# The Iridium System:
## A New Paradigm In Personal Communications

*The Iridium System employs 66 low earth orbit satellites which provide a means for direct radio linkage between a satellite and a hand-held radio telephone anywhere in the world at any time.*

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The Iridium Communications System is being de signed as a global, digital, satellite-based, per sonal communications system primarily intended to provide low-density, portable service via handheld subscriber units, employing low-profile antennas. Calls can be made and received anywhere in the world with a personal, pocket-size, portable unit. A constellation of small, "smart" satellites will be internetted to form the network's backbone. Small, battery-powered, cellular-telephone-like user units would communicate directly with the satellites. Terrestrial gateways would interface the satellite network with the Public Switched Telephone Network. The system is intended to complement the terrestrial telephone network in densely populated areas by providing a similar service everywhere else in the world.

Subscribers to this system may be widespread and varied. A business person with a portable unit in a coat pocket could have easy access to the home office, and the head of a large multinational corporation could quickly call any colleagues, whether they are at home or traveling, on the earth's surface or in the air, anywhere in the world. The mountain climber, skier, or recreational sailor could continue to communicate with family, friends, or business associates. Developing countries without a telephone infra-structure might have subsidized, solar-powered, centrally-located telephone "booths" in every village. Land and sea mining operations could have continuous worldwide service. And, areas experiencing natural disasters could maintain a reliable communications linkage to the rest of the world.

At first thought, it would seem that we already have global communications. From the U.S., we can place calls to a vast number of domestic and international locations. However, there are many areas without telephone service, not only in emerging countries, but in developed nations as well. Consider that in Russia, with a population of 250 million, there are only 10 million telephones. In India, there are tens of thousands of villages without telephone service. In some countries the telephone system is archaic and even thunderstorms routinely disrupt service. Some countries have service within their boundaries, yet lack the capability of international calling. The objective of this system is to make world-wide, world-class communications practical.

The system originally conceived utilized 77 satellites networked together. The project name was selected because the element iridium has atomic number 77. Furthermore, the concept of 77 satellites orbiting the earth resembles the 77 electrons orbiting the nucleus in elemental iridium. As the system design evolved, taking into account several size, weight, performance and cost tradeoffs, the number of satellites was reduced to 66 (but the name was not changed to that of dysprosium with atomic number 66). The satellites are networked together via cross-links, and with a system control facility, gateways, and subscriber units. The system is shown in an overview in Figure 1.

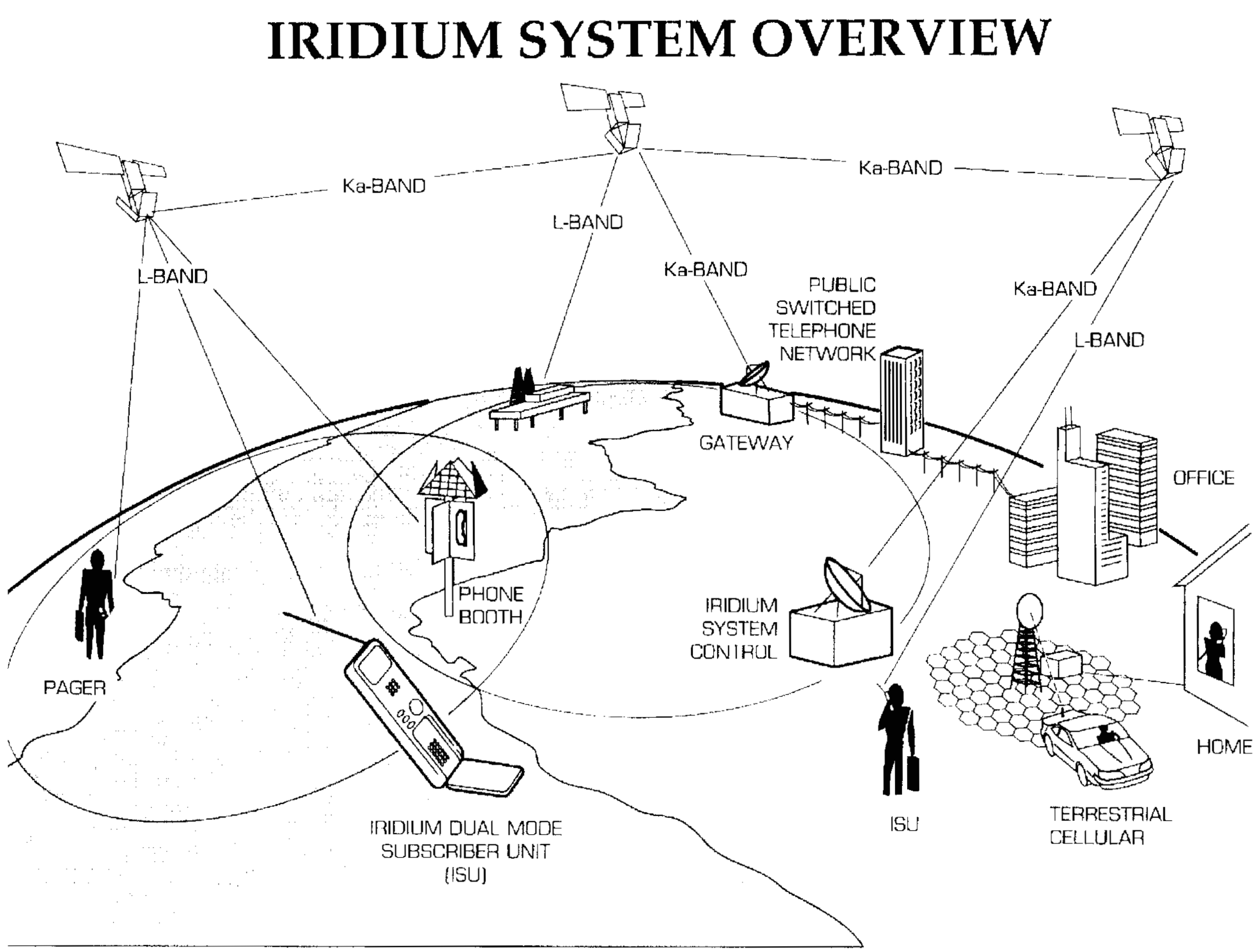


**Figure 1. Iridium System Overview**

Facility (SCF), which is to manage the constellation by tracking telemetry and attitude control information for each satellite to keep it in its appropriate envelope within its orbit and by monitoring the electrical, power and other support subsystems. Also, the facility would manage the communications network, informing satellites if a node is down in order to re-route calls. Two System Control Facilities, geographically separated, wouldbe built to help assure continuous operation.

### *Gateways*

A gateway, shown in Figure 1, is designed to interconnect the network with the Public Switched Telephone Network (PSTN). The gateway is intended to handle call set-up, caller location, and collection of the necessary data to support billing. Caller location is necessary because, a subscriber to this system who may reside, say, in Phoenix could carry the unit to Singapore or Tel Aviv, or to any other location.

The mobile subscriber unit is being designed, so that when powered on, it would communicate to the nearest satellite, which then will notify the access control processor, that in turn updates the location register of the home gateway.

Access to this system is to be controlled geographically to help ensure that communication will not occur between locations that are barred by their respective regulatory administration. This access is to be controlled by determining the user's current location and home location during the call set up process. When someone wishes to call the user, they will dial his or her individual system access number as usual. The necessary intercommunication protocols, essential to regulators and service providers, would be performed automatically by the system and would be transparent to the user.

Gateways, through their incorporated switch and other interface electronics, are designed to interconnect this network to the world's PSTN. In this manner, calls could not only be placed between two system subscribers, but also between any subscriber and any PSTN telephone.

In the current design, the gateways typically would employ a minimum of three 3.3 meter tracking dish antennas that are separated by about 30 Km. At least two dishes would be needed because, as a satellite disappears over the horizon, another will have appeared at a different location above the horizon; and the handover from one to another is to be virtually instantaneous. Most gateways are planned to have at least three tracking dishes to help ensure the availability of the communications link during maintenance activities. The antenna separation would provide optional communication paths for avoidance of rain/thunderstorm cells during adverse weather conditions. It also would provide an option to avoid "looking" into the sun; a source of considerable radio noise. These options reduce the amount of link margin (and peak transmitter power) required to maintain communication during these potentially detrimental conditions.

### *Subscriber Units*

It is explected that subscriber units will be in a variety of shapes and sizes. Initial development includes the individual portable/handheld unit, the mobile unit which can be installed in an automobile or boat, the transportable unit that can be moved between remote fixed locations, and a variety of paging products. The current concept for an individual handheld unit is illustrated in Figure 3.

**Figure 3. Iridium™ Dual-Mode Portable Telephone Model**

Our firm plans to manufacture dual-mode, handheld subscriber units, compatible with both terrestrial cellular systems as well as this system. Where the terrestrial system is available at home or as a roamer, the user could use the terrestrial cellular system. Where a terrestrial cellular system is not available, barring regulatory restrictions, the dial tone of this system should be available.

The portable/handheld unit is currently designed to operate for 24 hours on a single recharge in a combination of standby (able to receive a "ring" indicating an incoming call) and active modes. The system is now being designed to be operated with subscriber unit transmit power levels comparable to those of handheld cellular telephones.

### *The Communications Network*

The system would employ communication links in two portions of the spectrum. The up/down links between the satellites and the subscriber units would operate in the 1610.0 - 1626.5 MHz region of L-Band. This band was only recently allocated for satellite-based personal communications at the 1992 World Administrative Radio Conference (WARC) in Torremolinos, Spain.

The satellite crosslinks, as well as the up/down feederlinks to the gateways, are designed for operation in the 20 - 30 GHz region of K-band. Licenses are required for operation in each Country; some are pending now.

### *L-Band Links Satellite*

L-Band phased arrays would form the 48 spot beams and would have gains between 17 and 25 dBi depending upon the beam location from nadir. The hand-held portables would employ a short, simple antenna with a near-omnidirectional pattern with a gain of +1 dB and right-circular polarization (RCP).

The maximum satellite L-band transmitter high-power amplifier (HPA) output power per channel would be 3.5 watts PEP, while the hand-held portable would produce a maximum HPA output of 3.7 watts PEP. Adaptive transmitter power control (a type of ALC, or Automatic Level Control) would be employed on each carrier, on a user-by-user basis.

Receiver low-noise amplifiers (LNAs) with 0.8 dB device noise figures will complete the major link-budget allocations which would net a link margin of 15 dB in an open-terrain, line-of-sight environment at full transmitter power. The extra 15 dB potential would allow the transmitter power to be increased on demand for operation in foliated environments, in automobiles, and in other difficult propagation situations.

Transmitter power would be electronically adjusted to maintain the desired level of Eb/(No+Io) received at the opposite end of each link. A received signal metric would be sent to the originating transmitter during periodic "maintenance bursts, or "handshakes". This would allow considerable savings in satellite and handset battery lifetimes while maintaining a high quality of service in a wide range of terrain and climates.

The 48 beams would provide Spatial Division Multiple Access (SDMA), which, when combined with Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA), would allow a great degree of dynamic reallocation of capacity by geographical location in response to demands for service. The combination of SDMA, TDMA & FDMA provides very efficient spectral use.

### *K-Band links*

The intersatellite links would employ antennas with 37 db gain and transmitter peak output powers to 3.4 watts. For the space-to-gateway feeder links, the satellite would employ antennas with 27 db gain and transmitter peak output powers to 1.0 watt. Receiver LNAs would have 3.0 dB noise figures. In the latter links, the up and downlink transmitter powers would be varied to maintain signal quality under varying climate conditions. Multiple ground terminals will also be utilized to minimize rain losses and to avoid sun-noise outages.

### *The System doesn't intend to obsolete cellular service*

This service is not intended as a substitute for service as provided by existing telephone or cellular telephone systems, which by their nature have much more capacity and lower calling fares. Rather, this system is intended to extend service beyond the current service areas, especially in areas outside of cities where the provision of terrestrial cellular service is not economically probable. Subscriber units should be available that operate both in the local terrestrial cellular system as well as this system. The terrestrial cellular system might be employed the first option when available.

*Acknowledgements*

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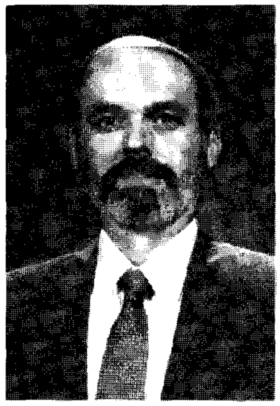

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