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SATTELITE SYSTEM

CHAPTER 1

1.1 Introduction:-

Satellites offer a number of features not readily available with other means of communications. Because very large areas of the earth are visible from a satellite, the satellite can form the star point of a communications net, simultaneously linking many users who may be widely separated geographically. The same feature enables satellites to provide communications links to remote communities in sparsely populated areas that are difficult to access by other means. Of course, satellite signals ignore political boundaries as well as geographic ones, which may or may not be a desirable feature.

Satellites are also used for remote sensing, examples being the detection of water pollution and the monitoring and reporting of2 Chapter One weather conditions. Some of these remote sensing satellites also form a vital link in search and rescue operations for downed aircraft and the like. Satellites are specifically made for telecommunication purpose. They are used for mobile applications such as communication to ships, vehicles, planes, hand-held terminals and for TV and radio broadcasting. They are responsible for providing these services to an assigned region (area) on the earth. The power and bandwidth of these satellites depend upon the preferred size of the footprint, complexity of the traffic control protocol schemes and the cost of ground stations. A satellite works most efficiently when the transmissions are focused with a desired area. When the area is focused, then the emissions do not go outside that designated area and thus minimizing the interference to the other systems. This leads more efficient spectrum usage.

Satellite's antenna patterns play an important role and must be designed to best cover the designated geographical area (which is generally irregular in shape). Satellites should be designed by keeping in mind its usability for short and long term effects throughout its life time. The earth station should be in a position to control the satellite if it drifts from its orbit it is subjected to any kind of drag from the external forces.

1.2 History of Satellite Communications

The first artificial satellite used solely to further advances in global communications was a balloon named Echo 1. Echo 1 was the world's first artificial communications satellite capable of relaying signals to other points on Earth. The first American satellite to relay communications was Project SCORE in 1958, which used a tape recorder to store and forward voice messages. It was used to send a Christmas greeting to the world from U.S. President Dwight D. Eisenhower. NASA launched the Echo satellite in 1960; the 100-foot (30 m) aluminised PET film balloon served as a passive reflector for radio communications. Courier 1B, built by Philco, also launched in 1960, was the world's first active repeater satellite. The first communications satellite was Sputnik 1. Put into orbit by the Soviet Union on October 4, 1957, it was equipped with an onboard radio-transmitter that worked on two frequencies: 20.005 and 40.002 MHz. Sputnik 1 was launched as a step in the exploration of space and rocket development. While incredibly important it was not placed in orbit for the purpose of sending data from one point on earth to another. And it was the first artificial satellite in the steps leading to today's satellite communications. Telstar was the second active, direct relay communications satellite. Belonging to AT&T as part of a multi-national agreement between AT&T, Bell Telephone Laboratories, NASA, the British General Post Office, and the French National PTT (Post Office) to develop satellite communications, it was launched by NASA from Cape Canaveral on July 10, 1962, the first privately sponsored space launch. Relay 1 was launched on December 13, 1962, and became the first satellite to broadcast across the Pacific on November 22, 1963.

CHAPTER 2: ORBITAL MECHANICS

Satellites (spacecraft) orbiting the earth follow the same laws that govern the motion of the planets around the sun. From early times much has been learned about planetary motion through careful observations. Johannes Kepler (1571–1630) was able to derive empirically three laws describing planetary motion. Later, in 1665, Sir Isaac Newton (1642 *–1727) derived Kepler's* laws from his own laws of mechanics and developed the theory of gravitation.

2.1 Kepler's Laws of Planetary Motion

Kepler's First Law:- *Kepler's first law* states that the path followed by a satellite around the primary will be an ellipse. An ellipse has two focal points shown as *F1* and *F2* in Fig.1.

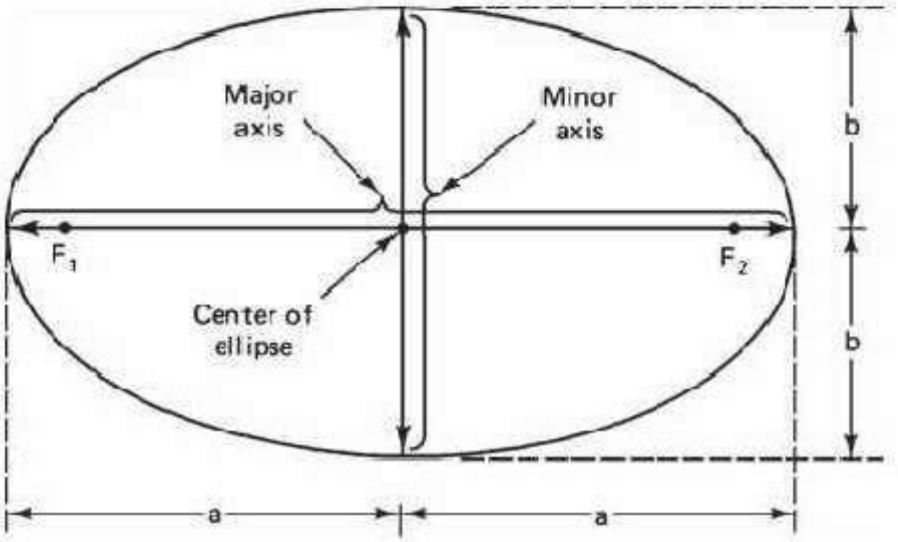


Fig.2.1 The foci *F1* and *F2,* the semimajor axis *a*, and the semiminor axis *b* of an ellips

The foci *F* The eccentricity and the semimajor axis are two of the orbital parameters specified for satellites (spacecraft) orbiting the earth. For an elliptical orbit, 0<*e*< 1. When *e* = 0, the orbit becomes circular.

Kepler's Second Law:- *Kepler's second law* states that, for equal time intervals, a satellite will sweep out equal areas in its orbital plane, focused at the barycenter. The center of mass of the two-body system, termed the *barycenter,* is always centered on one of the foci.

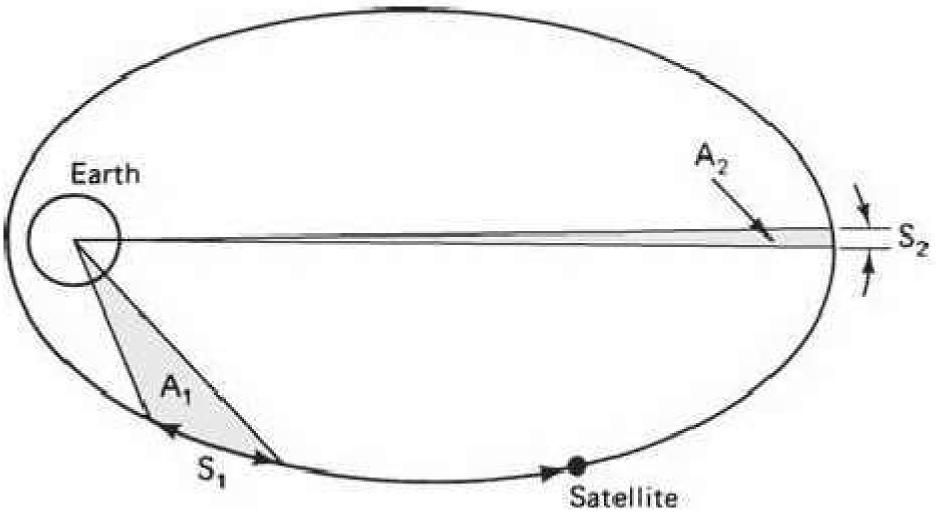


Figure 2.2. Kepler's second law. The areas $A1$ and $A2$ swept out in unit time are equal.

Kepler's Third Law:- *Kepler's third law* states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies. The mean distance is equal to the semimajor axis a. For the *artificial satellites orbiting the earth, Kepler's third law can be* written as follows

$$a^3 = \frac{\mu}{n^2} \qquad \ldots (1)$$

where n is the mean motion of the satellite in radians per second and μ is the earth's geocentric gravitational constant.

$$\mu = 3.986005 \times 10^{14} m^3 / s^3 \qquad \ldots (2)$$

The importance of Kepler's third law is that it shows there is a fixed relationship between period and semimajor axis.

2.2 Satellite Orbits

There are many different satellite orbits that can be used. The ones that receive the most attention are the geostationary orbit used as they are stationary above a particular point on the Earth. The orbit that is chosen for a satellite depends upon its application. These orbits are given in table 1.

Geostationary or geosynchronous earth orbit (GEO)

A satellite in a geostationary orbit appears to be stationary with respect to the earth, hence the name *geostationary*. GEO satellites are synchronous with respect to earth. Looking from a fixed point from Earth, these satellites appear to be stationary. These satellites are placed in the space in such a way that only three satellites are sufficient to provide connection throughout the surface of the Earth. GEO satellite travels eastward at the same rotational speed as the earth in circular orbit with zero inclination.

A geostationary orbit is useful for communications because ground antennas can be aimed at the satellite without their having to track the satellite's motion. This is relatively inexpensive. In applications that require a large number of ground antennas, such as DirectTVdistribution, the savings in ground equipment can more than outweigh the cost and complexity of placing a satellite into orbit.

Table: 1

STELLITE ORBIT NAME	ORBIT	SATELLITE ORBIT ALTITUDE (KM ABOVE EARTH'S SURFACE)	APPLICATION
Low Earth Orbit	LEO	200 - 1200	Satellite phones, Navstar or Global Positioning (GPS) system
Medium Earth Orbit	MEO	1200 - 35790	High-speed telephone signals
Geosynchronous Orbit	GSO	35790	Satellite Television
Geostationary Orbit	GEO	35790	Direct broadcast television

Low Earth Orbit (LEO) satellites

A low Earth orbit (LEO) typically is a circular orbit about 200 kilometres (120 mi) above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes. Because of their low altitude, these satellites are only visible from within a radius of roughly 1000 kilometers from the sub-satellite point. In addition, satellites in low earth orbit change their position relative to the ground position quickly. So even for local applications, a large number of satellites are needed if the mission requires uninterrupted connectivity. s. LEO systems try to ensure a high elevation for every spot on earth to provide a high quality communication link. Each LEO satellite will only be visible from the earth for around ten minutes.

Low-Earth-orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to proximity to the ground, do not require as high signal strength (Recall that signal strength falls off as the square of the distance from the source, so the effect is dramatic). Thus there is a trade off between the number of satellites and their cost. In addition, there are important differences in the onboard and ground equipment needed to support the two types of missions. One general problem of LEOs is the short lifetime of about five to eight years due to atmospheric drag and radiation from the inner Van Allen belt1.

Medium Earth Orbit (MEO) satellites

A MEO satellite is in orbit somewhere between 8,000 km and 18,000 km above the earth's surface. MEO satellites are similar to LEO satellites in functionality. MEO satellites are visible for much longer periods of time than LEO satellites, usually between 2 to 8 hours. MEO satellites have a larger coverage area than LEO satellites. A MEO satellite's longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network. One disadvantage is that a MEO satellite's distance gives it a longer time delay and weaker signal than a LEO satellite, though not as bad as a GEO satellite. Due to the larger distance to the earth, delay increases to about 70–80 ms. so these satellites need higher transmit power and special antennas for smaller footprints.

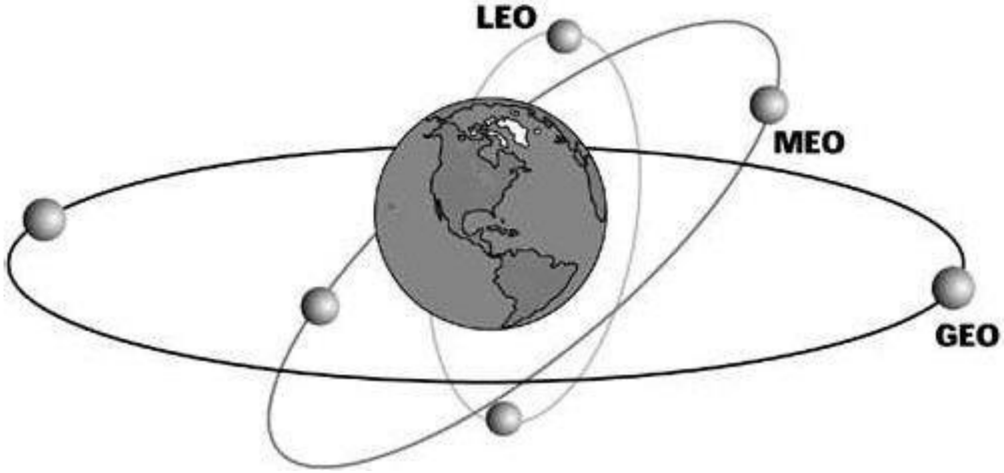


Fig. 2.3 Satellite Orbits

2.3 Spacing and Frequency Allocation

Allocating frequencies to satellite services is a complicated process which requires international coordination and planning. This is carried out under the supervision of the *International Telecommunication Union* (ITU). This frequency allocation is done based on different areas. So this world is divided into three areas.

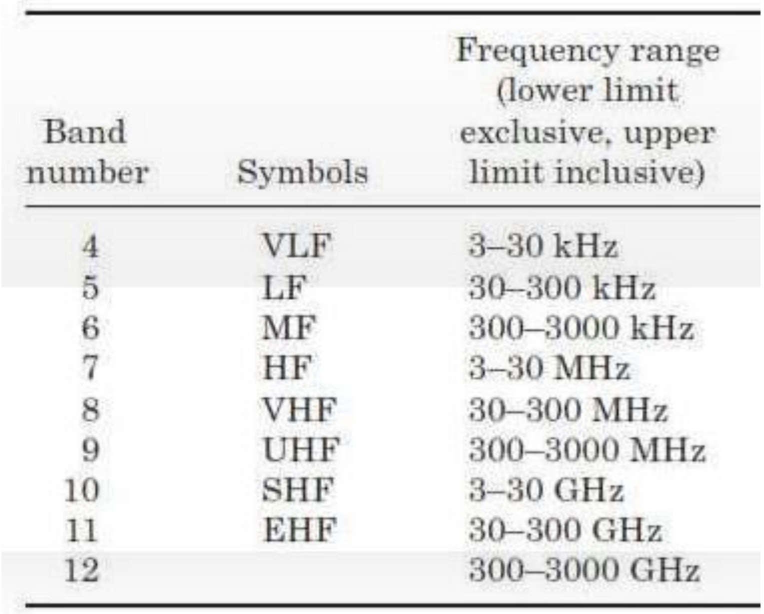
Area 1:- : Europe, Africa, Soviet Union, and Mongolia
Area 2: North and South America and Greenland
Area 3: Asia (excluding area 1 areas), Australia, and the south-west Pacific

Within these regions, frequency bands are allocated to various satellite services, although a given service may be allocated different frequency bands in different regions. Some of the services provided by satellites are:

- ***Fixed satellite service* (FSS)**

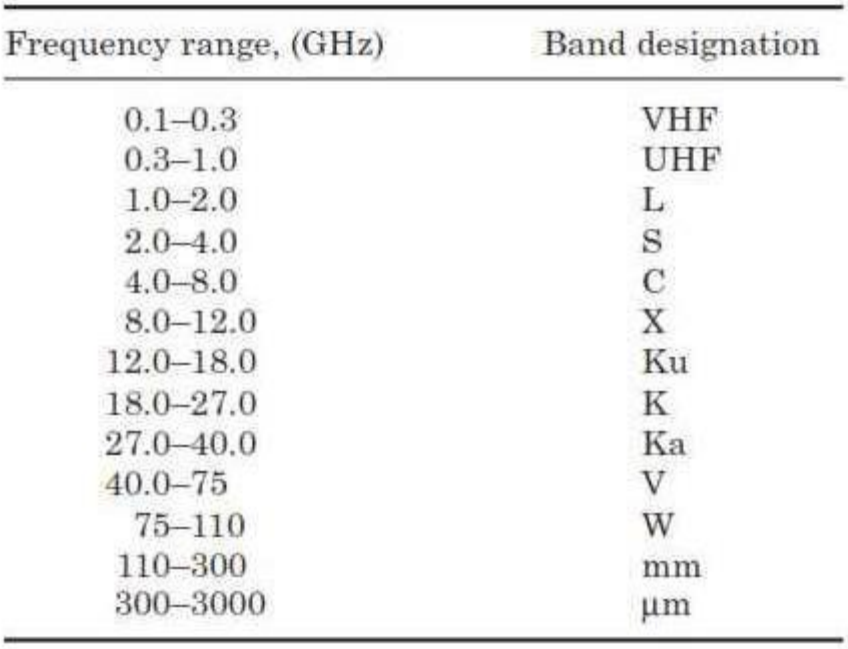
  The FSS provides links for existing telephone networks as well as for transmitting television signals to cable companies for distribution over cable systems. Broadcasting satellite services are intended mainly for direct broadcast to the home, sometimes referred to as *direct broadcast satellite* (DBS) service [in Europe it may be known as *direct-to-home* (DTH) service]. Mobile satellite services would include land mobile, maritime mobile, and aeronautical mobile. Navigational satellite services include *global positioning systems* (GPS), and satellites intended for the meteorological services often provide a search and rescue service.

TABLE 2: ITU Frequency Band Designations



Band number	Symbols	Frequency range (lower limit exclusive, upper limit inclusive)
4	VLF	3–30 kHz
5	LF	30–300 kHz
6	MF	300–3000 kHz
7	HF	3–30 MHz
8	VHF	30–300 MHz
9	UHF	300–3000 MHz
10	SHF	3–30 GHz
11	EHF	30–300 GHz
12		300–3000 GHz

TABLE 3: Frequency Band Designations



Frequency range, (GHz)	Band designation
0.1–0.3	VHF
0.3–1.0	UHF
1.0–2.0	L
2.0–4.0	S
4.0–8.0	C
8.0–12.0	X
12.0–18.0	Ku
18.0–27.0	K
27.0–40.0	Ka
40.0–75	V
75–110	W
110–300	mm
300–3000	µm

- ***Broadcasting satellite service*** **(BSS)**

  Provides Direct Broadcast to homes. E.g. Live Cricket matches etc.
- ***Mobile satellite services***
  - Land Mobile
  - Maritime Mobile
  - Aeronautical mobile
- ***Navigational satellite services***
  - Include Global Positioning systems
- ***Meteorological satellite services***
  - They are often used to perform Search and Rescue service.

2.4 Look Angle Determination

The satellite look angle refers to the angle that one would look for a satellite at a given time from a specified position on the Earth. The look angles for the ground station antenna are Azimuth and Elevation angles. They are required at the antenna so that it points directly at the satellite. Look angles are calculated by considering the elliptical orbit. These angles change in order to track the satellite.

Azimuth angle:- The azimuth angle is an angle measured from North direction in the local horizontal plane.

Elevation angle:- The elevation angle is the angle measured perpendicular to the horizontal plane (in the vertical plane) to the line-of-sight to the satellite.

The three pieces of information that are needed to determine the look angles for the geostationary orbit are

1. The earth-station latitude, denoted here by λ_E

2. The earth-station longitude, denoted here by ϕ_E

3. The longitude of the subsatellite point, denoted here by ϕ_{SS} (this is just referred to as the satellite longitude)

4. ES: Position of Earth Station
5. SS: Sub-Satellite Point
6. S: Satellite
7. d: Range from ES to S
8. *σ: angle to be determined*

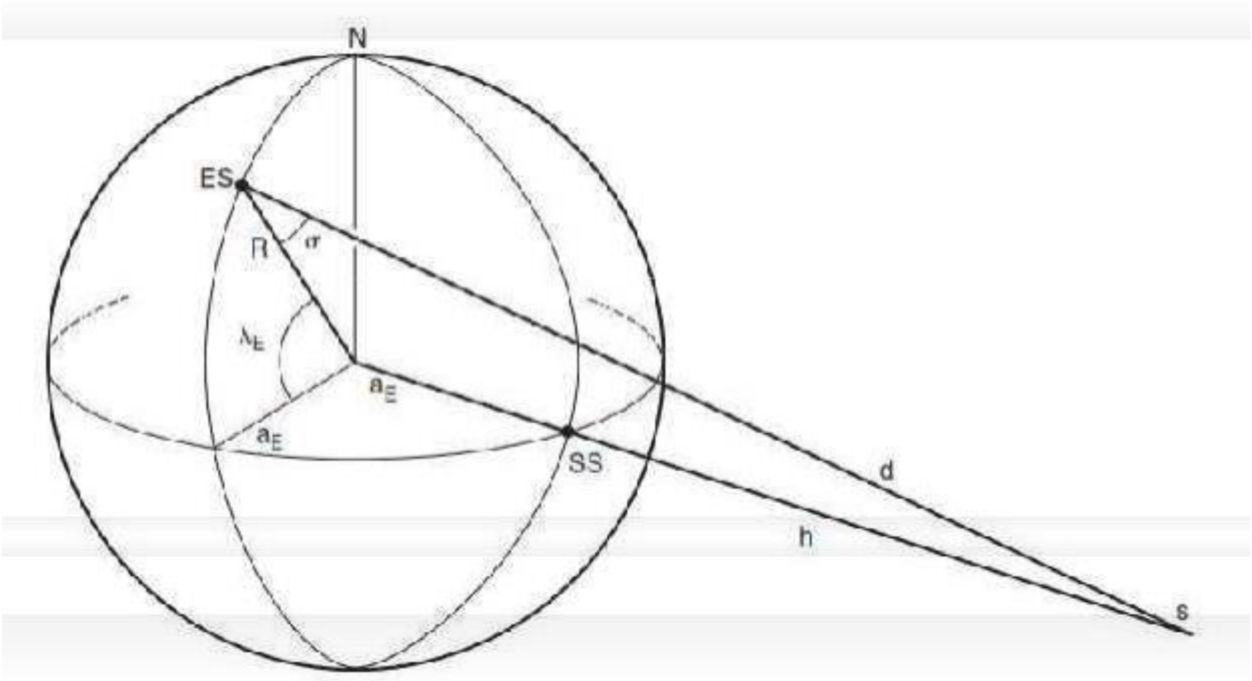


Fig. 2.4:- The geometry used in determining the look angles for a geostationary satellite.

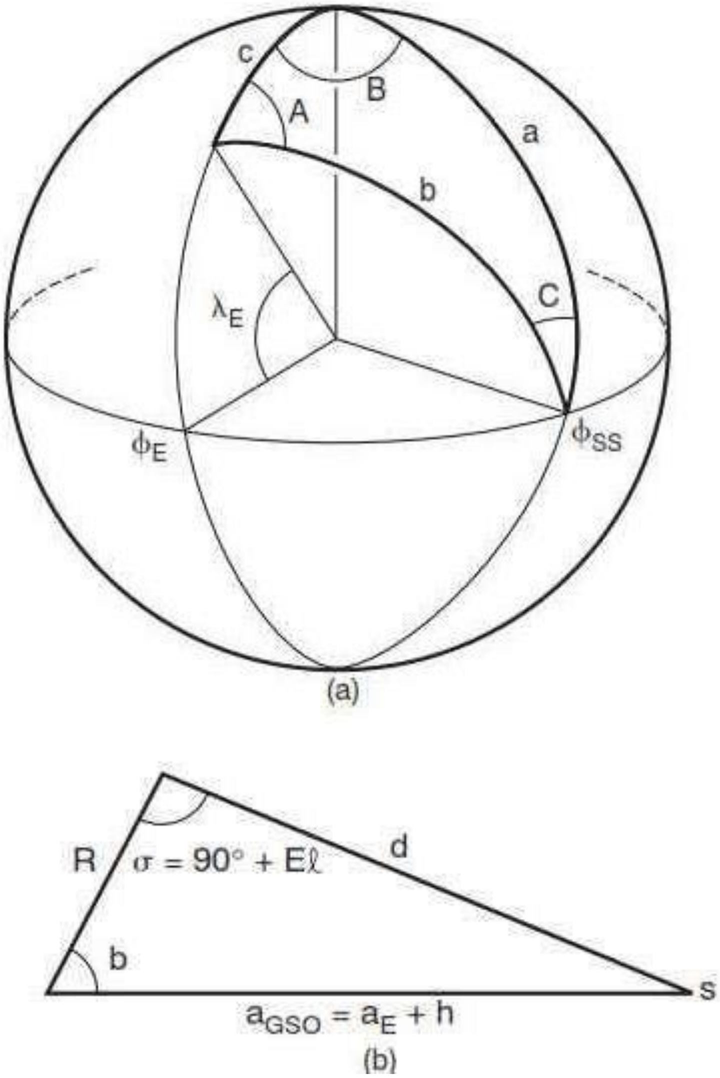


Figure 4.5 (*a*) The spherical geometry related to Fig. 4.4. (*b*) The plane triangle obtained from Fig. 4.4.

There are six angles in all defining the spherical triangle. The three angles *A, B*,and *C* are the angles between the planes. Angle *A* is the angle between the plane containing *c* and the plane containing *b.* Angle *B* is the angle between the plane containing *c* and the plane containing *a*.

Considering figure 5 (b), it's a spherical triangle. All sides are the arcs of a great circle. Three sides of this triangle are defined by the angles subtended by the centre of the earth.

Side a: angle between North Pole and radius of the sub-satellite point.

Side b: angle between radius of Earth and radius of the sub-satellite point.

Side c: angle between radius of Earth and the North Pole.
a = 90^{o} and such a spherical triangle is called quadrantal triangle. c = $90^{o} - \lambda$

Angle B is the angle between the plane containing c and the plane containing a.

Thus, $B = \phi_E - \phi_{SS}$

Angle A is the angle between the plane containing b and the plane containing c.
Angle C is the angle between the plane containing a and the plane containing b.

Thus,

$a=90^0$
$c=90^0 - \lambda_E$
$B=f_E - f_{SS}$

Thus, b = arcos (cos B cos λ_E

A = arc sin (sin |B| / sin b)

2.5 Orbital Perturbation

The *keplerian orbit* described so far is ideal in the sense that it assumes that the earth is a uniform spherical mass and that the only force acting is the centrifugal force resulting from satellite motion balancing the gravitational pull of the earth. In practice, other forces which can be significant are the gravitational forces of the sun and the moon and atmospheric drag. The gravitational pulls of sun and moon have negligible effect on low-orbiting satellites, but they do affect satellites in the geostationary orbit.
There are two types of perturbation:-

1- **Gravitational:- when considering third body interaction and the non-spherical shape of the earth.**
   The earth is very far away from perfectly spherical. This depends on the earth rotation, earth gravitational potential.

2- **Non-gravitational:- like Atmospheric drag, solar radiation pressure and tidal friction.**

For near-earth satellites, below about 1000 km, the effects of atmospheric drag are significant. Because the drag is greatest at the perigee, the drag acts to reduce the velocity at this point, with the result that the satellite does not reach the same apogee height on successive revolutions.

CHAPTER: 3 SATELLITES

3.1 Satellite Launching

A satellite is sent into space on top of a rocket. When a satellite is put into space, we say that it is *“launched.” The rocket that is used to launch a satellite is called a “launch vehicle.”* This satellite launching needs the earth stations in order to operate the satellite operation. The satellite launching can be divided into four stages.

1- **First Stage:-** The first stage of the launch vehicle contains the rockets and fuel that are needed to lift the satellite and launch vehicle off the ground and into the sky.

2- **Second Stage:-** The second stage contains smaller rockets that ignite after the first stage is finished. The rockets of the second stage have their own fuel tanks. The second stage is used to send the satellite into space.

3- **Third Stage (Upper Stage):-** The upper stage of the launch vehicle is connected to the *satellite itself, which is enclosed in a metal shield, called a “fairing.” The fairing protects* the satellite while it is being launched and makes it easier for the launch vehicle to travel through the resistance of the Earth's atmosphere.

4- Fourth Stage (Firing):- Once the launch vehicle is out of the Earth's atmosphere, the *satellite separates from the upper stage. The satellite is then sent into a “transfer orbit”* that sends the satellite higher into space. Once the satellite reaches its desired orbital height, it unfurls its solar panels and communication antennas, which had been stored away during the flight. The satellite then takes its place in orbit with other satellites and is ready to provide communications to the public.

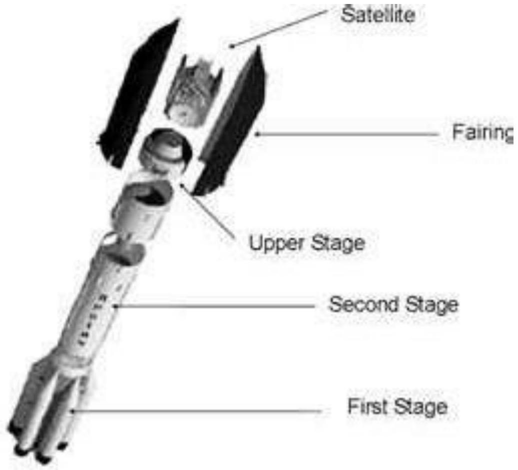


Figure 3.1 Steps of Satellite Launching

The launch process can be divided into two phases: the launch phase and the orbit injection phase.

1- **The Launch Phase**

   The launch vehicle places the satellite into the transfer orbit. An eliptical orbit that has at its farthest point from earth (apogee) the geosynchronous elevation of 22,238 miles and at its nearest point (perigee) an elevation of usually not less than 100 miles.

2- **The Orbit Injection Phase**

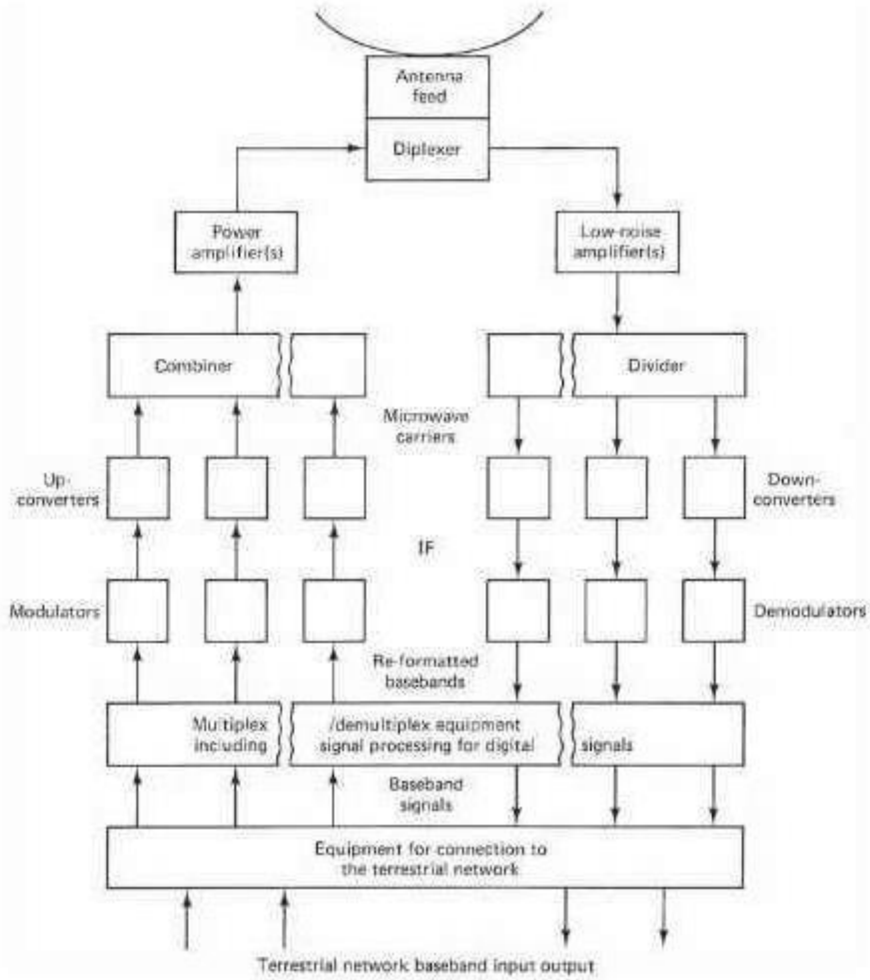
   The energy required to move the satellite from the elliptical transfer orbit into the geosynchronous orbit is supplied by the satellite's apogee kick motor (AKM). This is known as the orbit injection phase.

3.2 Earth Station

The earth segment of a satellite communications system consists of the transmit and receive earth stations. The station's antenna functions in both, the transmit and receive modes, but at different frequencies.

An earth station is generally made up of a multiplexor, a modem, up and downconverters, a high power amplifier (HPA) and a low noiseamplifier (LNA). Almost all transmission to satellites is digital, and the digital data streams are combined in a multiplexor and fed to a modemthat modulates a carrier frequency in the 50 to 180 MHz range. An upconverter bumps the carrier into the gigahertz range, which goes to the HPA and antenna.

For receiving, the LNA boosts the signals to the downconverter, which lowers the frequency and sends itto the modem. The modemdemodulates the carrier, and the digital output goes to the demultiplexing device and then to its destinations. See earth station on board vessel and base station. A detailed block diagram is shown in fig. 3.2.



and dish.

Figure 3.2:- Block diagram of a transmit-receive earth station

3.3 Satellite Sub-systems

A satellite communications system can be broadly divided into two segments —a ground segment and a space segment. The space segment will obviously include the satellites, but it also includes the ground facilities needed to keep the satellites operational, these being referred to as the *tracking, telemetry, and command* (TT&C) facilities. In many networks it is common practice to employ a ground station solely for the purpose of TT&C.

In a communications satellite, the equipment which provides the connecting link between the satellite's transmit and receive antennas is referred to as the *transponder*. The transponder forms one of the main sections of the payload, the other being the antenna subsystems.

PAYLOAD:- The payload comprises of a Repeater and Antenna subsystem and performs the primary function of communication.

1- **REPEATER:-** It is a device that receives a signal and retransmits it to a higher level and/or higher power onto the other side of the obstruction so that the signal can cover longer distance.
2- **Transparent Repeater:-** It only translates the uplink frequency to an appropriate downlink frequency. It does so without processing the baseband signal. The main element of a typical transparent repeater is a single beam satellite. Signals from antenna and the feed system are fed into the low-noise amplifier through a bandpass filter.
3- **Regenerative Repeater :-** A repeater, designed for digital transmission, in which digital signals are amplified, reshaped, retimed, and retransmitted. Regenerative Repeater can also be called as a device which regenerates incoming digital signals and then retransmits these signals on an outgoing circuit.
4- **Antennas :-** The function of an antenna of a space craft is to receive signals and transmit signals to the ground stations located within the coverage area of the satellite. The choice of the antenna system is therefore governed by the size and shape of the coverage area. Consequently, there is also a limit to the minimum size of the antenna footprint.

3.4 Satellite System Link Models

System Link Budget calculations basically relate two quantities, the transmit power and the receive power, and show in detail how the difference between these two powers is accounted for. Link-power budget calculations also need the additional losses and noise factor which is incorporated with the transmitted and the received signals. Along with losses, this unit also discusses the system noise parameters. Various components of the system add to the noise in the signal that has to be transmitted.

3.4.1 EQUIVALENT ISOTROPIC RADIATED POWER

The key parameter in link-power budget calculations is the equivalent isotropic radiated power factor, commonly denoted as EIRP. Is the amount of power that a theoretical isotropic antenna (which evenly distributes power in all directions) would emit to produce the peak power density observed in the direction of maximum antenna gain. EIRP can be defined as the power input to one end of the transmission link and the problem to find the power received at the other end.

$$\text{EIRP} = G\,P_s$$

Where,

G - Gain of the Transmitting antenna and G is in decibels.

Ps- Power of the sender (transmitter) and is calculated in watts.

$$\mathbf{[EIRP] = [G] + [Ps]\ dBW}$$

3.4.2 TRANSMISSION LOSSES:-

As EIRP is thought of as power input of one end to the power received at the other, the problem here is to find the power which is received at the other end. Some losses that occur in the transmitting – receiving process are constant and their values can be pre – determined.

3.4.2.1 Free-Space Transmission Losses (FSL)

This loss is due to the spreading of the signal in space. Going back to the power flux density equation

$$\psi_m = P_s / 4\pi r^2$$

The power that is delivered to a matched receiver is the power flux density. It is multiplied by the effective aperture of the receiving antenna. Hence, the received power is:

$$P_R = \psi_M A_{eff}$$
$$= \frac{EIRP \bullet \lambda^2 G_R}{4\pi r^2}$$

Where

r- distance between transmitter and receiver, G_R - power gain at the receiver

In decibels, the above equation becomes:

$$\left[P_R\right] = \left[EIRP\right] + \left[G_R\right] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[FSL] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$\left[P_R\right] = \left[EIRP\right] + \left[G_R\right] - [FSL]$$

3.4.2.2 Feeder Losses (RFL):- This loss is due to the connection between the satellite receiver device and the receiver antenna is improper. Losses here occur is connecting wave guides, filers and couplers. The receiver feeder loss values are added to free space loss.

3.4.2.1 Antenna Misalignment Losses (AML):- To attain a good communication link, the earth station‟s antenna and the communicating satellite‟s antenna must face each other in such a way that the maximum gain is attained.

3.4.2.1 Fixed Atmospheric (AA) and Ionospheric losses (PL):-The gases present in the atmosphere absorb the signals. This kind of loss is usually of a fraction of decibel in quantity. Along with the absorption losses, the ionosphere introduces a good amount of depolarization of signal which results in loss of signal.

3.5 Link Equations

The EIRP can be considered as the input power to a transmission link. Due to the above discussed losses, the power at the receiver that is the output can be considered as a simple calculation of EIRP– losses.

$$\text{Losses} = [FSL] + [RFL] + [AML] + [AA] + [PL]$$

The received power that is P

$$[P_R] = [EIRP] + [G_R] - [Losses]$$

Where;

$[P_R]$- Received power in dB, [EIRP] - equivalent isotropic radiated power in dBW.

[G_R]- Isotropic power gain at the receiver and its value is in dB.

[FSL]-Free-space transmission loss in dB.

[RFL] -Receiver feeder loss in dB.

[AA] -Atmospheric absorption loss in dB.

[AML] -Antenna misalignment loss in dB.

[PL] - Depolarization loss in dB.

CHAPTER 4: MODULATION AND MULTIPLEXING TECHNIQUES

4.1 Multiple Access

Multiple accesses is defined as the technique where in more than one pair of earth stations can simultaneously use a satellite transponder. A multiple access scheme is a method used to distinguish among different simultaneous transmissions in a cell. A radio resource can be a different time interval, a frequency interval or a code with a suitable power level.

If the different transmissions are differentiated for the frequency band, it will bedefined as the Frequency Division Multiple Access (FDMA). Whereas, if transmissions are distinguished on the basis of time, then it is considered as Time Division Multiple Access (TDMA). If a different code is adopted to separate simultaneous transmissions, it will be Code Division Multiple Access (CDMA).

4.1.1 Frequency Division Multiple Access (FDMA)

Frequency Division Multiple Access or FDMA is a channel access method used in multiple-access protocols as a channelization protocol. FDMA gives users an individual allocation of one or several frequency bands, or channels. It is particularly commonplace in satellite communication.

- In FDMA all users share the satellite transponder or frequency channel simultaneously but each user transmits at single frequency.
- FDMA can be used with both analog and digital signal.
- FDMA requires high-performing filters in the radio hardware.
- FDMA is not vulnerable to the timing problems that TDMA has. Since a predetermined frequency band is available for the entire period of communication, stream data (a continuous flow of data that may not be packetized) can easily be used with FDMA.
- Each user transmits and receives at different frequencies as each user gets a unique frequency slots.

4.1.2 Time Division Multiple Access (TDMA)

Time division multiple access (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity.

- Shares single carrier frequency with multiple users.
- Slots can be assigned on demand in dynamic TDMA.
- Less stringent power control than CDMA due to reduced intra cell interference
- Higher synchronization overhead than CDMA
- Cell breathing (borrowing resources from adjacent cells) is more complicated than in CDMA.
- Frequency/slot allocation complexity.

4.1.3 Code Division Multiple Access (CDMA)

Code division multiple access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, which is where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies (see bandwidth). CDMA is used as the access method in many mobile phone standards such as cdmaOne, CDMA2000 (the 3G evolution of cdmaOne), and WCDMA (the 3G standard used by GSM carriers), which are often referred to as simply *CDMA*.

- One of the early applications for code division multiplexing is in the Global Positioning System (GPS). This predates and is distinct from its use in mobile phones.
- The Qualcomm standard IS-95, marketed as cdmaOne.
- The Qualcomm standard IS-2000, known as CDMA2000, is used by several mobile phone companies, including the Globalstar satellite phone network.
- The UMTS 3G mobile phone standard, which uses W-CDMA.
- CDMA has been used in the Omni TRACS satellite system for transportation logistics.

4.2 Direct Broadcast Satellite Services

Direct-broadcast satellite (DBS) is a type of artificial satellite which usually sends satellite television signals for home reception through geostationary satellites. The type of satellite television which uses direct-broadcast satellites is known as direct-broadcast satellite television (DBSTV) or direct-to-home television (DTHTV). This has initially distinguished the transmissions directly intended for home viewers from cable television distribution services that are sometimes carried on the same satellite.

A DBS subscriber installation consists of a dish antenna two to three feet (60 to 90 centimeters) in diameter, a conventional TV set, a signal converter placed next to the TV set, and a length of coaxial cable between the dish and the converter. The dish intercepts microwave signals directly from the satellite. The converter produces output that can be viewed on the TV receiver. Broadcast services include audio, television, and Internet services. Direct broadcast television, which is digital TV, is the subject of this chapter. A Typical DBS system block diagram is shown in fig. 4.1. The home receiver consists of two units —an outdoor unit and an indoor unit.

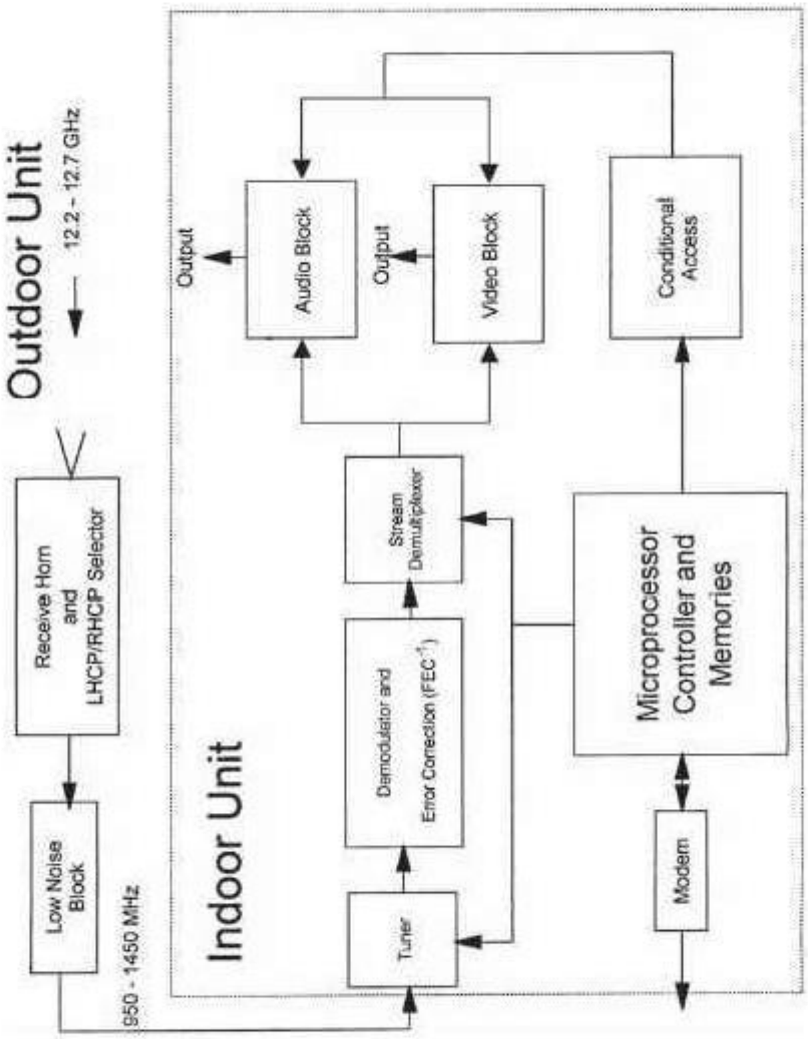


Fig. 4.1 Block schematic for the outdoor unit (ODU) and IDU unit of DBS.

The Home Receiver Outdoor Unit (ODU):- The downlink signal, covering the frequency range 12.2 to 12.7 GHz, is focused by the antenna into the receive horn. The horn feeds into a polarizer that can be switched to pass either left-hand circular or right-hand circular polarized signals. The low-noise block that follows the polarizer contains a *low-noise amplifier* (LNA) and a down converter. The down converter converts the 12.2- to 12.7-GHz band to 950 to 1450 MHz, a frequency range better suited to transmission through the connecting cable to the indoor unit.

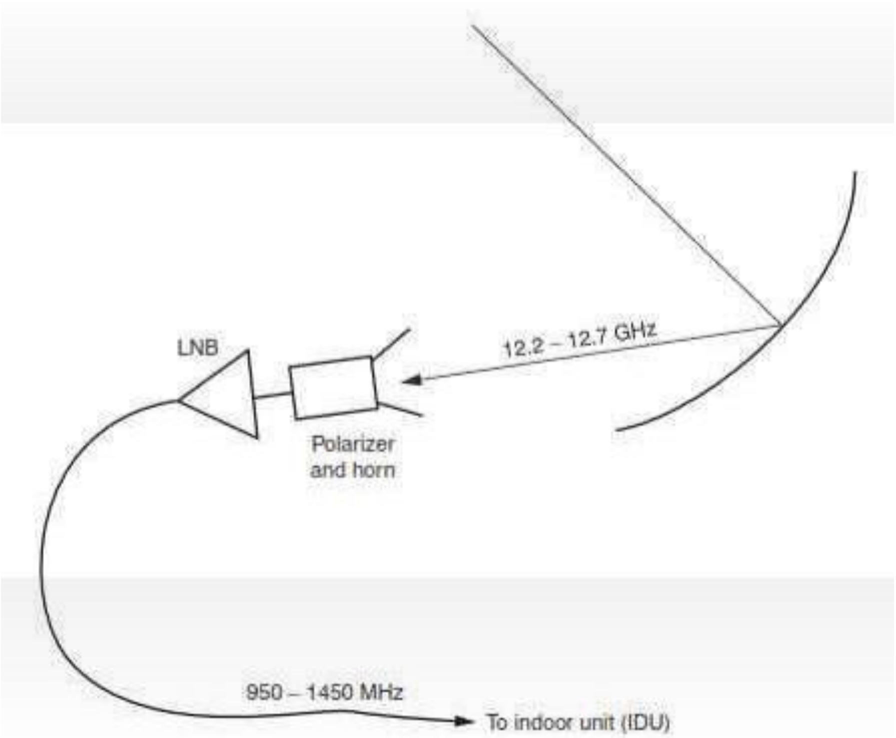


Fig. 4.2 Block schematic for the outdoor unit (ODU)

The Home Receiver Indoor Unit (IDU):- The transponder frequency bands shown in Fig. 16.2 are down converted to be in the range 950 to 1450 MHz, but of course, each transponder retains its 24-MHz bandwidth. The IDU must be able to receive any of the 32 transponders, although only 16 of these will be available for a single polarization. The tuner selects the desired transponder. It should be recalled that the carrier at the center frequency of the transponder is QPSK modulated by the bit stream, which itself may consist of four to eight TV programs TDM. Following the tuner, the carrier is demodulated, the QPSK modulation being converted to a bit stream. Error correction is carried out in the decoder block labeled FEC.

4.3 Application of LEO

The evolution from geo-stationary to low-Earthorbit (LEO) satellites has resulted in a number of proposed global satellite systems, which can be grouped into three distinct types - Little LEOs, Big LEOs, and Broadband LEOs. These systems can best be distinguished by reference to their terrestrial counterparts: paging, cellular, and fiber, as shown in Table 4.1. On the ground, paging, cellular, and fiber services are complementary, not competitive, because they offer fundamentally different kinds of services. Similarly, the Little LEOs, Big LEOs, and Broadband

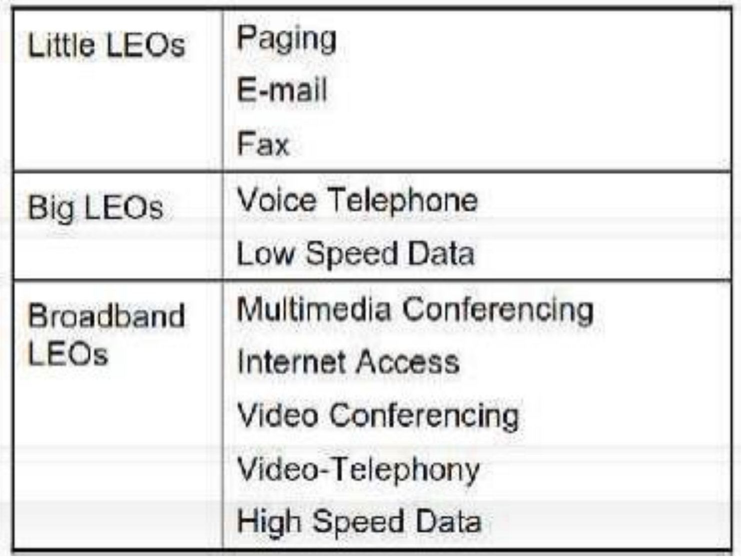
LEOs are complementary rather than competitive because they are providing distinctly different services targeted at different markets, and have different pricing structures.

Table 4.1 Terrestrial Counterparts

	Little LEO	Big LEO	Broadband LEO
Example Systems	ORBCOMM Starsys	IRIDIUM Globalstar ICO	Teledesic
Terrestrial Counterpart	Paging	Cellular	Fiber

Typical applications of the various types of LEO systems are shown in Table 2. Of course the Big LEOs can support the Little LEO applications, and the Broadband LEOs can support both the Big and Little LEO applications.

Table 4.2 Application of LEO Satellites



Little LEOs	Paging E-mail Fax
Big LEOs	Voice Telephone Low Speed Data
Broadband LEOs	Multimedia Conferencing Internet Access Video Conferencing Video-Telephony High Speed Data

4.4 MEO and GEO Satellites

Medium Earth orbit (**MEO**), sometimes called **intermediate circular orbit** (**ICO**), is the region of space around the Earth above low Earth orbit (altitude of 2,000 kilometres (1,243 mi)) and below geostationary orbit (altitude of 35,786 kilometres (22,236 mi)).The most common use for satellites in this region is for navigation, communication, and geodetic/space environment science.[1] The most common altitude is approximately 20,200 kilometres (12,552 mi)), which yields an orbital period of 12 hours, as used, for example, by the Global Positioning System (GPS). Other satellites in Medium Earth Orbit include Glonass (with an altitude of 19,100 kilometres (11,868 mi)) and Galileo (with an altitude of 23,222 kilometres (14,429 mi)) constellations.[*citation needed*] Communications satellites that cover the North and South Pole are also put in MEO.

Geostationary satellites appear to be fixed over one spot above the equator. Receiving and transmitting antennas on the earth do not need to track such a satellite. These antennas can be fixed in place and are much less expensive than tracking antennas. These satellites have revolutionized global communications, television broadcasting and weather forecasting, and have a number of important defenseand intelligence applications.

One disadvantage of geostationary satellites is a result of their high altitude: radio signals take approximately 0.25 of a second to reach and return from the satellite, resulting in a small but significant signal delay. This delay increases the difficulty of telephone conversation and reduces the performance of common network protocols such as TCP/IP, but does not present a problem with non-interactive systems such as television broadcasts. There are a number of proprietary satellite data protocols that are designed to proxy TCP/IP connections over long-delay satellite links—these are marketed as being a partial solution to the poor performance of native TCP over satellite links. TCP presumes that all loss is due to congestion, not errors, and probes link capacity with its "slow-start" algorithm, which only sendspackets once it is known that earlier packets have been received. Slow start is very slow over a path using a geostationary satellite. There are approximately 600 geosynchronous satellites, some of which are not operational

Table 4.3 Application of MEO and GEO Satellites

Satellites	Application
Medium Earth Orbit	High-speed telephone signals
Geosynchronous Orbit	Satellite Television
Geostationary Orbit	Direct broadcast television

References

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3- Satellite Communications Dennis Roddy 3rd edition, McGraw Hill publication.

4- http://www.radio-electronics.com/info/satellite/satellite-orbits/satellites-orbit-definitions.php.

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6-

LEOs - THE COMMUNICATIONS SATELLITES of 21Century by Mark A. Sturza