor Products Sector

The Semiconductor Products Sector designs and produces a broad line of discrete semiconductors and integrated circuits, including microprocessors, microcomputers and memories, to serve the advanced systems needs of the computer, consumer, automotive, industrial, federal government/military and telecommunications market.

Major Products

Bipolar and MOS Analog ICs
Bipolar, BIMOS, CMOS and Combined Technology
Data Conversion Circuits
Fiber Optic Active Components
Industrial Control Circuits
Microcomputers and Peripherals
Microprocessors and Peripherals
MOS and Bipolar Memories
Open Architecture CAD Systems
Optoelectronics Components
Pressure and Temperature Sensors
RF Modules
SMARTmos™ Products
Thyristors and Triggers
Voltage Regulator Circuits
Zener and Tuning Diodes
Bipolar and MOS Digital ICs
Custom and Semicustom Semiconductors
Customer Defined Arrays
Digital Signal Processors
Field Effect Transistors (FETs)
Interface Circuits
Microcontroller ICs
Microwave Transistors
Motor Control Circuits
Operational Amplifiers
Power Supply Circuits
Rectifiers
RF Power and Small Signal Transistors
Telecommunications Circuits
TMOS™ and Bipolar Power Products

General Systems Sector

The General Systems Sector designs and manufactures computer-based cellular radiotelephone systems, mobile and portable radiotelephones, microcomputer boards, and information processing and handling equipment, such as multi-user microcomputer systems.

Major Products

- Cellular Mobile, Portable, Transportable and Personal Subscriber Products
- Factory Automation Computer Control Systems
- Microcomputer (VME) Board Level Products
- Cellular Radiotelephone Systems
- Electronic Mobile Exchange (EMX) Series
- HD, LD and HD II Series Cellular Base Stations
- Multi-User Super Microcomputer Systems and Servers

Information Systems Group

The Information Systems Group combines the capabilities of Codex Corporation and UDS to provide all the elements for distributed data and voice networks from basic modems to network management systems.

Major Products

- Digital Service/Channel Service Units
- Electronic Data Switches
- ISDN Terminal Adaptors
- Micro-to-mainframe Plug-in Boards
- Multiplexers
- Network Management Systems
- Network Monitoring Services
- Distributed Communications Processors
- High Speed Digital Communication Products
- LAN/WAN Internetworking Products
- Modems
- Network Design, Installation and Maintenance Service
- Protocol Converters

Government Electronics Group

The Government Electronics Group specializes in research, development and production of electronic systems and equipment for the U.S. Department of Defense, the National Aeronautics and Space Administration (NASA) and other government agencies, commercial users and international customers.

Major Products

- Drone and target command and control systems
- Fixed and satellite communications systems
- Missile guidance systems
- Secure telecommunications
- Electronic fuze systems
- Electronic positioning and tracking systems
- Intelligent display terminals and systems
- Missile and aircraft instrumentation
- Satellite survey and positioning systems
- Space communications systems

Automotive and Industrial Electronics Group

The Automotive and Industrial Electronics Group serves the motor vehicle and industrial equipment industries through the development and production of a variety of electronic components, modules and integrated electronic systems.

Major Products

Agricultural Vehicle Controls	Anti-lock Braking System Controls
Automotive and Industrial Sensors	Automotive Body Computers
Gasoline and Diesel Engine Controls	Ignition Modules
Instrumentation	Keyless Entry Systems
Motor Controls	Multiplex Systems
Power Modules	Solid State Relays
Steering Controls	Suspension Controls

New Enterprises

The New Enterprises' organization manages Motorola's entry into strategically relevant, emerging, high growth, high technology business arenas, including hospital clinical information software systems, selected imaging systems, as well as data communications products and services.

Major Products

Software and Hardware for Hospital Intensive Care Units	Supervisory Control and Data Acquisition (SCADA) Systems

WORLDWIDE FACILITIES

Motorola maintains sales and service offices worldwide, with major facilities in: Australia (Melbourne); Canada (Richmond, British Columbia; Brampton and North York, Ontario); Costa Rica (Guadalupe); Denmark (Copenhagen); France (Angers, Bordeaux, Toulouse); Germany (Flensburg, Munich, Taunusstein); Hong Kong (Kowloon, Tai Po); Ireland (Cork); Israel (Arad, Tel Aviv); Japan (Aizu Wakamatsu, Sendai, Tokyo); Korea (Seoul); Malaysia (Kuala Lumpur, Penang, Seremban); Mexico (Guadalajara, Leon, Mexico City); Philippines (Manila); Singapore; Switzerland (Geneva); Taiwan (Chung-Li); United Kingdom (Basingstoke, East Kilbride, Stotfold, Swindon); United States (Huntsville, Ala.; Chandler, Mesa, Phoenix, Scottsdale and Tempe, Ariz.; Cupertino and Torrance, Calif.; Boynton Beach and Plantation, Fla.; Arlington Heights, Northbrook and Schaumburg, Ill.; Mount Pleasant, Iowa; Mansfield, Mass.; Albuquerque, New Mexico; Elma, New York; Austin, Dallas, Fort Worth and Seguin, Texas; Bothell, Washington); Vega Baja, Puerto Rico.

BUSINESS ASPECTS OF THE IRIDIUM™ SYSTEM

SUMMARY

The IRIDIUM™ system is designed as a worldwide satellite-based digital communications system. It will use small portable terminals linked through a network of low earth orbit (LEO) satellites to provide point-to-point communication between users located anywhere on the earth's surface. When it becomes fully operational in 1997, we expect the IRIDIUM™ system to support voice communication, facsimile and data transmission, and paging for millions of users throughout the world.

The IRIDIUM™ system's design concept makes it ideally suited for use in sparsely populated areas that cannot support a heavy investment in conventional communications facilities. Once the IRIDIUM™ satellite network is in place, very little else is required by way of infrastructure to provide a viable communications system. Therefore, the IRIDIUM™ system can be used effectively in areas of low potential traffic density where other systems would not be economically feasible.

The IRIDIUM™ system is intended for use in business, government, and personal applications. Business applications might include business aircraft, long-haul trucking operations, and exploration, mining, or drilling operations in remote areas. Government agencies could use the system for rescue and law enforcement operations and as an auxiliary communications system during natural disasters. Business and government officials, as well as private subscribers, may use the IRIDIUM™ system when travelling in regions lacking standard telephone service, as is the case in many emerging countries. Personal applications will also include private use for pleasure and recreation.

The IRIDIUM™ system consists of three main elements:

1. A satellite constellation of 77 LEO satellites, equally distributed in 7 different polar orbits.
2. Gateways (ground stations) that will link IRIDIUM™ subscribers with public telephone system users.
3. IRIDIUM™ user terminals: voice, facsimile, Radiodetermination Satellite Service (RDSS), pager.

The satellite constellation will be owned and operated by an international IRIDIUM™ Consortium consisting of Motorola and other international business entities such as telephone companies, industrial and financial concerns. The constellation will cost approximately $2.5 billion. Financing for the project is to be provided directly by Consortium members, who may use a variety of financial mechanisms.

Gateway ownership may be vested in individual governments, national entities such as PTTs (Postal, Telephone, & Telegraph), or private PSTNs (Public Switched Telephone Metworks), which would provide the IRIDIUM™ service in their own country and possibly in neighboring areas. The gateway operator licensed by the country's government to provide the service will have a contract with the IRIDIUM™ Consortium authorizing this operation. Gateway cost is estimated at $10-$15 million.

The laws and customs of the host country will determine whether IRIDIUM™ terminals will be privately owned by the user or leased from the gateway operator. It is expected that the host country, the gateway operator, and the terminal manufacturers will explore the various alternatives and mutually agree on an arrangement that will best serve the customer.

The IRIDIUM™ system is currently scheduled to become fully operational early in 1997. Global paging and partial voice service are expected as early as 1996.

We believe that the IRIDIUM™ system can offer a variety of services to China. The IRIDIUM™ system may be used in rural areas of China. Various levels of government should be able to use the IRIDIUM™ system for emergency communications during natural disasters such as floods, earthquakes and fires. Government officials, law enforcement, Ministry of Defence, and diplomatic personnel should find it advantageous to communicate via the IRIDIUM™ system in many situations. The system is designed to have numerous business applications in domestic and international travel, shipping, construction, and natural resource exploration.

IRIDIUM™ SERVICE

The IRIDIUM™ system is designed to provide global telecommunications service on a continuous basis, with coverage of all points from the North Pole to the South Pole. The system will support many geographic and application markets with a single infrastructure. Once the satellite constellation is in service, the IRIDIUM™ system can provide service to all markets with minimal additional infrastructure costs.

Present plans call for bulk transmission capacity on the IRIDIUM™ system to be provided to licensed and authorized operators, who in turn will sell service to the public in their authorized area. These operators will collect payments from customers and also serve as an outlet for the IRIDIUM™ terminals.

In terms of reliability, quality and performance, we expect IRIDIUM™ service to be comparable to future digital cellular telephone service. The system is designed to allow worldwide usage of the phone regardless of the subscriber's home location.

Five types of IRIDIUM™ service are planned, each with a separate terminal or a family of terminals:

1. DIGITAL VOICE TRANSMISSIONS - The system is intended to provide two-way, high-quality, 4800 bps voice communications using handheld, portable and vehicle-mounted terminals. IRIDIUM™ mobile phones should also be available in combination with terrestrial cellular phones and with a GPS (Global Positioning System) unit.

2. FACSIMILE - Two types of mobile facsimile units are planned: a stand-alone facsimile unit and a unit to be used with an IRIDIUM™ telephone.

3. DATA TRANSMISSION - A modem that works with the IRIDIUM™ voice terminal is planned that will provide data transmission at the rate of 2400 bps.

4. GEOPOSITIONING AND TWO-WAY MESSAGING - The IRIDIUM™ system intends to offer an RDSS type unit to be used for automatic location reporting and two-way messaging.

5. GLOBAL PAGING - An alphanumeric pager for instantaneous global paging is being designed, which would be similar in size and performance to present-day terrestrial pagers and would be capable of receiving messages inside buildings. It is primarily intended for use in domestic and international metropolitan areas where adequate telephone service is available to allow timely response.

EQUIPMENT AND SERVICE COSTS

IRIDIUM™ user terminals should be comparable in complexity to present day cellular phones. Motorola and other manufacturers will produce the terminals. Their prices will probably follow a reduction pattern somewhat similar to that of cellular phones. However, because the number of IRIDIUM™ units manufactured should be smaller by an order of magnitude, their price reductions are not expected to be as rapid or as dramatic as was the case with cellular phones.

Initial introduction prices for the basic handheld telephone are expected to be about $3,000 (1990 dollars) and may drop below $1000 in a few years. The pager unit, which is expected to be comparable in complexity to the present day pagers, is expected to have an initial introductory price of not more than $500.

Service costs may vary depending on country and time of day. Countries that use the IRIDIUM™ system as a public telephone service may choose to reduce cost to the public through subsidies and special arrangements with the IRIDIUM™ Consortium, such as the leasing of bulk capacity and preleasing contracts.

In performing its financial analysis of the IRIDIUM™ project, Motorola has used a toll rate of $3 per minute and a subscriber fee of $50 per month . However, these numbers should be considered to be only an approximation for the worldwide average, rather than a proposed actual cost to the user.

MARKETS AND CUSTOMER APPLICATIONS

The IRIDIUM™ system is not intended to be a substitute for, or replacement of, existing telephone or cellular telephone systems which, by their nature, have greater capacity and lower rates. It is also not intended to bypass local, national, or international regulatory organizations. Where an area is covered by a terrestrial-based cellular system, the IRIDIUM™ system becomes a backup or an emergency service. In areas of the world where no mobile service is readily available, the IRIDIUM™ system is the mobile system. In areas where mobile service is only provided with geostationary satellites, the IRIDIUM™ system will provide more channels, shorter delays and worldwide networking. And in areas of the world where no telephone service exists, the IRIDIUM™ system should provide the primary method of telephone service.

IRIDIUM™ markets primarily consist of: (1) sparsely populated areas with insufficient demand to support land-based service (fixed or mobile), (2) areas in many developing countries with no existing telephone service, (3) small urban areas with no mobile communications infrastructure and (4) a variety of specialized applications inaccessible with current technology.

The IRIDIUM™ system will find a variety of applications among business, government, and personal users. The penetration rates for various applications will vary with geography and level of development throughout the world.

BUSINESS USE

Because of its rate structure and capacity, the IRIDIUM™ system is not expected to compete with landlines and terrestrial cellular phone service. Major applications of the system should be in international and domestic travel, commercial air travel, business aircraft, coastal and inland shipping, long- haul trucking, construction, oil and mineral exploration.

Business Travel - IRIDIUM™ service should be useful to businessmen on domestic and international travel. They will benefit from IRIDIUM™ global paging, voice, and data service.

Business Aircraft - Continuous and high-quality data and voice service is not at present readily available to business aircraft. A variety of IRIDIUM™ equipment to meet this need is planned for manufacture, including voice, FAX, and data terminals for a complete flying office.

Coastal and Inland Shipping - At present, ships operating in coastal waters, rivers, canals and lakes lack affordable, reliable and continuous communications service.IRIDIUM™ based voice, FAX, and data services are also being planned for this market.

Long-Haul Trucking - Radiodetermination Satellite Service (RDSS) services are beginning to be introduced for fleet management. Motorola intends to offer this service, which will be based on the IRIDIUM™ LEO satellite network rather than on geosynchronous satellites.

GOVERNMENT USE

Being a satellite-based mobile communications system, the IRIDIUM™ system is by its very nature essentially disaster-proof, and should be invaluable in emergency situations such as earthquakes, floods and fires. Various levels of local, provincial, and central government could use it as a secondary communications system in situations where standard communications are inconvenient or impossible. Individual local governments could have a limited number of units available for emergency communications. Law enforcement personnel, rescue teams, firefighters, and others may well use the IRIDIUM™ system as a primary communications system in many situations. Government officials on travel in areas without adequate communications should also benefit from this system.

PERSONAL USE

In the areas without land cellular coverage, IRIDIUM™ terminals can be used in cars, performing the same function as land cellular terminals. This application would involve a mobile voice unit, possibly in a combination with a land cellular phone.

In many areas in the world where there is no telephone service, such service would be possible almost immediately without any need for investment in terrestrial infrastructure. A telephone booth unit is being planned that will permit public use of the IRIDIUM™ system.

MARKET FORECAST

The IRIDIUM™ subscriber base has been forecast for years 2001 and 2006, which will be Year 5 and Year 10, respectively, of the full operation of the IRIDIUM™ system. The world wide total number of subscribers is estimated to exceed 1.8 million in 2001 and 2.8 million in 2006.

BRIEF DESCRIPTION OF THE IRIDIUM™ CONSORTIUM

Present plans call for the IRIDIUM™ constellation to be owned and operated by a Consortium of international entities such as major telecommunications companies, major industrial concerns, PTTs and financial institutions. The Consortium may consist of 5-10 major members and a number of minor owners and will be operated as a "for profit" business.

The Consortium earns a profit for its owners by providing commercial mobile satellite capacity to the global community of service retailers. The main revenues are expected to be payments from local service providers (gateway operators) in the form of revenue sharing and possible franchise fees.

It is anticipated that the Consortium will enforce technical and air interface standards for all equipment used in the IRIDIUM™ network. It would coordinate efforts of all parties interested in LEO mobile satellite services with respect to issues of common interest, including initial and future global frequency allocation, changes and developments in the system infrastructure and new services.

Motorola plans to sign a contract with the Consortium by which Motorola will provide the satellite constellation and system control facilities, which would be owned by the Consortium. In addition, Motorola intends to make sure that a sufficient number of gateways and user terminals are available to allow the use of the system.

Together, the satellite constellation and the control facilities, the principal assets of the Consortium, should cost approximately $2.5 billion in 1991 dollars. The project would be funded by the Consortium between 1991 and 1997 following an agreed-upon funding schedule.

Motorola intends to be a Consortium member and an equity owner. The structure of the Consortium will be determined jointly by its members.

IRIDIUM™ SCHEDULE

The dates below are the major anticipated milestones in development of the IRIDIUM™ system.

1991 - Consortium Formation

1994 - First Seven Satellites Launched
- System Control Facility Operational
- Four Gateways Operational

1996 - Early IRIDIUM™ Service Available
- Full Constellation Deployed

1997 - The IRIDIUM™ System Fully Operational
- Additional Gateways Operational

THE IRIDIUM™ SYSTEM OVERVIEW

SYSTEM DESCRIPTION

The IRIDIUM™ system is a worldwide, digital, satellite-based personal communications system. Calls can be made and received and data can be sent and received anywhere in the world using small, portable, battery-powered terminals. The units communicate via a constellation of 77 low earth orbit satellites. The system can support millions of users throughout the world.

The IRIDIUM™ system consists of three main elements: the satellite constellation and its ground control facilities; gateways (ground stations that provide the interface to public telephone systems); and user terminals (voice, data, FAX). The IRIDIUM™ system is depicted in Figure 1.

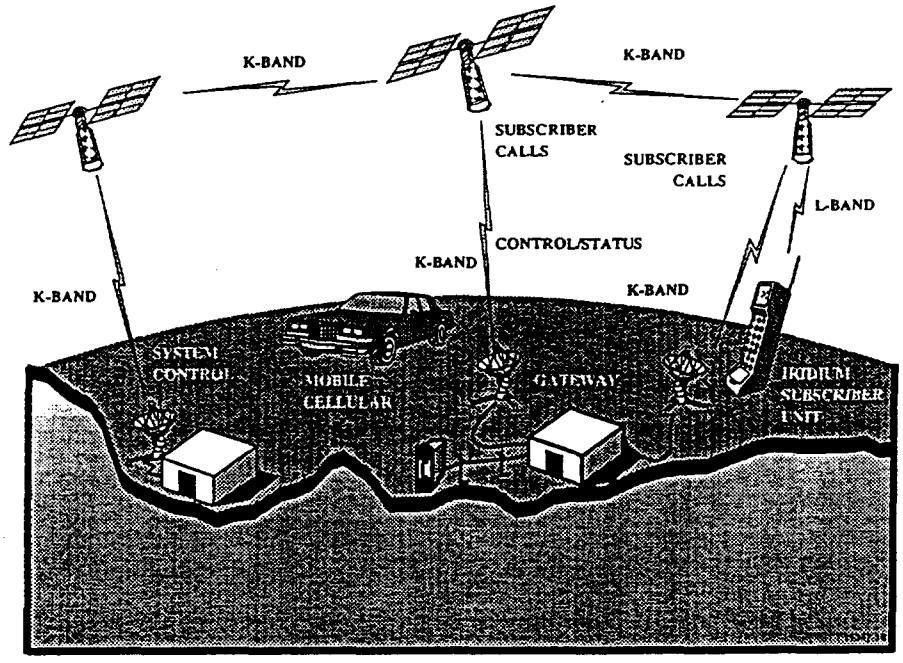


Figure 1: IRIDIUM™ System Overview

SATELLITE CONSTELLATION

The backbone of the system is the network of 77 small, smart satellites interconnected to one another by microwaves as they circle the globe at 413 nautical miles above the earth in seven polar orbits. Each satellite communicates with the user terminals and gateway stations on the ground and other satellites in the constellation.

The IRIDIUM™ satellite design represents a departure from current concepts of mobile satellite telecommunications, which are currently dominated by large, geostationary satellites costing hundreds of millions of dollars. By contrast, the IRIDIUM™ system uses a small (2.3 meters x 1.2 meter), relatively simple, "smart" satellite that can be launched by a variety of existing commercial launch vehicles. To maintain effective cost control, we have adopted a design philosophy that emphasizes size, weight, and power constraints and focuses on simplicity over complexity.

The IRIDIUM™ system employs communications links in two portions of the RF spectrum. The up/down links between the satellites and the subscriber units are designed for L-band operations. The satellite crosslinks, as well as the up/down links to the gateways, are designed for Ka-band.

The IRIDIUM™ system's innovative digital cellular design is somewhat analogous to present day cellular telephone systems, except in reverse. The cell pattern is fixed relative to the space vehicle, but rapidly moving on the earth's surface. Handoffs occur from cell to cell as a subscriber unit is operated, similar to today's cellular telephones. But unlike the case of terrestrial cellular telephones, the IRIDIUM™ cells move across the user, rather than the user moving through the cells. In the current design for the IRIDIUM™ constellation, the typical 372 nautical mile (689-km) diameter cell can service up to approximately 110 simultaneous users per cell (assuming 10.5 MHz of spectrum), while isolated individual cells can handle twice that number.

A seven-cell reuse pattern has been adopted for the IRIDIUM™ system which provides a buffer of two cells between any two cells using the same frequency. The reuse pattern offers part of the spectral efficiency realized with the system, allowing the same channel to be reused over 200 times worldwide. An example of the IRIDIUM™ cell pattern is shown in Figure 2.

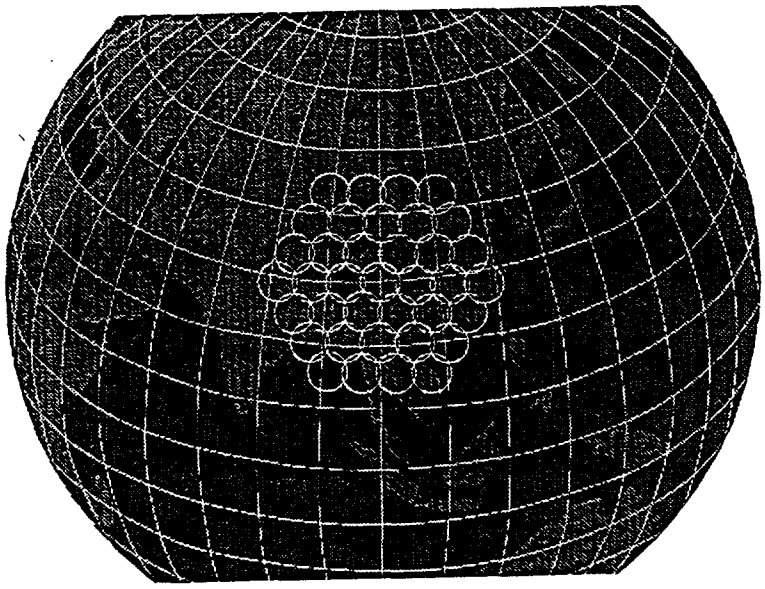


Figure 2: IRIDIUM™ Cell Pattern

Management of the constellation is performed in the System Control Segment. Such critical functions as network management, mission planning, anomaly analysis and resolution, and link management are accomplished here. The IRIDIUM™ system design calls for the System Control Segment to be located at relatively high latitudes to provide for optimum satellite visibility.

GATEWAYS

Gateways are ground stations that provide the interface between the IRIDIUM™ system and public telephone systems allowing communications between IRIDIUM™ units and any other telephones, FAX or data terminals connected to public telephone systems. The gateways collect and maintain call records and billing information for registered users. The gateways may also perform certain technical functions in setting up calls and conducting cell handoff. The home gateway is the gateway where the ISU is registered. Normally the billing information originates from this gateway. This gateway determines if the ISU may originate a call or utilize a service. A local servicing gateway is a gateway near the ISU position. This gateway may be performing network operations, i.e. call setup, cell handoff, and ISU location determination. Whether these functions are performed on the ground will be governed by the space vehicle design.

IRIDIUM™ TERMINALS

The terminals are designed to communicate directly with the satellites overhead. A variety of different products are planned based on the portable voice unit. This unit is designed to have all the desirable features of modern cellular phones. Derivatives of the voice unit could include mobile (car, truck) units, an avionics integrated unit (private aircraft) and FAX and data attachments. Global positioning capability (GPS), an RDSS unit and a global pager should also be available. The family of IRIDIUM™ terminals is shown in Figure 3.

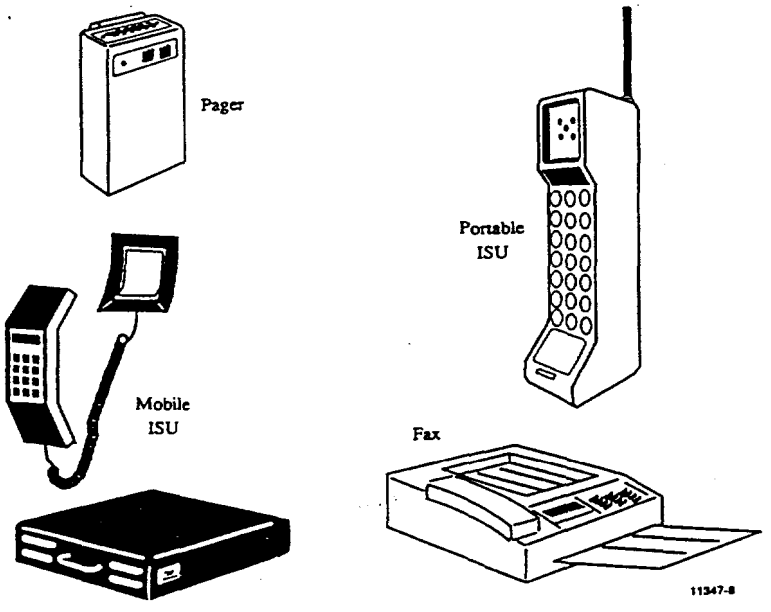


Figure 3: IRIDIUM™ Terminals

PACKET MESSAGES

The IRIDIUM™ system utilizes packet message technology. The reservation of channels exists only in the uplink from the ISU to the servicing satellite. Elsewhere the messages are routed on an individual or bundled message basis to open channels instead of reserving a specific channel for exclusive use regardless of usage. This operation is analogous to the movement of mail in the postal system.

The ISU processes its input data for 60 milliseconds. Then this data package is transmitted to arrive at the satellite at a designated time period. At the satellite, the address header containing the destination satellite is attached. The message is then passed satellite to satellite in accordance with the then current routing algorithm (or routing lookup table) in each satellite. The prior or following message may travel a different route. At the destination satellite the message packets are sorted for delivery to the appropriate cell or gateway.

IN-SERVICE REGISTRATION

An in-service registration message is required to provide a location to page (ring) a unit which has been of service. Also, it provides for eliminating paging (ringing) ISUs which are out of service. When an individual ISU is turned on, a message is sent to its home gateway, informing the home gateway that the ISU is turned on and where it is located. Should the unit be on standby (waiting for a call) for a significant length of time and have moved a sizeable distance, an update message will be sent to the home gateway.

CALL SETUP

The following is an abbreviated description of how a call is setup:

1. The ISU will accept from the user the service desired and the number of the destination terminal. The terminal could either be another ISU or any PTT terminal number.
2. A request for service message containing the initiating user's registration number, and the number of the destination terminal is sent to the satellite in view. This message is then forwarded to the local servicing gateway for call setup.
3. The local servicing gateway inquires of the initiator's home gateway the authorization of the initiating unit to utilize the system.
4. The call setup servicing gateway inquires of the destination home gateway the authorization of the destination unit to utilize the system, and type of service. Also requested are whether the unit is in service and the location of the destination unit.
5. If the authorizations are approved, the system will assign the channels for the users link to the satellites, and initiate a page to (ring) the destination terminal.
6. If the destination is an ISU, the unit will be paged in the destination cell and if necessary the cells surrounding the destination cell. Appropriate signaling will be returned to the initiating unit.

CALL MAINTENANCE AND TERMINATION

The following is an abbreviated description of how a call is maintained and terminated:

1. Cell handoff for an ISU may be maintained by the local servicing gateway for the ISU.
2. Should an ISU not respond to a handoff message, the message will be repeated for a period of time. If a response is not received in the time out period, the call will be terminated.
3. When a call is terminated, either by a termination message or a time out message, appropriate call records will be sent from the local servicing gateways to both home gateways.

CHARACTERISTICS OF THE L-BAND LINK

The L-band networks support the links between the IRIDIUM™ Subscriber Units (ISU) and the satellite in view. Each satellite has the capability of projecting 37 spot beams on the surface of the earth. The spot beams form a continuous hexagonal pattern as shown in Figure 2. Each of the 37 spot beams is created such that they are approximately the same size (372 nautical miles in diameter), and combine to cover a circular area with a diameter of about 2,200 nautical miles for each satellite.

Each satellite has six multiple beam phase array antennas plus one fixed beam antenna. The phased array antennas are located on the side panels of the hexagonal satellite, each of which forms six cellular beams. The fixed beam antenna is located on the bottom of the satellite and forms a single cellular beam in the nadir direction.

The IRIDIUM™ system operates with a 7-cell frequency reuse pattern. This is achieved by utilizing the total frequency band for each cell, while time multiplexing the cells through seven basic time slots. Each of the six beams on a panel is separately activated in one of the seven time slots. Note that one panel activates only one beam at a time. The nadir beam is also activated during only one of the seven time slots.

The transmit time for each cell is 1.3 millisecond. However, the receive time is 2.9 millisecond. The difference in the transmit and receive time is achieved by transmitting only the active channels (DSI). When guard time between bursts are included, 14 cells may be addressed in a basic frame time of 60 milliseconds.

The transmission times from each ISU are advanced from the satellite receive time to compensate for the range delay. Likewise, the frequency of the ISU is adjusted for Doppler.

The L-band RF up and down links will operate bi-directionality in the 1610-1626.5 MHz band. The transmit and receive will operate in a TDMA mode between cells and transmit and receive.

The uplink for a given cell will consist of 64 channels, per 10.5 MHz, with 9 channels set aside for control channels. This leaves 55 message channels for each cell visit, or an average of 110 message channels per cell per frame. These channels are spaced 160 KHz apart with a bandwidth of 126 KHz each.

The downlink for a given cell will consist of 29 channels, per 10.5 MHz, with four channels for control. This leaves 25 message channels for each cell visit. These 25 channels are the equivalent of 55 message channels when compacted by DSI. Again this averages to 110 message channels per cell per frame. These channels are spaced 350 KHz apart with a bandwidth of 280 KHz each.

The ISU will communicate with satellites which are visible 10 degrees or more in elevation. Transmitter RF output electronic power control will be utilized on the subscriber links to compensate for up to 12 dB vegetative shadowing.

CHARACTERISTICS OF THE KA-BAND LINKS

The IRIDIUM™ program has requested, in its application to the U. S. FCC, six 15 MHZ feederlinks each in the uplink band of 27.5-30.0 GHz and the downlink band of 18.8-20.2 GHz. Similar requests will be made to other administrations which govern locations where gateways are located.

Several frequencies are required as the gateway must track at least two satellites during the handoff process. Several frequencies are also required to avoid transmitting co-frequency to the geostationary orbit.

For the intersatellite links, eight 25 MHz channels are required to establish four to six links from each satellite. The fore and aft in-plane links are constant distance (4024 Km) and look angle of negative 17 degrees from the tangential plane to the satellite orbit. The inter-plane links utilize steerable fan beams which point to the side of the orbit. The range of the link varies from 3886 Km near the equator to approximately 2012 Km at the pole.

SPECTRUM REQUIREMENTS

The initial[1] IRIDIUM™ system has filed for a license in the United States to receive and transmit signals at the following frequencies:

Table 1: Spectrum Requirements

Subscriber Unit	1610-1626.5 MHz	Bi-directional, TDMA
Assumed usable spectrum with full sharing is 10.5 MHz which yields 110 voice channels per cell		
Gateway and Satellite Control Segment	27.5-30.0 GHz (Uplink)	8-25 MHz chan., 2 per Sat.
	18.8-20.2 Ghz (Downlink)	8-25 MHz chan., 2 per Sat.
Intersatellite Crosslinks	22.55-23.55 GHz	6-15 MHz chan., 4 per Sat.

The IRIDIUM™ system is designed for single L-band operation. This means that no frequency spacing is required between the up and down link carriers, and that the paired RDSS band (2483.5-2500 MHz) will not be needed.

As the system matures, more subscriber spectrum will be needed[1]. This growth is shown in Table 2 and Figure 4 . The spectrum requirement details are located in the U. S. paper submitted to the CCIR JIWP in Geneva in March 1991. The paper is entitled, "JIWP 92/0060: AMENDMENT OF SECTION 6.1.1.3.1.4 ON SPECTRUM NEEDS FOR LOW EARTH ORBIT MOBILE SATELLITE COMMUNICATIONS ABOVE I GHZ".

Table 2: LEO MSS Spectrum Requirements

1996-2001	2001-2005	2005-2010	2010-2115
10.5 MHz	40.8 MHz	59.8 MHz	96.3 MHz

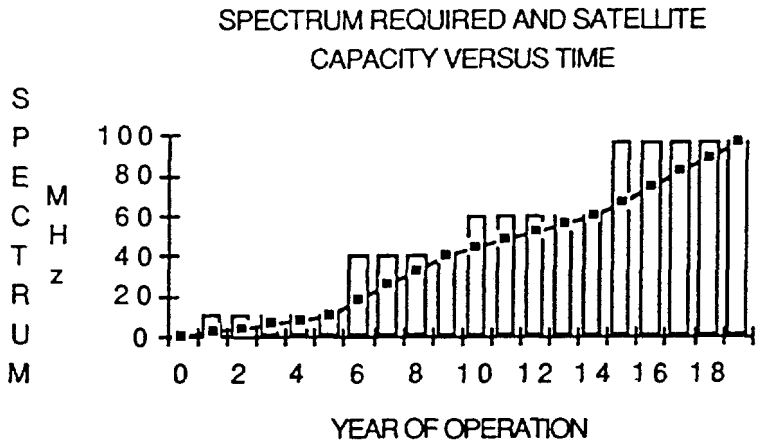


Figure 4: Required Spectrum for Growth

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[1] The Iridium system will require 10.5 MHz of L-band spectrum during the initial five year period, 1996-2001. As the System matures, additional L-band spectrum will be required. Additional spectrum may be located in the 1850-1990 MHz band.

THE IRIDIUM™ SYSTEM'S APPLICATIONS IN CHINA

1.0 INTRODUCTION

China is one of the biggest countries on earth; it has more people than any other country in the world. Almost all the people live along the coast on the plains and in the basins drained by the great rivers. The percentage of densely populated and used land is just a small number in comparison with the unused land. On the other hand, abundant natural resources which have not yet been discovered, analyzed, and utilized are scattered at less densely populated, remote areas. Because of the size of the land and the natural characteristics of the terrain (about two thirds of China is mountainous), it would not be economical or practical to install typical landline communications systems even to support the domestic communications. Note that the rough terrain would not permit the installation of cables easily, not to mention that the initial and maintenance costs would take many years to recover if lines are to be installed in these mountainous areas. In fact, due to the size of the country and the cultural differences among the provinces, domestic communications in China are just as difficult as international communications for many other countries.

The IRIDIUM™ system can provide both worldwide and domestic communications services for China. It can play an important role in helping China in her future development.The IRIDIUM™ system consists of a space segment and a ground segment. The space segment consists of 77 small Space Vehicles (SVs); the space segment will be owned by the IRIDIUM™ Consortium. The ground segment consists of gateways, subscriber units, and primary and secondary System Control Segments (SCSs).The SCSs will also be owned and operated by the Consortium. The ISU design will be documented in the ISU design specifications. The units are expected to be manufactured by different vendors worldwide in accordance with the design specifications and consent of the Consortium. The ownership of the gateways may be vested in individual governments, national entities, or private providers; it is on a country-by-country basis.

2.0 GROUND SUBSYSTEMS FOR CHINA

The IRIDIUM™ system was initially planned to provide worldwide communications services between any two IRIDIUM™ Subscriber Units (ISUs), as well as between any ISU and a local Postal, Telegraph, and Telephone (PTT) customer. In other words, one end user must be an ISU user. The thought of relaying landline traffic was discarded because such bulk traffic transmissions could easily saturate the system capacity in the denser traffic areas. For applications in China, however, we have since modified our earlier system concept. That is, the IRIDIUM™ system can also be used for "hauling" local and long-distance traffic within China, in addition to providing the worldwide communications service for users located in China.

2.1 K-Band Gateway

Due to the large size of China, we have suggested that one or two full capacity K-band gateways be deployed in the country. In addition to these gateways, we also envision deploying multiple low capacity K-band gateways scattered in the suburbs of major cities, such as Harbin, Shanghai, etc. From a functional point of view, each full capacity gateway can serve as a servicing gateway (SGW) for setting up calls, collecting operational data, taking care of global or nationwide billing data, and performing a home gateway's (HGW's) functions. The less-capacity gateways can be set up as SGWs or just as HGWs, depending upon the desired configuration for the entire country. One dominant factor for configuring China's gateways would be the projected user numbers in different provinces and metropolitan areas. A HGW is responsible for managing its subscribers' files, collecting service charges, and relaying K-band up- and down-link traffic. The current design permits each SV to have direct Line-of-sight (LOS) links with four gateways at any instant in time

as a maximum. Each SV is designed to consist of six different frequency sub-bands for LOS gateway links.

2.2 L-Band Transportable Multiple Unit

An L-band telephone booth was part of the initial concept. The phone booth could only provide service to one user at a time. Each telephone booth behaves as an ISU; numerous L-band telephone booths can be scattered anywhere in the country, including the Gobi desert, oil fields in Shinkiang, heavy industrial areas in Manchuria, etc. For multiple users' applications, the Transportable Multiple Unit (TMU), which was previously defined as the "Bridge", is also envisioned as another major product line that can be installed in China. Each TMU consists of multiple L-band links and a multi-line processor. Depending on the "size" of the TMU, i.e., the required capacities of the L-band links in that specific area, a TMU could provide services for tens or hundreds of users simultaneously. The cost for a TMU is significantly less than the cost of a K-band gateway.

There are several advantages in using the TMUs in China. A TMU: (1) could integrate Motorola's existing terrestrial cellular system or the conventional telephone system for an isolated area; (2) would permit the users to use less expensive handsets (i.e., for terrestrial system) to either communicate with local users in the same village or communicate with people of neighboring villages via the IRIDIUM™ network; (3) could have sufficient L-band link margin for better performance, i.e., the peak power for the link could be much higher than that of an ISU because the safety issues of a direct human interface would not be a concern; and (4) could provide a reconfigurable ground subsystem which can be tailored and customized for a specific province and/or for a specific village.

2.3 Other L-Band Terminals

Another member of the ground segment family is the IRIDIUM™ terminal. Each terminal or subscriber unit is an L-band unit without connection to any landline system. The unit can be a global pager, a voice ISU or a FAX/data terminal. Usable at any place in the world, this is the most convenient unit for an individual to carry. The terminals can be used by tens of thousands of government personnel, researchers, land or nature resource surveyors, medical personnel, and construction groups who can report their work back to their cities or central offices in real time. This type of application will expedite national research activities and developments.

2.4 Ground Segment Discussions

All ground subsystems will have direct links to and from the SVs, either in K-band or L-band. An L-band ISU or a telephone booth will not have a direct physical link to and from another ground system; they are stand-alone units. Each K-band gateway and each L-band TMU, however, will be connected physically to the ground switching subsystems. The ground switching subsystem can be either linked to the conventional landline telephone system or a cellular telephone system, such as Motorola's terrestrial cellular system. As such, the users in the service area of a gateway or a TMU can use the regular telephone handsets or cellular phones to communicate with the outside world through the IRIDIUM™ network.The outside world includes international countries or just to neighboring villages.

The IRIDIUM™ system can be used as a "traffic hauler" to "haul" communications traffic from any rural area to its neighboring area and then to the outside world through another land switch center, e.g., a PSTN. Installation of Motorola's terrestrial cellular system in an area with no infrastructure would be a cost-effective approach in comparison with the installation of other telephone systems. The only drawback may be the cost of the current cellular handset unit.This minor disadvantage could be mitigated by a well-planned master production in the country.

3.0 EXAMPLES OF CALL OPERATIONS

We envision that a call may be made in several ways in China: (a) an ISU user to another ISU user, (b) an ISU user to or from a TMU user, (c) a TMU user to or from another TMU user, (d) an ISU user to or from a PTT user (i.e., a PTT is connected to a K-band gateway), and (e) a TMU user to or from a PTT user. For connecting a call, a TMU link to the system is the same as an ISU link to the system; both are L-band entities. The only difference is that a TMU user is expected to be stationary on the earth's surface. An ISU's location, however, may be changed depending upon the user's location, i.e., it could be anywhere in the world. Note that once an ISU is registered to the system, the call operation of an ISU user will be the same as a TMU user. Therefore, the IRIDIUM™ system's call operations can only be categorized into two types, an L-band to another L-band link and an L-band to a K-band link.

3.1 L-Band to L-Band Call

For an L-band user calling another L-band user, the operation may involve several gateways depending upon the locations of the L-band users. As an example, Mr. Lee (Lee), who lives in Beijing and registers his unit with the Beijing gateway, will call Mr. Chen (Chen). The Beijing gateway is Lee's HGW. Lee is now in Tibet for the day. Chen lives in Wuhan and registers his unit with the Wuhan gateway, but he is currently in Paris for a business trip. The Wuhan gateway is Chen's HGW, but the gateway in Paris is Chen's current SGW. They do not know each other's current location, but Lee will originate a call to Chen.

In order to use the IRIDIUM™ system, both units must be turned on first. Once the units are powered on, the system will perform the acquisition function between the SV and the ISU, and then perform the geolocation function. As such, the current locations of Lee's and Chen's units can be registered to their local servicing gateways. That is, the gateways provide services in Tibet and Paris. Each SGW will then interface with its user's HGW to validate the usage privilege and register that user's new location to his HGW. As a result, if other user wants to call the registered user, the system could quickly locate the user and connect the call.

Assuming the geolocation registration is completed and the user is a legal user, the origination caller (Lee) can now dial the destination caller's number, which is Chen's telephone number. The message from Lee's unit will be sent through the SV(s) to the SGW in Tibet. The Tibet SGW will first locate Chen's HGW by examining Chen's telephone number and then send the request to the Wuhan gateway (Chen's HGW); each SGW will be equipped with the database for performing such operations. The Wuhan gateway will check Chen's registration data and tell the Tibet gateway to contact the Paris gateway. Tibet's gateway will then request Paris' gateway to find and "ring" the unit. The call will thus be connected. The processing procedures in each node and the exchanged messages among the nodes are too detailed for this paper.

3.2 L-Band to/from K-Band Call

For an L-band user calling a K-band user, only the L-band user's location must be registered first. The call procedure is quite similar as in the case discussed before. As an example, now Lee wants to call Mr. Sun (Sun) who uses a landline telephone system that is connected to the gateway located in Harbin. Once Lee dials Sun's number, the message will be sent to the Tibet gateway, Lee's SGW. The Tibet gateway checks Sun's telephone number and realizes that Harbin is the ground node for Sun. The message will then be sent to Harbin to connect the call.

For Sun to call Lee, the Harbin gateway will check Lee's number and first interface with Beijing's gateway (Lee's HGW) to check Lee's usage validation. The Beijing gateway will then tell Harbin to contact the Tibet gateway where Lee is currently located. The Harbin gateway will then notify the Tibet gateway to acquire Lee's unit and connect the call.

Regardless of the call type, the SGW will always play an important role. In fact, before the call is connected, the SGWs will determine the users' message routing cues which, in turn, will permit the SVs to send the messages through the appropriate crosslinks. At the end of the call, the SVs will also download the call-related data to the SGWs for billing purposes.

4.0 APPLICATIONS IN CHINA

The IRIDIUM™ system can provide services for Chinese residents as well as for those worldwide travelers who visit China and have IRIDIUM™ terminals. The current system design will permit China to collect revenues from residents of other countries who activate the system in China. In other words, as long as a user is in China, regardless if he is the origination caller or a destination caller, China will collect revenue for providing the IRIDIUM™ system's service.

4.1 Government Use

The IRIDIUM™ system can provide a great service to the government in many different areas. The system can play an important role in helping China's future development. The following are just a few of the many possible applications:

a. Discovery of Natural Resources: China is a country filled with natural resources, but these resources are located in rural and remote areas. Without further analyses of the sampled data, additional explorations may not be a wise choice. With the IRIDIUM™ system, the sampled data can be sent back to the research center for computerized analyses, and thus, the follow-on activities can be directed wisely and quickly through the IRIDIUM™ network.The operation will result in cost-effective and more structured operation.

b. Nationwide Statistics Data Collection: The collection of the nation-wide population data, rural medical diagnostics and practice data, localized manufacture and production data, etc. can be easily collected through the IRIDIUM™ system. The bulk of such data can be transmitted at low traffic times, i.e., night times, to utilize available channels and system capacities. The turn-around time to use the collected data will be significantly reduced by using the IRIDIUM™ system.

c. Educational and Entertainment Programs: The government can use the IRIDIUM™ system to load digitized data to different provinces or organizations for educational or entertainment purposes. The digital transmissions could bring the most updated worldwide technologies to universities, research organizations, and field researchers for broadening researchers' knowledge and helping their work. International activities and entertainment programs can also be sent to any place in China, including remote areas such as Tibet and Mongolia.

d. Control and Direction Dissemination: The centralized government can use the IRIDIUM™ system to request information from the local government or from its subordinate organizations. The government can also use the system to give real-time commands and directions to local organizations. The system can provide the most efficient means for communications among different organizations with varying levels of authority and among different provinces.

e. Construction Site Communications: China will continue to construct new dams, bridges, roads, tunnels, industrial plants, mines, and sites for special projects. The IRIDIUM™ system will permit the officers to monitor the activities without actually attending the activities. The remote site personal, on the other hand, can use the system to communicate constantly and in real-time with the project resources for consultations. The entire site operation will be executed more effectively through the system's communication capability.

f. Emergency Use: The IRIDIUM™ system is practically a disaster-proof system in comparison with any landline systems. In a natural disaster environment, such as flood or earthquake, an IRIDIUM™ system's terminal can still be used to communicate with other organizations in real-

time. Rescue teams can communicate with the centralized direction office and among themselves for more efficient task executions. Law enforcement personnel can also use the system to communicate with other law enforcement personnel for carrying out their missions more effectively.

4.2 Personal Use

China has been playing a major role in worldwide trading in recent years. China's trading activities will continue to grow. As such, the demand for faster and more convenient worldwide personal communications for both voice and data is envisioned to increase dramatically in China. Such a demand cannot be met by the existing telephone systems. The IRIDIUM™ system is the solution to alleviating such a problem.

An ISU may be expensive for an average-income user, but it will be in demand by the world-class business man, traveller, and foreign visiting government personnel. The convenience of using such a unit, at any time and anywhere in the world, without any restrictions of the system or any special actions from the user, will make the unit a popular device. A large number of these foreign users would need the IRIDIUM™ system's service in China when the system is deployed.

The IRIDIUM™ system can also provide service for landline users in China. The users can use their low-cost handsets to communicte with other L-band users through the network. With the TMUs installed in thousands of different locations, the users even in isolated areas can use the IRIDIUM™ system to communicate with other users in different (isolated) areas; both users can use the low-cost handsets. The L-band telephone booth will be used by the public. The pager users in China can use the phone booth to communicate with other worldwide users.

5.0 SUMMARY

Because of the size of the land and the mountainous nature of the terrain, a nationwide landline system is practically impossible to build in China. The recovery rate for the initial investment of such a landline system would be very slow. The IRIDIUM™ system, on the other hand, is the solution to such a problem.

The service provided by the IRIDIUM™ system would help China to discover natural resources, collect nationwide research data, enrich educational programs, ease government and personal communications, and bring in new technologies. This system is the most cost-effective system for China's international and domestic communications system.