Satellite Telephony for Fixed and Mobile Applications

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Abstract—The author focuses on the use of satellite telephony for commercial fixed and mobile applications. Currently users can choose between Inmarsat, American Mobile, Iridium and VSAT services. Globalstar, ICO, Thuraya and ACeS should be available within a few years. Each service offers distinct technical capabilities allowing tailored solutions based on individual requirements.

The choice of satellite telephony service and equipment depends primarily on the cost and capabilities required. Equipment costs range from $1,000-$40,000 with airtime ranging from $1.19-$6.75 per minute. While all the satellite systems provide basic voice services, they differ dramatically in data related features. Through a system comparison, architecture, coverage areas, features, benefits and drawbacks an educated choice can be made.

Commercial satellite telephony usage occurs in industries such as shipping, fishing, yachting, energy, mining and construction. Remote site usage where landline infrastructure is flawed or nonexistent is growing as costs of ownership and operation shrink.

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1. INTRODUCTION

The use of satellite telephone services in the commercial marketplace has grown with the increased availability of services and decreased costs. Industries that typically operate in remote, inaccessible areas have become dependent upon satellite telephony as an integral part of their business operations.

This paper will provide a comparison of the current satellite systems available, their architecture and capabilities, equipment configurations and costs of purchase and operation. We will also look at the satellite services expected to be available within the next few years and how they will enhance the mix of satellite telephony products and services.

Additionally we will discuss the practical use for satellite telephony in the commercial marketplace. Specifically we will look at commercial maritime, energy, mining and construction and how those industries are currently using satellite telephony.

2. CURRENTLY AVAILABLE SATELLITE SYSTEMS

Current options for satellite telephony are Inmarsat, American Mobile (or similar regional systems), Iridium, and VSAT services.

INMARSAT

The Inmarsat system is the most mature of the satellite systems available today and provides the standard by which other systems are measured. This system provides global coverage through three Inmarsat-2 and four Inmarsat-3 geosynchronous satellites which cover the four major ocean regions.

The Inmarsat-2s, launched 1990-1992, are three-axis-stabilized spacecraft with a ten-year life expectancy. The effective L-band isotropic radiated power (EIRP) is 39dBW and each of the satellite's beams covers roughly one-third of the earth's surface.

The Inmarsat-3s, launched 1996-1998, use spot-beam technology and higher power to deliver an L-band EIRP of up to 48dBW. They can also dynamically reallocate both RF power and bandwidth among a global beam and five spot-beams for greater reuse of available spectrum.

The Inmarsat system operates in the L-band (1.5/1.6GHz) and uses a *bent-pipe* technology. Calls originating from a mobile terminal go up to the satellite, are then transmitted down to a Land Earth Station (LES) and terminated via the Public Switched Telephone System (PSTN). Conversely, calls originating from the PSTN would follow the reverse route to the mobile terminal. There are 36 Land Earth Stations around the globe with at least one on each continent providing access to the PSTN. Additionally,

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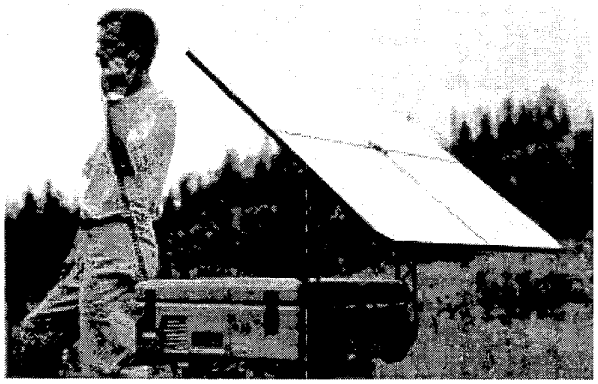
communications traffic is monitored by four network coordination stations (NCS), one for each ocean region. These stations ensure proper call set-up and appropriate LES functionality.

Inmarsat A — Inmarsat A was the first commercial satellite telephone service providing analog voice, data, telex and fax services to maritime users. Those users who are currently using Inmarsat A are likely to continue to do so however, we do not anticipate any growth in this particular service.

The Inmarsat A terminal is effectively a small self-contained satellite earth station made up of a parabolic antenna, electronic units, a power supply interface and communications connections. The equipment cost is approximately $35,000 with airtime ranging from $5.25 - $6.75.

Inmarsat B — Inmarsat B is the digital successor to Inmarsat A and provides all the communications of a well-equipped office, including voice, Group 3 fax and data at 9600 baud. A unique feature of Inmarsat B is the High-Speed Data option which allows Inmarsat B customers to transmit data at 56kpbs and 64kpbs - the highest satellite data transmission speed available today. Inmarsat B is the workhorse of the Inmarsat family as it provides all the essential ingredients for extensive business communications from remote or inaccessible locations.

Equipment for use with Inmarsat B is relatively large with an average cost of about $20,000. Inmarsat B marine equipment costs from $26,000-$35,000 while transportable and fixed site units range from $15,000-$20,000. Airtime rates range from $3.00-$3.95 per minute, typically with no monthly service charge. In addition to the High-Speed Data option, Inmarsat B allows for a Public Address Branch Exchange (PABX) connection and the potential for four voice lines through its single antenna.



Nera Inmarsat B Terminal

Inmarsat M — Consumer demand for smaller equipment and lower airtime costs lead to the emergence of Inmarsat M. Typically known for its briefcase-size mobile terminal, Inmarsat M provided portability for the first time in commercial satellite telephone history.

Inmarsat M marine terminals cost approximately $15,000 with airtime consistent with Inmarsat B. Transportable units cost $8,000. Data speeds top out at 2400 baud for both data and fax transmissions. Multi-channel units are available for 2 voice lines for Inmarsat M and PABX connectivity is also available.

Inmarsat Mini-M (MiniPhone via Inmarsat) — Inmarsat's Mini-Phone uses the Inmarsat-3 satellites and corresponding LES's, and employ smaller spot beams to allow for smaller antennas and thus smaller phones. Compact equipment size, low equipment costs and lower global airtime rates distinguish Inmarsat Mini-M. Very small gyro-stabilized maritime antennas with compact below-decks transceiver units can send and receive voice transmissions and fax and data calls at 2400 baud to anywhere in the world.

Equipment costs range from $2,500 to $6,000 with the marine unit at the higher end of the spectrum. The transportable phones are the size of a small laptop with detachable lid antennas providing increased placement flexibility. Vehicular mounted satellite phones have been added to the mix and provide additional functionality to satellite telephone usage. Per minute pricing for fully terminated calls to anywhere in the world ranges from $1.95 to $2.95 per minute. Dual voice lines and PABX connectivity are both available with the MiniPhone.

Nera Inmarsat Mini-M Terminal

With the MiniPhone we also see the introduction of the subscriber identity module (SIM) card also considered the "brains" of the telephone. The SIM card holds all of the user information including user identity and billing information in an encrypted format. Phones can be shared by different billing entities without complicated reprogramming and SIMs can be replaced easily if lost or stolen.

Global Area Network — In early 2000, Inmarsat plans to introduce Inmarsat Global Area Network. Inmarsat GAN couples Mini-M voice, fax and data service with high-speed data capabilities of up to 64kbps. Equipment and service pricing have yet to be determined.

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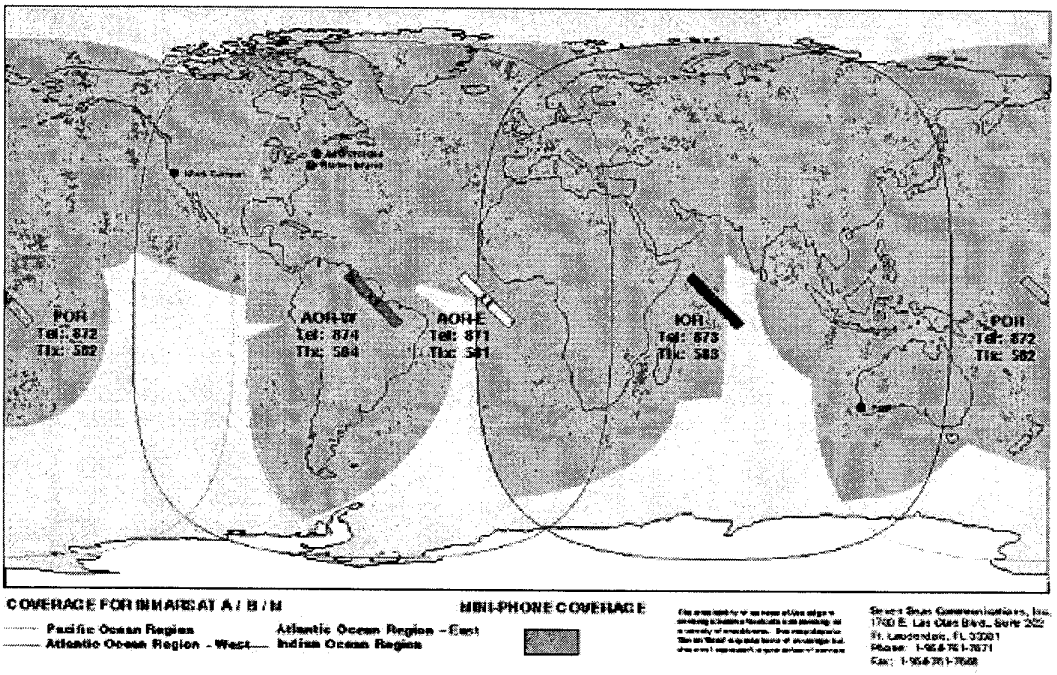
INMARSAT WORLDWIDE COVERAGE MAP



Coverage

The Inmarsat constellation located 22,300 miles above the equator provides a footprint which covers the majority of the globe with the exception of the Polar Regions. These satellites are located at 178 ° E for the Pacific Ocean Region, 54° W for the Atlantic Ocean Region – West, 15.5° W for the Atlantic Ocean Region – East and 64° East for the Indian Ocean Region. Areas within 15° of each pole are unable to access the satellites due to look angle limitations.

Inmarsat A, B and M have more coverage than Mini-M due to the spot beam technology used. Spot beams are more concentrated within the larger ocean regions and are indicated by the darker areas in the map above.

AMERICAN MOBILE

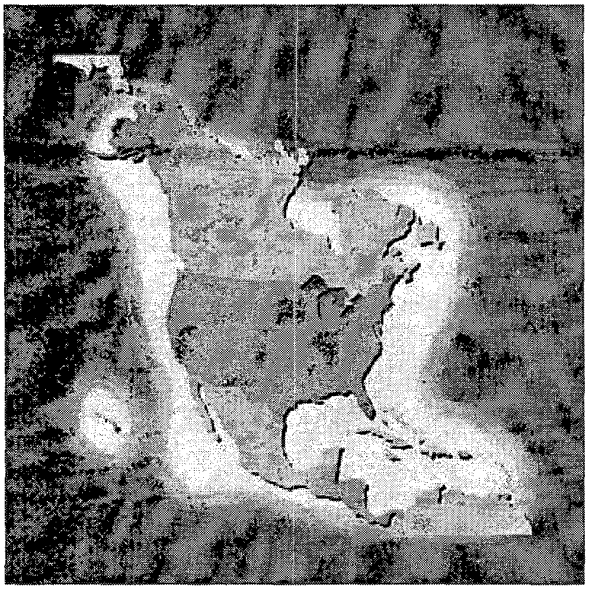
American Mobile is the first regional satellite telephony provider. Since its launch in 1994, other satellite systems, such as Optus in Australia, with similar capabilities have been launched. Also using a geosynchronous satellite and bent-pipe technology, American Mobile provides voice, Rico, the US Virgin Islands and 200 miles of coastal waterways. American Mobile's MSAT-2 satellite was launched in 1994, is located at 101 °W, has an eleven-year life expectancy and emits 550,000 watts of power (EIRP). Communications to the satellite from the mobile terminals occur in the L-Band with the return in the Ku-band. The satellite utilizes five spot beams providing its North American footprint. The American Mobile system uses a single earth station located in Reston, VA where all calls are processed and terminated through the PSTN. Its 33-meter antenna and Radio Frequency RF station, Network Operations Center (NOC), Network Control Center (NCC) and Customer Management Information System (CMIS) are all part of the Communications Ground Segment (CGS) and are co-located within the same facility.

A measure of redundancy is provided through an agreement with American Mobile's Canadian counterpart, TMI. TMI operates an identical satellite, MSAT-1, orbiting at 106 ° W, and a very similar ground station in Ottawa. The footprints of the two satellites are extremely similar although TMI's leans more toward the east. American Mobile's traffic can be routed to TMI's bird, and vice versa, should a space segment failure occur.

Equipment is available in a variety of configurations including transportable, maritime, vehicular mount, and fixed site. Maritime units are larger than the MiniPhone though smaller than the Inmarsat-B terminals. Two of the three varieties of marine terminals are fully stabilized and account for the pitch and roll of smaller vessels. Second-generation transportable terminals are laptop size and

similar in size and functionality to the MiniPhone transportable unit. The cost for mobile terminals range from $1,000 to $5,000 and airtime is generally $1.19 - $1.45 including domestic long distance. There are also monthly service fees of $25.00-$45.00 with an additional $15.00 for the data service and/or fax service. Although fax is considered an option for the American Mobile service, it is a store and forward service with the switch in Canada making for a slow and expensive service, albeit workable.

Dispatch — A unique feature of the American Mobile service is the dispatch service option. Point to multi-point two-way broadcast functionality is available with the use of a push to talk microphone. Talk groups are configured according to customer requirements and a single terminal can be a member of up to 16 different talk groups. Private mode talk groups are also available enabling point-to-point communications within the dispatch service. Dial-in, dial-out and barge-in capabilities are all part of this unique service. Call processing for the dispatch service does not go through the PSTN but remains within the CGS. Dispatch service costs are dependent upon coverage and the number of talk groups accessible, but prices are as low as $65 per mobile terminal per month for one talk group in one region for unlimited usage.



American Mobile Coverage Area

Coverage

The American Mobile footprint covers all of North America, Central America, the Caribbean and parts of northern South America. Mobile terminals should be expected to work from Nome, Alaska through the Bering Sea and south to central Venezuela. Additionally, signal can be expected at least 200 miles off the east and west coasts of the United States and as far east as Trinidad and Tobago. Licensing restrictions rather than technical constraints limit the use of the service in territories outside of the United States. It should also be noted that due to the same licensing requirements, Inmarsat services are not permitted within the American Mobile licensed areas.

IRIDIUM

Iridium is the newest commercialized satellite system and is markedly different from the others. Iridium is the first commercially available Low Earth Orbit (LEO) system and provides voice, paging and cellular roaming services to the entire globe. Data and fax at 2400 baud are expected to be available toward the end of 1999 or the beginning of 2000. The Iridium system uses a constellation of 66 satellites in 6 orbital planes orbiting 485 miles above the earth. Each satellite has 48 spot beams, orbits the earth in just over 100 minutes and has a life expectancy of five to eight years. The satellites were launched and the system became operational in 1997 - 1998. Frequencies for telephone and messaging reside in the L-band (1616-1626.5 MHz), inter-satellite links and ground segment links are in the Ka-band (23.18-23.38 GHz for inter-satellite, 19.4-19.6 GHz for downlinks and 29.1-29.3 GHz for uplinks). The lower orbit combined with a link margin of 16 dBs on average allow the Iridium system to operate using smaller antennas and hand-held phones.

This system uses satellite-switching technology. A call originating from the Iridium Satellite Unit (ISU) is transmitted up to the closest satellite and is then handed off between satellites to the gateway closest to the terminating PSTN phone. There are nineteen gateways internationally providing access to the PSTN and controlling customer validation, billing and call processing in their respective areas. There are two network control centers in the United States and Italy.

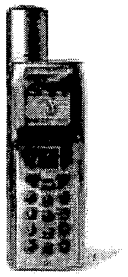
A distinct advantage to the LEO system is that there is no perceptible delay in voice communications as is experienced in the geosynchronous satellite communications systems.

Equipment is available in a variety of configurations starting at $1000 for hand held units and going up to $5,500 for marine units. Multi-channel units and docking stations with external antennas provided are also available. Activation and monthly fees apply depending on the service package

and airtime will generally run from $1.69 - $4.00 per minute.

World Roaming Service — Through the addition of a cellular cartridge to the ISU, Iridium users can access local terrestrial wireless services in areas in which Iridium has roaming agreements. AMPS and GSM cartridges are currently available with the PDC cartridge under development. The service allows the user to choose cellular or satellite service thereby utilizing the lowest cost option. Additionally, only one phone number is used for all services and billing is consolidated regardless of service type usage.

World Paging Service — This one-way service allows the user to receive 120 character alphanumeric messages and works as a stand-alone service or in conjunction with the phone service. A caller can send a page using a telephone, the Internet or the Iridium web site making page sending economical. Additionally, because the signals are sent in a "broadcast" fashion, in-building penetration is higher. Optimally, the Iridium subscriber can be in a meeting with his pager, receive a message while inside, and call the sender back if needed.



Iridium Handset

Coverage

The Iridium system provides the first truly global coverage of any satellite system. Satellites are set in polar orbits so that even those areas of the globe are covered. The only limitation to coverage resides in the political realm. Only in those countries where agreements have not been struck or have refused permission to operate will the phone service be blocked.

VSAT

Whereas Inmarsat, American Mobile, and Iridium can serve fixed applications, they are intended primarily for mobile users. VSAT systems (Very Small Aperture Terminal) on the other hand are designed to provide fixed telephony and data services. VSAT systems first appeared in the late 1970's in the US to fulfill the need for long distance communications between plants and headquarters of multinational corporations. Whereas the first VSAT systems were used for broadcast, two-way VSATs began to develop in the early 1980's. Currently several generations of VSAT coexist in the marketplace and differ from each other in size and speed as well as other features. While older VSAT systems used the C band (6/4 GHz), current systems generally use the Ku band (14/12 GHz) and future systems will likely use the Ka band (30/20 GHz).

VSAT systems have a number of key capabilities. With VSAT systems users, can purchase a fixed amount of satellite bandwidth and utilize it for whatever types of applications they choose. This makes them optimal for users with heavy communications requirements. While they are not mobile, VSAT terminals can be transported to a new place at a relatively low expense and in a short time. Also, besides providing better security and independence from ground networks, the quality and availability of satellite communications systems tends to be far better (99.9%) than for corresponding ground networks.

VSAT systems tend to be more complicated to procure, install and operate than the current mobile systems. However, for users that have large data transmission requirements, it is often the most economic form of satellite communications. A typical VSAT network requires 4 main components: end-user terminal and multiplexing equipment, space segment, earth segment, and central node multiplexing equipment. Equipment costs for the terminal side of the connection, including a .6 to 2.4 meter dish, a satellite transceiver and multiplexing equipment start at $40,000. Space segment costs on Intelsat, PanAmSat or similar satellites typically range from $5,000 to $10,000 per month for a 64K channel. Earth segment costs vary dramatically depending on the services required and the distance from the receiving teleport to the customer premise equipment. The final component of the VSAT network would be customer premise equipment that would break the incoming data circuit into the appropriate channels - including potentially voice, fax, slow speed data or high speed data connections. Equipment costs for customer premise equipment begin at $5,000.

Coverage

Since VSAT systems can utilize a whole range of satellites, VSAT technologies can be used globally. In any given area, users typically have a choice between a number of satellites that can provide service. While in some cases, country licensing requirements may force users to contract with a particular satellite supplier, this is typically not the case.

Iridium	Mini-Phone	Inmarsat B / GAN	Oceancell
Coverage: Global	Global	Global	North America Only
Equipment Costs: $1,400 - $4,500	$2,500 - $6,000	$10,000 - $30,000	$1,000 - $5,000
Per Minute Charges: $1.69 - $2.99	$1.95 - $2.95	$2.50 - $3.50 HSD: $5.00 - $10.00	$1.09 - $1.45
Capabilities: 4.8 kpbs Voice 2.4 kbps Data* 2.4 kbps Fax* Paging Cellular Roaming	4.8 kpbs Voice 2.4 kbps Data 2.4 kbps Fax	16 kpbs Voice 9.6 kbps Data 9.6 kbps Fax 64 kbps HSD	4.8 kpbs Voice 4.8 kbps Data Dispatch

* Available late 1999

Satellite System Comparison Chart

2. FUTURE SYSTEMS EXPECTATIONS

GLOBALSTAR

Globalstar is the next satellite service out of the gate and should be operational in early 2000. They expect to provide users voice and data services at 9600 baud via their constellation of 48 LEO satellites in 8 orbital planes. CDMA and bent-pipe technologies are used in this system so that a satellite call will travel from the mobile terminal to the nearest satellite in view, down to the closest ground station and into the PSTN. The call will hand off to the next approaching satellite so that calls will not be interrupted or the signal lost. Ground station to satellite up-links are in the C-band (forward at 5091-5250 MHz and reverse at 6875-7075 MHz) while satellite to mobile terminal or user links reside in the L-band, 1610-1626.5 MHz for the reverse up-link and S-band, 2483.5-2500 MHz for the forward down-link. In North America there will be two earth stations in Canada, one in Puerto Rico, one in Texas and one in Mexico.

The Globalstar service is expected to complement local terrestrial cellular networks. The phones will be fully programmable on cellular CDMA AMPS or GSM networks for cellular use. The user can decide on which cellular network to activate the phone. They are designed to look for the cellular network and access the satellites only in the absence of cellular. The phone will hold two numbers – one for cellular and one for satellite. The intelligence for the phone will be held in the phone itself as opposed to a SIM card. There will be an additional card that will be inserted into the phone but will be a security module – a hard PIN code as it were. Hand-held terminals will be available at the start of service and are expected to sell for about $1,200. Vehicular mount and fixed site configurations are under development but are not expected to be marketed for about 12 months. Fixed site phones are expected to cost approximately $2,500.00. Both desk phones and pay phones will be available as fixed site configurations. The type of phone purchased will be dependent upon the local cellular standard. Airtime charges are expected to range from $1.39 to $3.00 per minute plus long distance and additional monthly access charges.

Coverage

Although Globalstar is considered a global satellite telephone service it is actually made up of several regional services that have reciprocal roaming agreements. Each region acts independently and the end user needs to register in the visiting region when he or she roams into it. The satellites' orbits are not polar orbits so those areas of the globe are uncovered.

The satellite footprints are large, typically 3600 miles in diameter. Satellites are "visible" from the earth's surface for about 15 minutes from each location though typically two to four satellites will be visible at one time.

Coverage is dependent upon earth stations as well. At the time of this writing coverage at launch of service will include North America excluding Alaska, southern South

America, Eastern Europe, southern Africa, eastern Australia, and the Pacific rim. Other areas will be brought up in stages although it is anticipated that there will be parts of the world, such as middle Africa, northeastern Russia and Alaska that will remain uncovered through Globalstar.

ICO

The ICO system is expected to be commercially available in early 2001, is the first expected Middle Earth Orbit (MEO) satellite system. As a MEO system, satellites operate at 6,400 miles above the earth and therefore provide a dramatically larger footprint than the LEO systems. Consisting of 10 satellites orbiting in 2 orbital planes, the ICO system will provide voice and low speed data up to 9600 bps. As with Iridium and Globalstar, ICO also plans to offer a short messaging service. While offering similar services to Iridium and Globalstar, ICO plans to differentiate itself by leveraging its low cost structure, providing a higher quality service, and utilizing a stronger distribution network.

A call from an ICO phone would first be transmitted at 1.9 to 2.1 GHz to the nearest ICO satellite. The downlink would occur at 5 to 7 GHz to one of the 12 earth stations or satellite access nodes (SANs). The ICO system is built on ICONET, an integrated worldwide fiber backbone that connects the 12 ICO SANs to each other. Once a call is received at a SAN it is dumped on ICONET and eventually routed into the PSTN for final termination.

As with the LEO systems, a key feature of the ICO system is its integrated cellular capabilities. ICO has agreements with eleven GSM networks to provide ICOroam. Each user can therefore utilize his ICO phone to make either satellite or cellular calls.

A number of manufacturers including NEC, Samsung, Hughes and Mitsubishi are planning on offering ICO terminals in various configurations. Pocket-sized handheld phones with integrated GSM capabilities will be available by the start of service. Marine, transportable and fixed versions are also expected to be available.

Coverage

Through its MEO satellite topology, ICO provides full global coverage. Although the system has been designed to provide coverage of the entire earth's surface, service areas will be rolled out and it is expected that 88% of the earth's surface will be covered within 14 months of initial service delivery. The orbital pattern of the constellation provides for coverage overlap ensuring that two or more satellites will be in view of the user and a SAN for more than 80% of the time in most latitudes. Each satellite is expected to cover more that 25% of the earth's surface at any given time.

Cellular coverage will be limited by the current cellular coverage areas and established roaming agreements.

THURAYA

The Thuraya system will utilize a geosynchronous satellite covering 99 nations. The satellite is expected to be launched in May, 2000 with commercial service following in September, 2000. This system expects to provide voice, fax, data (up to 9.6 Kbps), short messaging, and location determination services.

The satellite will orbit at 44° East and is expected to have a twelve to fifteen year life expectancy. Uplinks are at 1626.5 – 1660.5 MHz and downlinks at 1525.0 – 1559.0 MHz with 10dB link margins. This satellite will have 250-300 spot beams allowing for efficient spectrum reuse and digital beam forming providing the capability for dynamic area coverage changes according to traffic demand.

The ground segment is comprised of a primary gateway located in Sharjah, UAE which will be responsible for the entire network as well as serving as the main digital exchange for the system. Hosted here is Satellite Control including the Satellite Operations Center (SOC), Uplink Beacon Station (UBS), Satellite Payload Central Point (SPCP); and the Gateway Station including the Gateway Station Subsystem (GSS), Network Switching Subsystem (NSS), Advanced Operations Center (AOC), Operations Support Subsystem (OSS), centralized billing and customer administration. Individual regional gateways could be established later in other countries if the need arises.

User terminals are expected to be comparable in form and function to GSM terminals and will be offered in hand-held, vehicular, fixed terminal and payphone configurations. Hughes Network Systems and Ascom are developing the terminals using flexible dual-mode technology allowing for access to both GSM cellular and satellite systems providing for cellular roaming capabilities.

Coverage

The Thuraya satellite footprint will provide border-to-border coverage for 99 nations spanning Eastern Europe, North and Central Africa, the Middle East, Central Asia and the Indian Subcontinent.

ASIA CELLULAR SATELLITE (ACeS)

The ACeS satellite system is regional and will consist of a geosynchronous satellite orbiting at 123° East providing mobile and fixed voice, data, fax and paging services. Commercial service has been postponed several times with the last proposed satellite launch date given as late 1999.

ACeS will utilize a state-of-the-art Garuda satellite built by Lockheed Martin with 140 spot beams and a life expectancy of at least twelve years. A second satellite is expected to expand the footprint into the West and Central Asia, Europe and Northern Africa. Each satellite should provide 11,000 simultaneous telephone channels and support 2 million subscribers.

The Satellite Control Facility (SCF) will be located at Batam Island, Indonesia along with the NCC and ACeS Customer Management Information System (ACMIS) and a 15.5-meter tracking antenna. The four national gateways provide the primary interface with other communications systems including the PSTN and public land mobile networks (PLMN) and will be located in Indonesia, Philippines, Thailand and Taiwan. Each gateway provides an individual network over the service area with home subscribers able to roam between other gateways and GSM networks. Gateways will each have a 12-meter antenna and the responsibility for subscriber, user terminal and numbering management, traffic monitoring, SIM generation, customer service and billing functions.

Terminals are being developed by Ericsson and will provide the dual mode functionality that will allow users to roam on GSM cellular networks and onto the satellite network. Configurations are expected to include handheld, mobile and fixed and will be similar to existing GSM phones. Airtime is supposed to be in the USD1 range.

Coverage

The coverage will include South East Asia, India, China and Australia - 11 million square miles - reaching about 60% of the world's population.

2. COMMERCIAL MARKET USAGE

MARITIME

Satellite services were originally designed with the mariner in mind. Safety was at the forefront of that design decision as prior wireless services did not have the reach required for communications at sea. Safety and emergency/distress calls remain a primary requirement for satellite communications in every maritime application, but now, in addition to safety, the marine community uses satellite telephony as a business communications tool aboard ship.

Yachting -- Yachts fall into two categories, charter and private, both with similar communications needs. Charter yachts operate seasonally primarily in the Mediterranean, Caribbean and New England. Typically the yacht will be chartered for a period of time and the communications on board will be available to guests as an added amenity. These yachts function as floating private hotels complete with a full service business center so guests can communicate with offices ashore if need be.

Charter yachts are generally large enough to handle the Inmarsat B equipment used to support the business center. Satellite communications on charter yachts, as on cruise ships or in hotels provide a profit center for the vessel. Phone and business center usage is charged to the guest at premium rates. Charters that are smaller, 60' yachts, are now incorporating the MiniPhone for their guests' use into their amenities package.

The captain and crew often have their own MiniPhone or two so that they can use satellite communications for personal and ship's business. SIM cards can be used for the crew to identify the individual usage and provide an accounting of calls made. This telephone usage can be given to the crew as a benefit of employment or they can be charged for the use of the phone.

Ship's business includes all the operations and administrative functions required to keep the ship afloat. Port of call information needs to be transmitted with notification of arrival, fueling and docking information. Administration and contact with the owner is particularly important for charter yachts. Provisioning or ordering supplies such as food and wine, chandlery for equipment needs such as engine room supplies or air conditioning parts are all communicated through the use of satellite telephony.

Private yachts utilize a lot of the same functionality but the motive is somewhat different. These mega-yachts are effectively the family's second home and have all the functionality and convenience of home. Inmarsat B is used to give the yacht owner the capabilities of a home office and enables him or her to use voice, fax and high-speed data to conduct business while away from the land office. The captain and crew normally will have their own MiniPhone for the same reasons and purposes as in the charter scenario and there may be another MiniPhone on board to accommodate additional calling by the owner and guests.

Fishing

The fishing industry utilizes satellite communications to maintain the operations of a small company afloat. The size and functionality of the boat will determine the equipment and services used.

The larger factory trawlers range from 200 – 350" in length and do both the catching and processing of fish at sea. Trips range from one week to twenty-five days although the crew generally signs for ninety-day periods. Between trips the boats are in port for only 24 to 48 hours during which the crew is required to stay in the dock area for loading and unloading. These fishing boats use Inmarsat A or B for their satellite communications needs depending upon the age of the vessel. Many of the Inmarsat A terminals are aging and are now being replaced by Inmarsat B terminals. Data usage is high and transmissions include crew reports, requests for equipment, parts and personnel issues. Crews of 30-150 people require on board personnel management more often than not. Other general reports would include fishery status, administrative and accounting reports. Additionally, the National Marine Fishery Service requires that these vessels submit daily reports on what, where and how much they are catching. Voice services are used quite a bit as well. Vendor calls, operations requirements and personal use crew calling keep the satellite phones busy for in excess of 1,000 minutes of use per month for most ships.

Smaller fishing boats called shore plant trawlers range in size from 120'-140' and are limited by the fact that they must return to shore plants to have the fish processed. Their trips are therefore shorter lasting only a few days. However these boats target different fisheries with the goal of fishing for as many months as possible during the year and are back out to sea as quickly as they can manage.

If any of the fishing boats are within the American Mobile footprint for a good percentage of time, that service will be added to the mix of communications services aboard. The lower cost of the equipment and airtime make this service the most economical for use in this industry.

Many of these boats fish in groups. They will use the dispatch service so they can work together to determine the best fishing areas for their fleet, what gear is working and where they are being most successful. Shore plants working with the boats will also have a fixed site configuration installed so that they can be a part of the dispatch group enabling them to keep abreast of the progress the boats are making and when they can expect to receive fish for processing. The dispatch service is the most cost-effective method of communication for boats that can use that service.

Voice service enables fishermen to check market prices before coming in to shore to sell their fish. The difference of $.10 per pound of fish can make a $7,000 difference in a haul. Crew calling is also often provided on these vessels so the crew can talk to their loved ones at home. Additionally, the fishermen who own and manage these smaller trawlers may also own other businesses ashore and use voice service to check on those businesses.

Commercial Shipping

Satellite telephony services are used in commercial shipping in much the same way as in other marine industries. Large ocean-going vessels are used to transport commodities internationally over pre-determined shipping lanes. Although the ships are generally about 600' in length, crew requirements are minimal with only about 25 people aboard. Data requirements are high in that spreadsheet reports are required by shipping company offices for logistics, consumables use, fuel consumption and progress. Port of call information is done by voice so that docking and unloading requirements can be met when the ship comes to port.

Commercial vessels use Inmarsat A or B depending upon when they have been outfitted or re-outfitted.

MINING AND CONSTRUCTION

Mining

Typically mining operations are located in remote areas where terrestrial communications systems are non-existent. Decisions are made regarding communications requirements at different stages of the project and are dependent upon the size of the company, the project, the country's landline and cellular infrastructure and the cost effectiveness of each communications solution.

Generally a geologist will go to search for ore and do rudimentary testing in the field in a small pick-up truck, or even on foot depending upon the terrain. Compact size and weight are key so the Iridium phone is used for safety and security purposes, to check in at the home office and to report general location. Dig samples are sent back to the office for evaluation and if the site warrants further exploration the geologist will go back into the region with the Iridium phone and a piece of small drilling equipment for more extensive sampling.

Once the determination is made to actually start mining the size of the company, the project and the revenue potential will determine the communications system used. Terrestrial and permanent solutions are considered along with satellite options.

Inmarsat Mini-M

Generally, data transmission is less important than voice communications. The primary reasons for having communications are for ordering supplies, maintaining administrative contact with home offices, logistics management, and personal use. The mining companies would more likely continue using the Iridium phone or may move to the MiniPhone if maps must be faxed back to the home office. If the project is in the American Mobile footprint a fixed site phone would prove to be most cost effective.

There is a movement toward the increased use of computer analysis on site so the use of satellite equipment and service may change with the arrival of the Global Area Network.

Construction

The construction industry is similar to mining in that work is generally done in remote areas where there are no terrestrial communications systems available or are limited to urban centers. Often satellite communications are used in under-developed countries where projects include the building of bridges, plants, manufacturing facilities, dams roads and airports. Along with construction companies, engineering firms are instrumental in the construction of a myriad of other projects. Data usage is also low so the selection of communications service focuses on voice as well. Iridium or MiniPhone can be used for budget and accounting, logistics, and personal communications.

The fundamental difference between mining and construction for our purposes is that construction projects are of a much shorter duration with projects lasting from one to four years. Permanent terrestrial options are not typically considered. Construction is a shifting market as well and the potential for remote projects fluctuates.

OIL & GAS

The Oil & Gas industry is a huge satellite communications user. A variety of configurations are used depending upon the particular location of the equipment and the purpose it will serve. The introduction of deep water drilling technology allowed oil companies to explore and drill in 8,000 – 10,000 feet of water after the near shore fields were depleted. Operations further out at sea present different requirements and challenges.

To start the process a seismic vessel will be sent to a potential site to do a geophysical survey. These vessels are 160'-220' in length and carry about 100 people. Their mission is to obtain as much information about the sea floor and telephony requirements are extremely data intensive. Inmarsat A or B is the method of choice for this data transfer. Voice and fax requirements must also be met so that information is instantaneous for the home offices of both the survey company and the oil company that contracted their services.

After the seismic acquisition phase, a drill ship with a semi-submersible will be sent to obtain core samples. Again, a highly data intensive application with additional requirements for voice and fax. Holes are being drilled, information is constantly acquired from the sea floor, temperatures, flows and pressures are monitored and summaries sent back to base. These vessels will have several satellite systems aboard to accommodate the needs of the 50-100 people aboard as well as the business operations of the ship. VSAT may be used but is subject to environmental fade so Inmarsat is also aboard. If in the American Mobile footprint, that service can also be used primarily for voice and some dispatch applications.

Platforms and rigs are deployed and fixed site applications are installed. Again, a multitude of systems is used as these structures are in use for months at a time. Additionally barges, the workshops for the platform, are sent long with a few hundred people and a small crane to perform all of the maintenance functions, machining, fabrication and any other job that needs to be done. The barges are an integral part of the overall operation and communications both to the platform, to other vessels and to land bases are imperative.

Additionally, crew boats are used to rotate crew every 28 days. They use voice communications only for logistics purposes and so that the platform knows when to lower the crew basket or for emergencies. Workboats carrying supplies and equipment will also utilize voice service for similar purposes.

5. SUMMARY

This paper summarizes the majority of mobile satellite telephony options available today, expected in the future and their practical applications in the commercial marketplace. The satellite services discussed include Inmarsat, Iridium, American Mobile, VSAT, Globalstar, ICO, Thuraya and ACeS.. It must be stated that data only satellite services like Orbcomm and Teledesic have been