# SATTELITE PERSONAL COMMUNICATION SYSTEMS

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Call them PSMNs *(Public Skyline Mobile Networks)* or SPCSs *(Satellite Personal Communication System).* Satellite Personal Communication Systems, SPCSes for short, promise to change the way all of us live.

Communication does miracles. It brings people closer. For a change, it is now bringing satellites closer, to earth. Yes, communication satellites today do not necessarily mean INSATs and INTELSATs, revolving at an altitude of 35,000 km. They are now closer to us, much smaller, and of course, much smarter. Soon, they will be crowding the skies.

By the turn of the century, more than a hundred of them would be orbiting around the earth. Above a distance of as low as 400 km. These are called the Low Earth Orbit (LEO) satellites, to distinguish them from the traditional communication satellites like INSAT and INTELSAT, often called geostationary satellites. Then, there are satellites that can be placed at a distance of between 8000 and 11 000 km, with similar kind of functionalities. Placed between the high orbit geostationary and low-orbit LEO satellites, these are expectedly called Medium Earth Orbit (MEO) satellites.

Landline cellular networks do have certain limitations. Most of the times, you are deprived of a communication link where you need it most in villages, rural roads, forests, and such remote locations. It is uneconomical for any landline cellular operator to cover these places. Mobile satellite services expand the service territory to cover the entire world. "It is like having base stations in the sky," explains Ming Louie, vice-president, Globalstar.

Put simply, SPCSes are LEO and MEO satellite constellations that will provide mobile voice and data communication facilities the world over.

Since an LEO or an MEO can cover much less geographical area than a geostationary satellite, usually more satellites are used to provide global connectiity.

# APPLIED SATELLITE ORBITS

The satellite communication systems operate on three orbits : LEO (Low earth orbiter) MEO (Medium earth orbiter) and GEO (Geostacioner earth orbiter)

The height of the satellites is determined by different physical factors. One of these determining factors is the magnetic field of the earth, and the zones created as the interaction of day and wind, the employment of which would result in ruining the satellites. These zones are called the Van Allen zones.

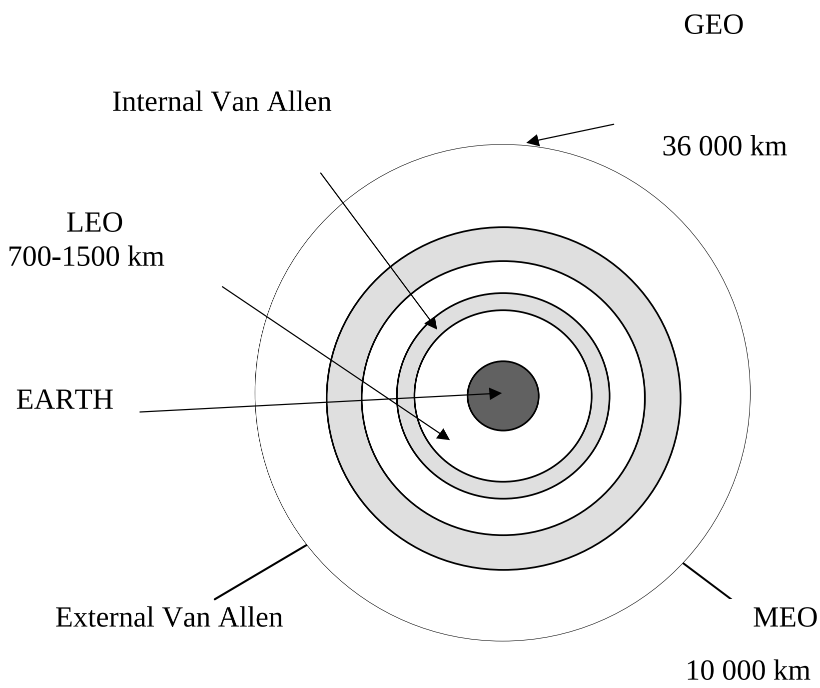


Figure 1. Applied Satellite orbits

There is something called the Clarke Orbit (some also call it the Clarke Belt) or GEO. It is an orbit in the space about 35 860 km above the equator where the period of revolution of an object is roughly 24 hours, the same amount of time that the earth takes to revolve around itself. A satellite, which is placed there, can maintain a constant elevation and angle from a particular point on the earth, always. In other words, it appears stationary to that particular point. Hence, the name geostationary. All the geostationary satellites are placed in the Clarke Orbit. Geostationarz orbit is just one orbit at a single altitude. Satellite are many. There is, of course, no possibility of physical collision or congestion. Because, even a spacing of two degrees is actually a distance of about 1300 km in the Clarke Orbit. The problem, however, is that the antennas on the ground fail to discriminate among satellites, if they are too close in the sky, for all practical purposes, two to four degrees. That means, there cannot be more than 180 satellites, even if we assume a two degree space.

LEOs and MEOs , on the other hand, do not have to operate at fixed orbit. They can be placed anywhere between altitudes of 400 to 10 000 km. So, we have no orbit constraint. Hence, no crowding. No problems for antennas on the ground. If tomorrow, there is a need to add new satellites, or to launch a completely new system, that can be done without pains.

Another fact that works in favour of LEOs and MEOs is what is called the inverse square law for signal power. According to this, a signal in space attenuates in direct proportion to the square of the distance it travels. The lower the altitude of a satellite orbit, lower is the required transmitting power for a signal. Of course, there is an alternative — that of using large antennas. But, that is also not an attractive proposition. LEOs and MEOs, which are at a lower altitude, require less power while using smaller antennas.

The LEOs also offer another advantage. There is negligible transmission delay as the distance traveled by a call using an LEO is several times lower than the same using a geostationary satellite. This means, for mobile communications, which is predominantly voice communications, they are better. The final deciding factor is, of course, cost of satellites and the cost of launch. LEOs are much cheaper.

## THE IRIDIUM SYSTEM

The Iridium system is planned to operate with the employment of global, digital LEO satellites, the father of which is Motorola. The satellite orbit was set in 1997, while the test operation started on 23 August 1998.

## SATELLITE ORBITS

The 66 satellites will revolve on six 780 km high Earth Orbits Eleven satellites will revolve on the 6 orbits altogether.

# THE OPERATION OF THE IRIDIUM SYSTEM

Calls can be started and received with the small, mobile units from any part of the world. The central unit of the system is provided by the intelligent satellite network connected to each other and to the controlling on the earth. The LEO satellites are connected with each other (direct satellite signal transmission) and with the earth system (bent-pipe) through the MSC (Mobile Switching Center).

In order to provide continuous service, call-transmissions are needed between the satellites. Some of the call-transmissions are within the satellite, while others are between the satellites.

There is naturally a need for the harmonised co-ordination of the satellited directed from the earth. This is the task of the system-directing sub-system, SC (System Control), which controls the orbit data of the satellites, and supervises the condition of the service units providing the operation of the satellites. The celestial system will also be controlled by SC (System Control) and will set an alternative route in case of a failure.

The disadvantage of the system is that it depends how far the earth system is built and a great number of gateways is needed. (Figure 2.)


Figure 2. The Iridium System

The Iridium use TDMA access technique. The TDMA frame includes 4 uplink and 4 downlink channels, which are separated from each other with defined protective time-gaps. As to the user equipment, the Iridium system will operate in the K-band frequency zone in the inter-satellite and in the connection between the satellite and gateway (33-36 GHz and 10.9-36 GHz).

As to the satellite and user relation (phone, fax, etc.) the system use the L-band frequency zone (1618.25-1625 MHz).

# THE GLOBALSTAR SYSTEM

## SATELLITE ORBITS

The satellites will be equally distributed on 8 orbits and will be located 1414 km far from the earth. Globalstar covers the globe from the north latitude of 70 till the south latitude of 70, leaving the polar regions out. This means that full coverage cannot be realised.

## SERVICES

GLOBALSTAR offers voice, data, message, facsimile and position location services in four primary environments:

- Mobile users working in and/or residing in areas with-out terrestrial mobile coverage.
- Mobile users roaming into areas without terrestrial mobile coverage.
- Fixed terrestrial users in areas without fixed telecommunications service.
- Private or specialized networks.

In addition to voice service, GLOBALSTAR provides transmission at rates up to 9600 bits per second for asynchronous message, data, and facsimile terminals. Subscribers will be able to access remote databases, send and receive electronic mail, and perform data transfer functions. Paging will also be available.

## THE OPERATION OF THE GLOBALSTAR SYSTEM

In contrary to the Iridium system, there is no connection between the satellites. The satellite based on the so called ‘Bent-Pipe’ architecture will send back the signs from the mobile units to the starting cell without any processing.

The satellites are located in the space segment of the Globalstar system, the portable units, the moving vehicles and the fixed phones in the user segment, while the earth-built networks in the earth segment. Similarly to Iridium, the dual-operation radio phones are also used here.

In the earth section of the system, SOCC, the Satellite Operations Control Centre supervises the operation of the satellites as defined.
GOCC, the Ground Operations Control Centre has the task to direct the earth segment of Globalstar. The Globalstar system bases on the already existing telecommunication infrastructure in each case.

Gateway creates the connection with the satellite network and the earth segment, the mobile users will enter the existing public and private phone networks. (Fig. 3.)

The GLOBALSTAR system utilizes the code division multiple access (CDMA) technology developed by QUALCOMM, Incorporated. Thus modulation provides an excellent voice quality, relatively low RF power levels, security, reliability and capacity benefits. With CDMA, and the use of satellite diversity, permitted by the coverage of service areas by multiple satellites, continuous communication will be provided even when a path to one satellite may be blocked. CDMA also permits sharing of the user link with other satellite system, and permits capacity limits to be exceeded when traffic requires.

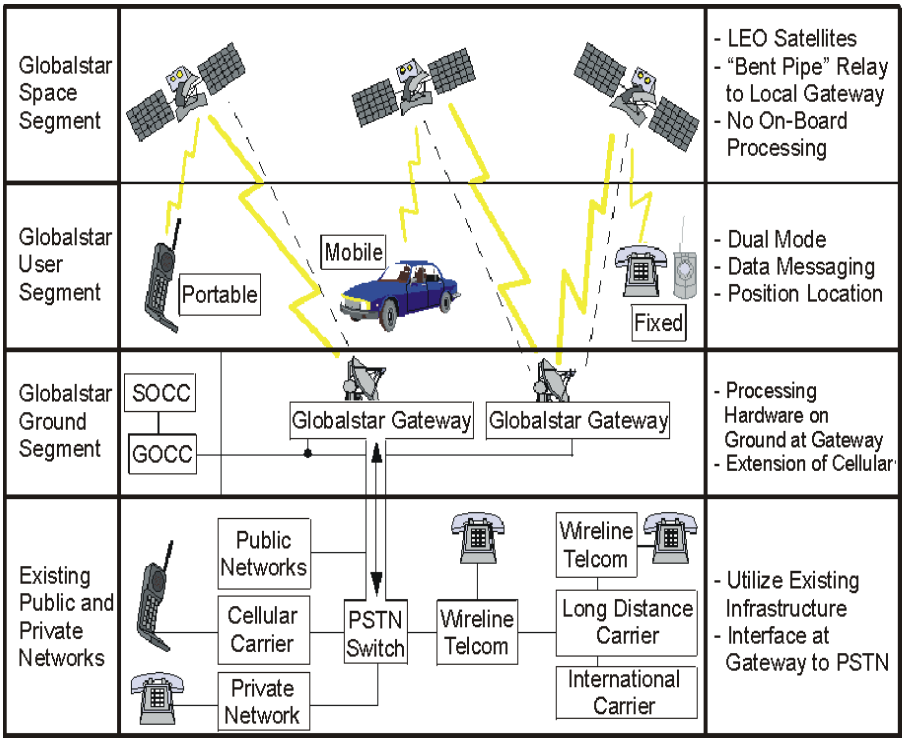


Figure 3. The Globalstar System

The mobile satellite connection is created in the L-band (1610-1625.5 MHz), while the satellite-mobile in the S-band (2483.5-2500 MHz). The satellite and earth station connection operates in the C-bank (uplink 5091-5250 MHz, downlink 6875-7055 MHz).

# TELEDESIC SYSTEM

## PRESENTATION OF THE TELEDESIC SYSTEM

The basic idea of Teledesic came from Bill Gates and Craig McCaw in 1990. They wish to create a system which would provide the full range of communication with the help of 288 low-orbit satellites. Teledesic is building a global, wide-range ‘sky-Internet’. Teledesic is planned to start operation in 2002.

Teledesic will operate in the K-band of the big frequency (uplink frequence at 28,5-29,1 GHz, downlink at 18,8-19,3 GHz).

## THE TELEDESIC NETWORK

The Teledesic Network consists of a ground segment (terminals, network gateways and network operations and control systems) and a space segment (the satellite-based switch network that provides the communication links among terminals). Terminals are the edge of the Teledesic Network and provide the interface both between the satellite network and the terrestrial end-users and networks. They perform the translation between the Teledesic Network's internal protocols and the standard protocols of the terrestrial world, thus isolating the satellite-based core network from complexity and change. (Figure 4.)

Teledesic terminals communicate directly with the satellite network and support a wide range of data rates. The terminals also interface with a wide range of standard network protocols, including IP, ISDN, ATM and others.

Although optimized for service to fixed-site terminals, the Teledesic Network is able to serve transportable and mobile terminals, such as those for maritime and aviation applications.

Most users will have two-way connections that provide up to 64 Mbps on the downlink and up to 2 Mbps on the uplink. Broadband terminals will offer 64 Mbps of two-way capacity. This represents access speeds up to 2,000 times faster than today's standard analog modems.

The ability to handle multiple channel rates, protocols and service priorities provides the flexibility to support a wide range of applications including the

Internet, corporate intranets, multimedia communication, LAN interconnect, wireless backhaul, etc. In fact, flexibility is a critical network feature, since many of the applications and protocols Teledesic will serve in the future have not yet been conceived.

Terminals also provide the interconnection points for the Teledesic Network's Constellation Operations Control Centers (COCC) and Network Operations Control Centers (NOCC).

COCCs coordinate initial deployment of the satellites, replenishment of spares, fault diagnosis, repair, and de-orbiting.

The NOCCs include a variety of distributed network administration and control functions including network databases, feature processors, network management and billing systems.

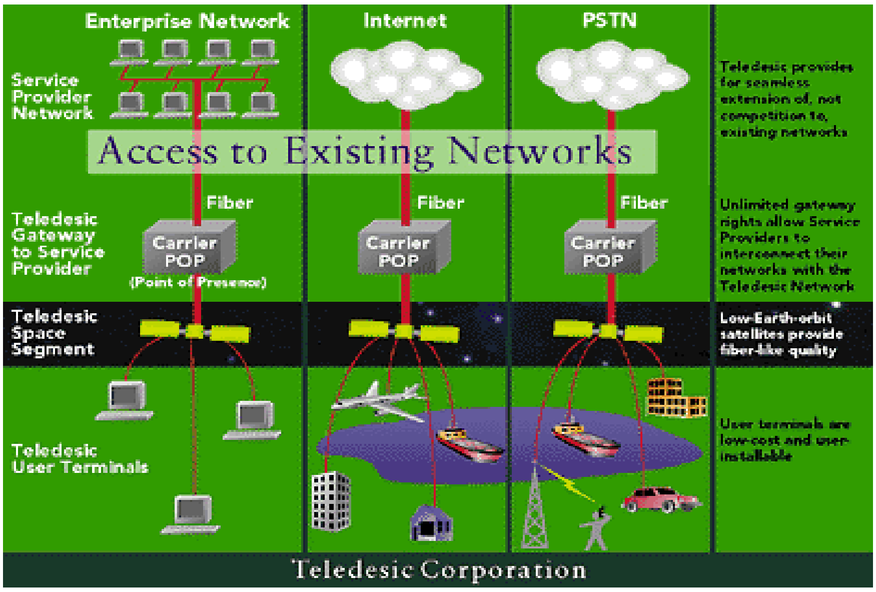


Figure 4. The Teledesic System

## FAST-PACKET SWITCHING

Teledesic's space-based network uses fast-packet switching. Communications are treated within the network as streams of short, fixed-length packets. Each packet contains a header that includes destination address and sequence information, an error-control section used to verify the integrity of the header, and a payload section that carries the digitally-encoded user data (voice, video, data, etc.). Conversion to and from the packet format takes place in the terminals at the edge of the network.

The topology of a LEO-based network is dynamic. The network must continually adapt to these changing conditions to achieve the optimal (least-delay) connections between terminals. The Teledesic Network uses a combination of destination-based packet addressing and a distributed, adaptive packet routing algorithm to achieve low delay and low delay variability across the network. Each packet carries the network address of the destination terminal, and each node independently selects the least-delay route to that destination. Packets of the same session may follow different paths through the network (figure 5.). The terminal at the destination buffers and if necessary reorders the received packets to eliminate the effect of timing variations.

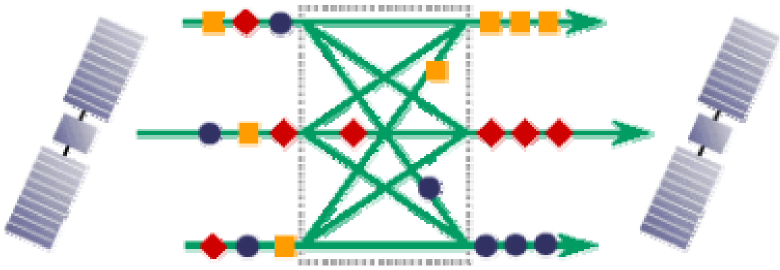

Figure 5. The Teledesic's Distributed Adaptive Routing Algorithm

## THE SATELLITE CONSTELLATION

Each satellite is a node in the fast-packet-switch network and has intersatellite communication links with other satellites in the same and adjacent orbital planes. This interconnection arrangement forms a robust non-hierarchical mesh, or "geodesic," network that is tolerant to faults and local congestion. The network combines the advantages of a circuit-switched network (low delay "digital pipes"), and a packet-switched network (efficient handling of multi-rate and bursty data).

From a network viewpoint, a large constellation of interlinked switch nodes offers a number of advantages in terms of service quality, reliability and capacity.

To achieve high system capacity and channel density, each satellite is able to concentrate a large amount of capacity in its relatively small coverage area. Overlapping coverage areas plus the use of on-orbit spares permit the rapid repair of the network whenever a satellite failure results in a coverage gap. In essence, the system reliability is built into the constellation as a whole rather than being vulnerable to the failure of a single satellite.

## MULTIPLE ACCESS

Since the Teledesic Network uses wireless access, communication channels are not dedicated to terminals on a permanent basis. The channel resources associated with a cell are shared among terminals in that cell, with capacity assigned on demand to meet their current needs. This flexibility allows Teledesic to handle efficiently a wide variety of user needs: from occasional use to full-time use; from bursty to constant bit-rate applications; from low-rate to high-rate data; from low usage-density areas to areas of relatively high usage density.

A multiple access scheme implemented within the terminals and the satellite serving the cell manages the sharing of channel resources among terminals. Within a cell, channel sharing is accomplished with a combination of Multi-Frequency Time Division Multiple Access (MF-TDMA) on the uplink and Asynchronous Time Division Multiplexing Access (ATDMA) on the downlink.

## NETWORK CAPACITY

To make efficient use of the radio spectrum, frequencies are allocated dynamically and reused many times within each satellite footprint. The Teledesic Network supports bandwidth-on-demand, allowing a user to request and release capacity as needed. This enables users to pay only for the capacity they actually use, and for the Network to support a much higher number of users. Thus, the Teledesic Network is designed to support millions of simultaneous users. The Network scales gracefully to much higher capacity by adding additional satellites.

## SUMMARY

There are saying that the space communication will soon appear also in the households – in a form of telecommunication. Nowadays TV programmes already come from satellite, even the latest car alarm systems are connected to sky channels. It is however sure that space communication is a long-term investment with a great number of technical difficulties and risks.

The appearance of such systems is already a big step forward compared to the GSM cellular systems and also to the satellite communication systems on the geostationary orbits. It is important to note that these are not to be regarded as successors to them, but they represent totally new technical trends. Moreover these will be capable of providing wide-band multimedia service as well.

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