UNIT V

SATELLITE APPLICATIONS

INTELSAT Series, INSAT, VSAT, Mobile Satellite Services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. GPS Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH).

5.1 INTELSAT SERIES

INTELSAT stands for International Telecommunications Satellite. The organization was created in 1964 and currently has over 140 member countries and more than 40 investing entities.

In July 2001 INTELSAT became a private company and in May 2002 the company began providing end-to-end solutions through a network of teleports, leased fiber, and points of presence (PoPs) around the globe.

Starting with the Early Bird satellite in 1965, a succession of satellites has been launched at intervals of a few years. Figure 1.1 illustrates the evolution of some of the INTELSAT satellites. As the figure shows, the capacity, in terms of number of voice channels, increased dramatically with each succeeding launch, as well as the design lifetime.

These satellites are in geostationary orbit, meaning that they appear to be stationary in relation to the earth. At this point it may be noted that geosta-tionary satellites orbit in the earth's equatorial plane and their position is specified by their longitude.

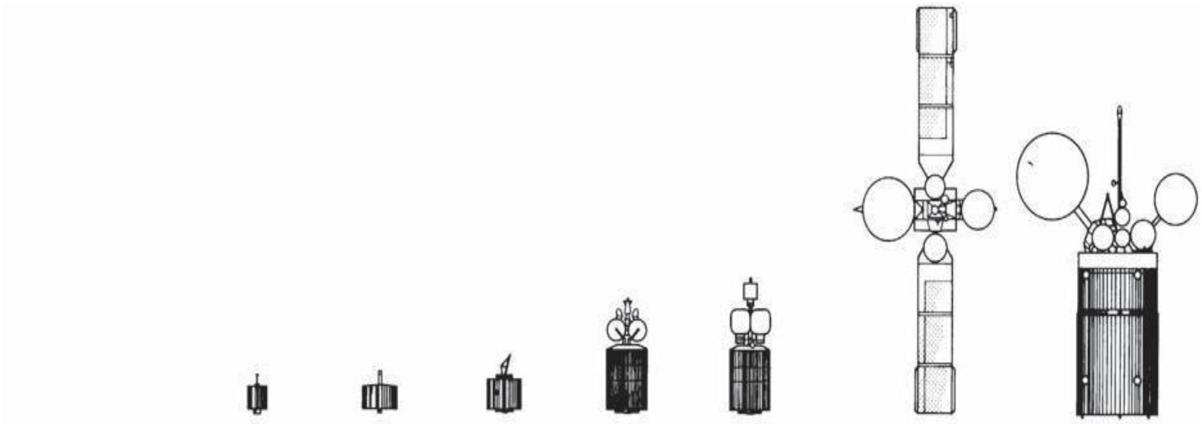
For international traffic, INTELSAT covers three main regions—the Atlantic Ocean Region (AOR), the Indian Ocean Region (IOR), and the Pacific Ocean Region (POR) and what is termed Intelsat America's Region.

For the ocean regions the satellites are positioned in geostationary orbit above the particular ocean, where they provide a transoceanic telecommunications route. For example, INTELSAT satellite 905 is positioned at 335.5° east longitude.

The INTELSAT VII-VII/A series was launched over a period from October 1993 to June 1996. The construction is similar to that for the V and VA/VB series, shown in Fig. in that the VII series has solar sails rather than a cylindrical body.

The VII series was planned for service in the POR and also for some of the less demanding services in the AOR. The antenna beam coverage is appropriate for that of the POR. Figure shows the antenna beam footprints for the C-band hemispheric coverage and zone coverage, as well as the spot beam coverage possible with the Ku-band antennas. When used in the AOR, the VII series satellite is inverted north for south, minor adjustments then being needed only to optimize the antenna patterns for this region. The lifetime of these satellites ranges from 10 to 15 years depending on the launch vehicle.

Recent figures from the INTELSAT Web site give the capacity for the INTELSAT VII as 18,000 two-way telephone circuits and three TV channels; up to 90,000 two-way telephone circuits can be achieved with the use of "digital circuit multiplication."



Designation: Intelsat	I	II	III	IV	IV A	V	V A/V B	VI
Year of first launch	1965	1966	1968	1971	1975	1980	1984/85	1986/87
Prime contractor	Hughes	Hughes	TRW	Hughes	Hughes	Ford Aerospace	Ford Aerospace	Hughes
Width (m)	0.7	1.4	1.4	2.4	2.4	2.0	2.0	3.6
Height (m)	0.6	0.7	1.0	5.3	6.8	6.4	6.4	6.4
Launch vehicles		Thor Delta		Atlas-Centaur		Atlas-Centaur and Ariane	Atlas-Centaur and Ariane	STS and Ariane
Spacecraft mass in transfer orbit (kg)	68	182	293	1385	1489	1946	2140	12,100/3720
Communications payload mass (kg)	13	36	56	185	190	235	280	800
End-of-life (EOL) power of equinox (W)	40	75	134	480	800	1270	1270	2200
Design lifetime (years)	1.5	3	5	7	7	7	7	10
Capacity (number of voice channels)	480	480	2400	8000	12,000	25,000	30,000	80,000
Bandwidth (MHz)	50	130	300	500	800	2137	2480	3520

Fig 5.1 INTELSAT Series

The INTELSAT VII/A has a capacity of 22,500 two-way telephone circuits and three TV channels; up to 112,500 two-way telephone circuits can be achieved with the use of digital circuit multiplication. As of May 1999, four satellites were in service over the AOR, one in the IOR, and two in the POR.

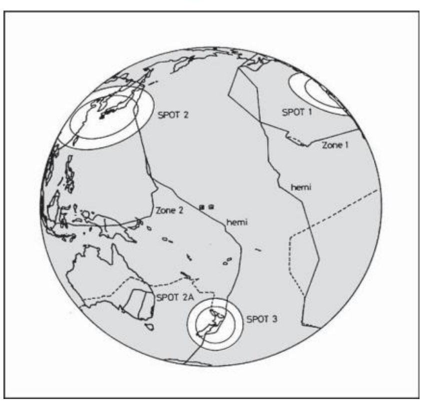


Fig 5.2 Region of glob

The INTELSAT VIII-VII/A series of satellites was launched over the period February 1997 to June 1998. Satellites in this series have similar capacity as the VII/Aseries, and the lifetime is 14 to 17 years.

It is standard practice to have a spare satellite in orbit on high-reliability routes (which can carry pre-emptible traffic) and to have a ground spare in case of launch failure.

Thus the cost for large international schemes can be high; for example, series IX, described later, represents a total investment of approximately $1 billion.

5.2 INSAT

INSAT or the **Indian National Satellite System** is a series of multipurpose geostationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue operations.

Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. It is a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, All India Radio and Doordarshan. The overall coordination and management of INSAT system rests with the Secretary-level INSAT Coordination Committee.

INSAT satellites provide transponders in various bands (C, S, Extended C and Ku) to serve the television and communication needs of India. Some of the satellites also have the Very High Resolution Radiometer (VHRR), CCD cameras for metrological imaging.

The satellites also incorporate transponder(s) for receiving distress alert signals for search and rescue missions in the South Asian and Indian Ocean Region, as ISRO is a member of the Cospas Sarsat programme.

5.2.1 INSAT SYSTEM:

The Indian National Satellite (INSAT) System Was Commissioned With The Launch Of INSAT- 1B In August 1983 (INSAT-1A, The First Satellite Was Launched In April 1982 But Could Not Fulfill The Mission).

INSAT System ushered in a Revolution in India’s Television and Radio Broadcasting, Telecommunications and Meteorological Sectors. It Enabled The Rapid Expansion Of TV And Modern Telecommunication Facilities To Even The Remote Areas And Off-Shore Islands.

5.2.2 SATELLITES IN SERVICE:

The 24 Satellites Launched In The Course Of the INSAT Program, 10 Are Still In Operation.INSAT-2E

It Is The Last Of The Five Satellites In INSAT-2 Series. It Carries Seventeen C-Band And Lower Extended C-Band Transponders Providing Zonal And Global Coverage With An Effective Isotropic Radiated Power (EIRP) Of 36 dBW.

It Also Carries A Very High Resolution Radiometer (VHRR) With Imaging Capacity In The Visible (0.55-0.75 µm), Thermal Infrared (10.5-12.5 µm) And Water Vapour (5.7-7.1 µm) Channels And Provides 2x2 Km, 8x8 Km And 8x8 Km Ground Resolution Respectively.

INSAT- 3A

The Multipurpose Satellite, INSAT-3A, Was Launched By Ariane In April 2003. It Is Located At 93.5 Degree East Longitude. The Payloads On INSAT-3A Are As Follows:

12 Normal C -Band Transponders (9 Channels Provide Expanded Coverage From Middle East To South East Asia With An EIRP Of 38 dBW, 3 Channels Provide India Coverage With An EIRP Of 36 dBW and 6 Extended C-Band Transponders Provide India Coverage With An EIRP of 36 dBW)

A CCD Camera Provides 1x1 Km Ground Resolution, In The Visible (0.63-0.69 µm), Near Infrared (0.77-0.86 µm) And Shortwave Infrared (1.55-1.70 µm) Bands.

INSAT-3D

Launched In July 2013, INSAT-3D Is Positioned At 82 Degree East Longitude. INSAT -3D Payloads Include Imager, Sounder, Data Relay Transponder And Search & Rescue Transponder. All the Transponders Provide Coverage over Large Part Of The Indian Ocean Region Covering India, Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka And Tanzania For Rendering Distress Alert Services

INSAT-3E

Launched In September 2003, INSAT - 3E Is Positioned At 55 Degree East Longitude And Carries 24 Normal C-Band Transponders Provide An Edge Of Coverage EIRP Of 37 dBW Over India And 12 Extended C-Band Transponders Provide An Edge Of Coverage EIRP Of 38 dBW Over India.

KALPANA-1

KALPANA-1 Is An Exclusive Meteorological Satellite Launched By PSLV In September 2002. It Carries Very High Resolution Radiometer And DRT Payloads To Provide Meteorological Services. It Is Located At 74 Degree East Longitude. Its First Name Was METSAT. It Was Later Renamed As KALPANA-1 To Commemorate Kalpana Chawla.

Configured For Audio-Visual Medium Employing Digital Interactive Classroom Lessons And Multimedia Content, EDUSAT Was Launched By GSLV In September 2004. Its Transponders And Their Ground Coverage Are Specially Configured To Cater To The Educational Requirements.

GSAT-2

Launched By The Second Flight Of GSLV In May 2003, GSAT-2 Is Located At 48 Degree East Longitude And Carries Four Normal C-Band Transponders To Provide 36 Dbw EIRP With India Coverage, Two Ku Band Transponders With 42 Dbw EIRP Over India And An MSS Payload Similar To Those On INSAT-3B And INSAT-3C.

INSAT-4 Series:

Fig 5.3 INSAT 4A

INSAT-4A is positioned at 83 degree East longitude along with INSAT-2E and INSAT-3B. It carries 12 Ku band 36 MHz bandwidth transponders employing 140 W TWTAs to provide an EIRP of 52 dBW at the edge of coverage polygon with footprint covering Indian main land and 12 C- band 36 MHz bandwidth transponders provide an EIRP of 39 dBW at the edge of coverage with expanded radiation patterns encompassing Indian geographical boundary, area beyond India in southeast and northwest regions.

Tata Sky, a joint venture between the TATA Group and STAR uses INSAT-4A for distributing their DTH service

- INSAT-4A
- INSAT-4B
- Glitch In INSAT 4B
- INSAT-4CR
- GSAT-8 / INSAT-4G
- GSAT-12 /GSAT-10
- China-Stuxnet Connection

5.3 VSAT

VSAT stands for very small aperture terminal system. This is the distinguishing feature of a VSAT system, the earth-station antennas being typically less than 2.4 m in diameter. The trend is toward even smaller dishes, not more than 1.5 m in diameter.

In this sense, the small TVRO terminals for direct broadcast satellites could be labeled as VSATs, but the appellation is usually reserved for private networks, mostly providing two-way communications facilities.

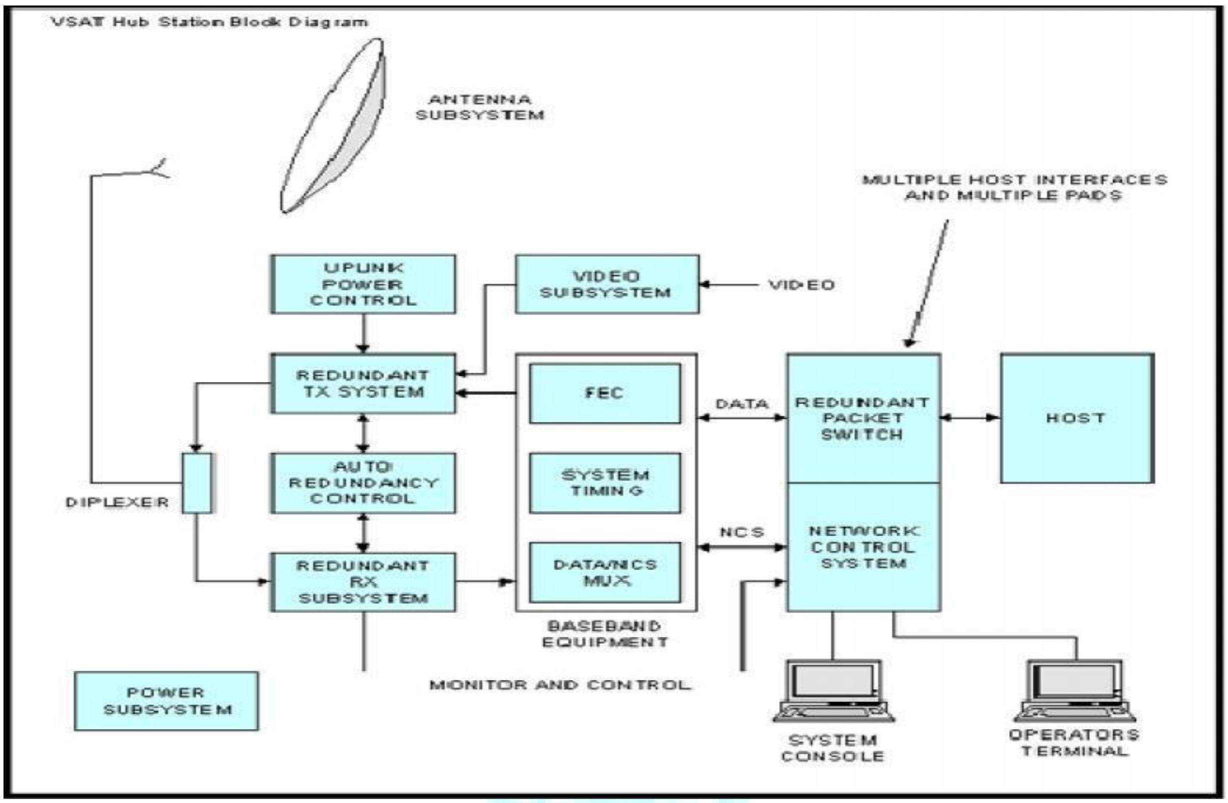


Fig 5.4 VSAT Block Diagrams

Typical user groups include banking and financial institutions, airline and hotel booking agencies, and large retail stores with geographically dispersed outlets.

5.3.1 VSAT NETWORK

The basic structure of a VSAT network consists of a hub station which provides a broadcast facility to all the VSATs in the network and the VSATs themselves which access the satellite in some form of multiple- access mode.

The hub station is operated by the service provider, and it may be shared among a number of users, but of course, each user organization has exclusive access to its own VSAT network.

Time division multiplex is the normal downlink mode of transmission from hub to the VSATs, and the transmission can be broadcast for reception by all the VSATs in a network, or address coding can be used to direct messages to selected VSATs.

A form of demand assigned multiple access (DAMA) is employed in some systems in which channel capacity is assigned in response to the fluctuating demands of the VSATs in the network.

Most VSAT systems operate in the Ku band, although there are some C-band systems in existence.

5.3.2 APPLICATIONS

- Supermarket shops (tills, ATM machines, stock sale updates and stock ordering).
- Chemist shops - Shoppers Drug Mart - Pharmaprix. Broadband direct to the home. e.g. Downloading MP3 audio to audio players.
- Broadband direct small business, office etc, sharing local use with many PCs.
- Internet access from on board ship Cruise ships with internet cafes, commercial shipping communications.

5.4 MOBILE SATELLITE SERVICES

5.4.1 GSM

SERVICES AND ARCHITECTURE

If your work involves (or is likely to involve) some form of wireless public communications, you are likely to encounter the GSM standards. Initially developed to support a standardized approach to digital cellular communications in Europe, the "Global System for Mobile Communications" (GSM) protocols are rapidly being adopted to the next generation of wireless telecommunications systems.

In the US, its main competition appears to be the cellular TDMA systems based on the IS-54 standards. Since the GSM systems consist of a wide range of components, standards, and protocols.

The GSM and its companion standard DCS1800 (for the UK, where the 900 MHz frequencies are not available for GSM) have been developed over the last decade to allow cellular communications systems to move beyond the limitations posed by the older analog systems.

Analog system capacities are being stressed with more users that can be effectively supported by the available frequency allocations. Compatibility between types of systems had been limited, if non-existent.

By using digital encoding techniques, more users can share the same frequencies than had been available in the analog systems. As compared to the digital cellular systems in the US (CDMA [IS- 95] and TDMA [IS-54]), the GSM market has had impressive success. Estimates of the numbers of telephones run from 7.5 million GSM phones to .5 million IS54 phones to .3 million for IS95.

GSM has gained in acceptance from its initial beginnings in Europe to other parts of the world including Australia, New Zealand, countries in the Middle East and the Far East. Beyond its use in cellular frequencies (900 MHz for GSM, 1800 MHz for DCS1800), portions of the GSM signaling protocols are finding their way into the newly developing PCS and LEO Satellite communications systems.

While the frequencies and link characteristics of these systems differ from the standard GSM air interface, all of these systems must deal with users roaming from one cell (or satellite beam) to another, and bridge services to public communication networks including the Public Switched Telephone Network (PSTN), and public data networks (PDN).

THE GSM ARCHITECTURE INCLUDES SEVERAL SUBSYSTEMS

The Mobile Station (MS)

These digital telephones include vehicle, portable and hand-held terminals. A device called the Subscriber Identity Module (SIM) that is basically a smart-card provides custom information about users such as the services they've subscribed to and their identification in the network

The Base Station Sub-System (BSS)

The BSS is the collection of devices that support the switching networks radio interface. Major components of the BSS include the Base Transceiver Station (BTS) that consists of the radio modems and antenna equipment.

In OSI terms, the BTS provides the physical interface to the MS where the BSC is responsible for the link layer services to the MS. Logically the transcoding equipment is in the BTS, however, an additional component.

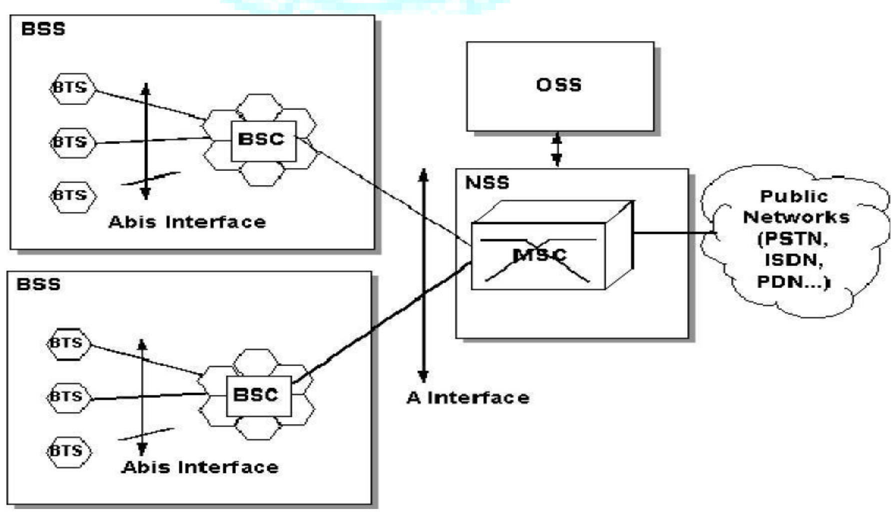


Fig 5.5 GSM Block Diagrams

The Network and Switching Sub-System (NSS)

The NSS provides the switching between the GSM subsystem and external networks along with the databases used for additional subscriber and mobility management.
Major components in the NSS include the Mobile Services Switching Center (MSC), Home and Visiting Location Registers (HLR, VLR). The HLR and VLR databases are interconnected through the telecomm standard Signaling System 7 (SS7) control network.

The Operation Sub -System (OSS)

The OSS provides the support functions responsible for the management of network maintenance and services. Components of the OSS are responsible for network operation and maintenance, mobile equipment management, and subscription management and charging.

SEVERAL CHANNELS ARE USED IN THE AIR INTERFACE

FCCH	The frequency correction channel - provides frequency synchronization information in a burst
SCH	Synchronization Channel - shortly following the FCCH burst (8 bits later), provides a reference to all slots on a given frequency
PAGCH	Paging and Access Grant Channel used for the transmission of paging information requesting the setup of a call to a MS.
RACH	Random Access Channel - an inbound channel used by the MS to request connections from the ground network. Since this is used for the first access attempt by users of the network, a random access scheme is used to aid in avoiding collisions.
CBCH	Cell Broadcast Channel - used for infrequent transmission of broadcasts by the ground network.
BCCH	Broadcast Control Channel - provides access status information to the MS. The information provided on this channel is used by the MS to determine whether or not to request a transition to a new cell
FACCH	Fast Associated Control Channel for the control of handovers
TCH/F	Traffic Channel, Full Rate for speech at 13 kbps or data at 12, 6, or 3.6 kbps
TCH/H	Traffic Channel, Half Rate for speech at 7 kbps, or data at 6 or 3.6 kbps.

Mobility Management:

One of the major features used in all classes of GSM networks (cellular, PCS and Satellite) is the ability to support roaming users. Through the control signaling network, the MSCs interact to locate and connect to users throughout the network.

"Location Registers" are included in the MSC databases to assist in the role of determining how and whether connections are to be made to roaming users. Each user of a GSM MS is assigned a Home Location Register (HLR) that is used to contain the user's location and subscribed services.

DIFFICULTIES FACING THE OPERATORS CAN INCLUDE

a. **Remote/ Rural Areas:**
   To service remote areas, it is often economically unfeasible to provide backhaul facilities (BTS to BSC) via terrestrial lines (fiber/microwave)

b. **Time to Deploy:**
   Terrestrial build-outs can take years to plan and implement.

c. **Areas of 'Minor' Interest:**
   These can include small isolated centers such as tourist resorts, islands, mines, oil exploration sites, hydro-electric facilities.

d. **Temporary Coverage:**
   Special events, even in urban areas, can overload the existing infrastructure.

GSM SERVICE SECURITY:

GSM was designed with a moderate level of service security. GSM uses several cryptographic algorithms for security. The A5/1, A5/2, and A5/3 stream ciphers are used for ensuring over-the-air voice privacy.

GSM uses General Packet Radio Service (GPRS) for data transmissions like browsing the web. The most commonly deployed GPRS ciphers were publicly broken in 2011The researchers revealed flaws in the commonly used GEA/1.

5.4.2 GLOBAL POSITIONING SYSTEM: (GPS)

The Global Positioning System (GPS) is a satellite based navigation system that can be used to locate positions anywhere on earth. Designed and operated by the U.S. Department of Defense, it consists of satellites, control and monitor stations, and receivers. GPS receivers take information transmitted from the satellites and uses triangulation to calculate a user's exact location. GPS is used on incidents in a variety of ways, such as:

- To determine position locations; for example, you need to radio a helicopter pilot the coordinates of your position location so the pilot can pick you up.
- To navigate from one location to another; for example, you need to travel from a lookout to the fire perimeter.
- To create digitized maps; for example, you are assigned to plot the fire perimeter and hot spots.
- To determine distance between two points or how far you are from another location.
- GPS is a satellite based navigation system. It uses a digital signal at about 1.5 GHz from each satellite to send data to the receiver. The receiver can then deduce its exact range from the satellite, as well as the geographic position (GP) of the satellite.

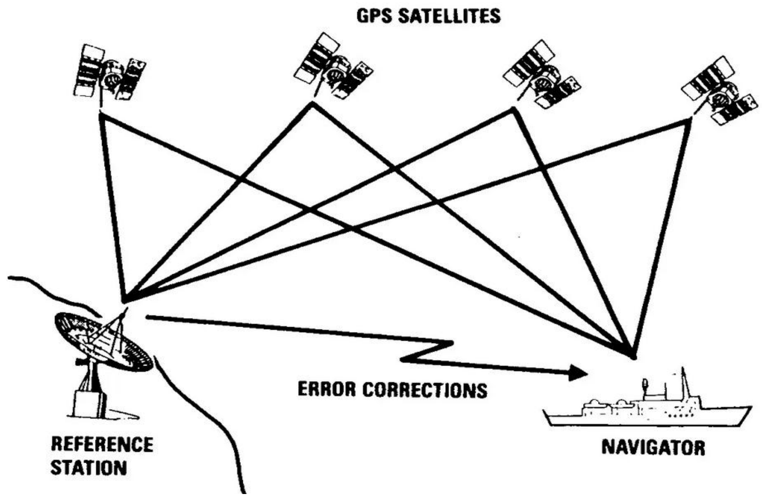


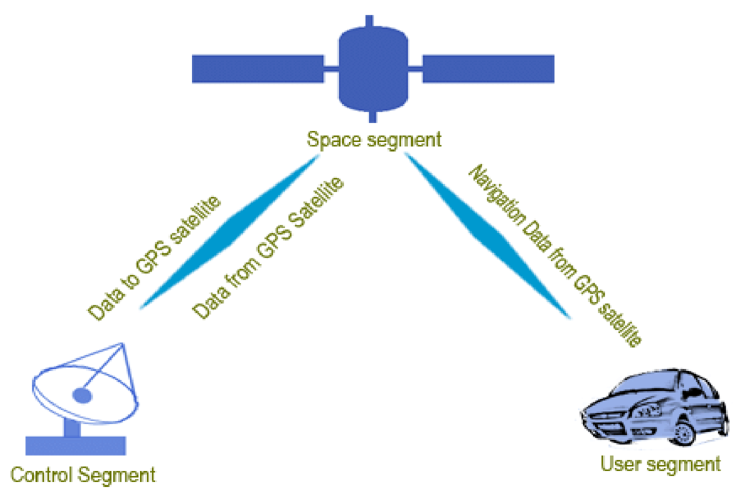
Fig 5.6 GPS Block Diagrams

THREE SEGMENTS OF GPS:

SPACE SEGMENT — Satellites orbiting the earth

The space segment is the number of satellites in the constellation. It comprises of 29 satellites circling the earth every 12 hours at 12,000 miles in altitude.

The function of the space segment is utilized to route/navigation signals and to store and retransmit the route/navigation message sent by the control segment. These transmissions are controlled by highly stable atomic clocks on the satellites. The GPS Space Segment is formed by a satellite constellation with enough satellites to ensure that the users will have, at least, 4 simultaneous satellites in view from any point at the Earth surface at any time.



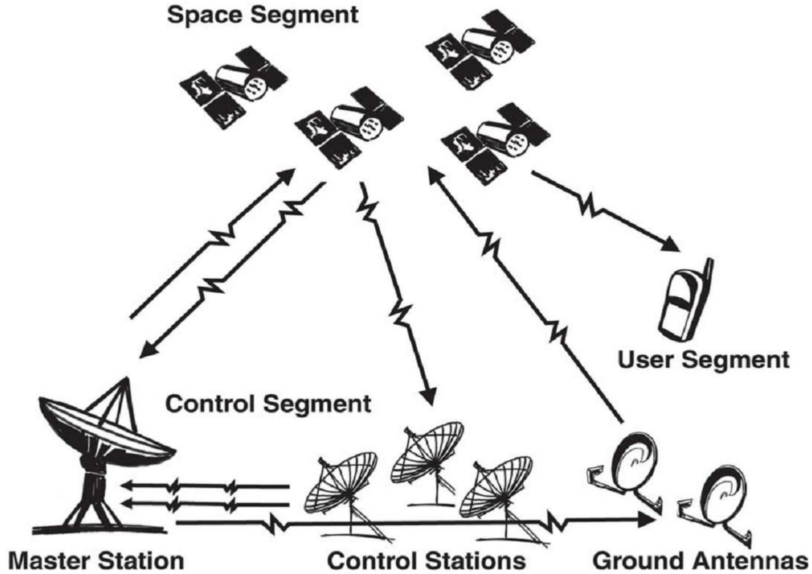


Fig 5.7 Three Segments of GPS

CONTROL SEGMENT — The control and monitoring stations

The control segment tracks the satellites and then provides them with corrected orbital and time information. The control segment consists of five unmanned monitor stations and one Master Control Station. The five unmanned stations monitor GPS satellite signals and then send that information to the Master Control Station where anomalies are corrected and sent back to the GPS satellites through ground antennas.

USER SEGMENT — The GPS receivers owned by civilians and military

The user segment comprises of the GPS receiver, which receives the signals from the GPS satellites and determine how far away it is from each satellite. Mainly this segment is used for the U.S military, missile guidance systems, civilian applications for GPS in almost every field. Most of the civilian uses this from survey to transportation to natural resources and from there to agriculture purpose and mapping too.

ADVANTAGES OF GPS

- GPS satellite based navigation system is an important tool for military, civil and commercial users
- Vehicle tracking systems GPS-based navigation systems can provide us with turn by turn directions
- Very high speed

DISADVANTAGES OF GPS

- GPS satellite signals are too weak when compared to phone signals, so it doesn’t work as well indoors, underwater, under trees, etc.
- The highest accuracy requires line-of-sight from the receiver to the satellite, this is why GPS doesn’t work very well in an urban environment.

USING A GPS RECEIVER

There are several different models and types of GPS receivers. While working with a GPS receiver it is important to have :

- A compass and a map.
- A downloaded GPS cable.
- Some extra batteries.
- Knowledge about the memory capacity of the GPS receiver to prevent loss of data, decrease in accuracy of data, or other problems.
- An external antenna whenever possible, especially under tree canopy, in canyons, or while driving.
- A set up GPS receiver according to incident or agency standard regulation; coordinate system.

5.4.3 LOCATION PRINCIPLES OF GPS:

The working/operation of Global positioning system is based on the 'trilateration' mathematical principle. The position is determined from the distance measurements to satellites. From the figure, the four satellites are used to determine the position of the receiver on the earth. The target location is confirmed by the 4th satellite. And three satellites are used to trace the location place. A fourth satellite is used to confirm the target location of each of those space vehicles. Global positioning system consists of satellite, control station and monitor station and receiver.

The GPS receiver takes the information from the satellite and uses the method of triangulation to determine a user's exact position.

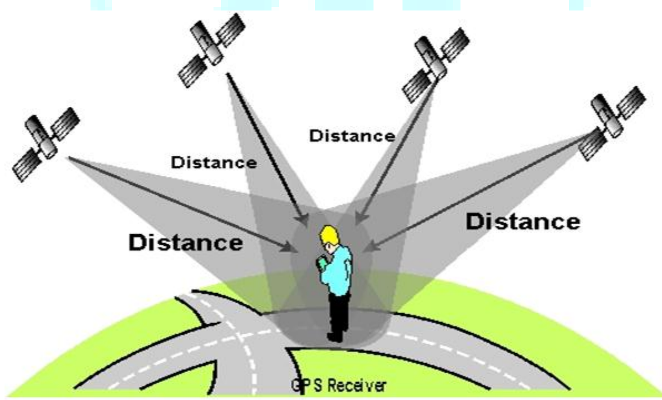


Fig 5.8 GPS Location Determination

PRECISE LOCATION OF SATELLITES

When a GPS receiver is first turned on, it downloads orbit information from all the satellites called an almanac. This process, the first time, can take as long as 12 minutes; but once this information is downloaded, it is stored in the receiver's memory for future use.

DISTANCE FROM EACH SATELLITE

The GPS receiver calculates the distance from each satellite to the receiver by using the distance formula: distance = velocity x time. The receiver already knows the velocity, which is the speed of a radio wave or 186,000 miles per second (the speed of light).

TRIANGULATION TO DETERMINE POSITION

The receiver determines position by using triangulation. When it receives signals from at least three satellites the receiver should be able to calculate its approximate position (a 2D position). The receiver needs at least four or more satellites to calculate a more accurate 3D position.

GPS ERROR

There are many sources of possible errors that will degrade the accuracy of positions computed by a GPS receiver. The travel time taken by the GPS satellite signals can be changed by atmospheric effects; when a GPS signal passes through the ionosphere and troposphere it is refracted, causing the speed of the signal to be different from the speed of a GPS signal in space. Another source of error is noise, or distortion of the signal which causes electrical interference or errors inherent in the GPS receiver itself. The information about satellite orbits will also cause errors in determining the positions, because the satellites are not really where the GPS receiver "thought" based on the information it received when it determine the positions.
Small variations in the atomic clocks on board the satellites can translate to large position errors; a clock error of 1 nanosecond translates to 1 foot or .3 meters user error on the ground. A multipath effect occurs when signals transmitted from the satellites bounce off a reflective surface before getting to the receiver antenna. During this process, the receiver gets the signal in straight line path as well as delayed path (multiple paths). The effect is similar to a ghost or double image on a TV set.

GEOMETRIC DILUTION OF PRECISION (GDOP)

Satellite geometry can also affect the accuracy of GPS positioning. This effect is refers as Geometric Dilution of Precision (GDOP). Which is refers to where the satellites are in related to one another, and is a measure of the quality of the satellite configuration. It can be able to modify other GPS errors. Most GPS receivers select the satellite constellation that will give the least uncertainty, the best satellite geometry.

GPS receivers usually report the quality of satellite geometry in terms of Position Dilution of Precision, or PDOP. PDOP are of two types, horizontal (HDOP) and vertical (VDOP) measurements (latitude, longitude and altitude). We can check the quality of the satellite positioning the receiver is currently available by the PDOP value. A low DOP indicates a higher probability of accuracy, and a high DOP indicates a lower probability of accuracy. Another term of PDOP is TDOP (Time Dilution of Precision). TDOP refers to satellite clock offset. On a GPS receiver can set a parameter known as the PDOP mask. This will cause the receiver to ignore satellite configurations that have a PDOP higher than the limit specified.

SELECTIVE AVAILABILITY (SA):

Selective Availability occurs when the DOD intentionally degraded; the accuracy of GPS signals is introducing artificial clock and ephemeris errors. During the implementation of SA, it was the largest component of GPS error, causing error of up to 100 meters. SA is a component of the Standard Positioning Service (SPS).

5.4.4 DIFFERENTIAL GPS

So far, we've learned how a GPS receiver calculates its position on earth based on the information it receives from four located satellites. This system works pretty well, but inaccuracies do pop up. For one thing, this method assumes the radio signals will make their way through the atmosphere at a consistent speed (the speed of light). In fact, the Earth's atmosphere slows the electromagnetic energy down somewhat, particularly as it goes through the ionosphere and troposphere. The delay varies depending on where you are on Earth, which means it's difficult to accurately factor this into the distance calculations. Problems can also occur when radio signals bounce off large objects, such as skyscrapers, giving a receiver the impression that a satellite is farther away than it actually is. On top of all that, satellites sometimes just send out bad almanac data, misreporting their own position.

Differential GPS (DGPS) helps correct these errors. The basic idea is to gauge GPS inaccuracy at a stationary receiver station with a known location. Since the DGPS hardware at the station already knows its own position, it can easily calculate its receiver's inaccuracy. The station then broadcasts a radio signal to all DGPS-equipped receivers in the area, providing signal correction information for that area. In general, access to this correction information makes DGPS receivers much more accurate than ordinary receivers.

The most essential function of GPS receiver is to pick up the transmissions of at least four satellites and combine the information in those transmissions with information in an electronic almanac, all in order to figure out the receiver’s position on Earth.

Once the receiver makes this calculation, it can tell you the latitude, longitude and altitude (or some similar measurement) of its current position. To make the navigation more user friendly, most receivers plug this raw data into map files stored in memory.

You can use maps stored in the receiver’s memory, connect the receiver to a computer that can hold more detailed maps in its memory, or simply buy a detailed map of your area and find your way using the receivers latitude and longitude readouts. Some receivers let you download detailed maps into memory or supply detailed maps with plug in map cartridges.

A standard GPS receiver will not only place you on a map at any particular location, but will also trace your path across a map as you move. If you leave your receiver on, it can stay in constant communication with GPS satellites to see how your location is changing.

With this information and its built-in clock, the receiver can give you several pieces of valuable information:

- How far you've traveled (Odometer)
- How long you've been traveling
- Your current speed (speedometer)
- Your average speed
- A "bread crumb" trail showing you exactly where you have traveled on the map
- The estimated time of arrival at your destination if you maintain your current speed

5.4.5 INMARSAT

Inmarsat-Indian Maritime SATellite is still the sole IMO-mandated provider of satellite communications for the GMDSS. Availability for GMDSS is a minimum of 99.9%
Inmarsat has constantly and consistently exceeded this figure & independently audited by IMSO and reported on to IMO.

Now Inmarsat commercial services use the same satellites and network &Inmarsat A closes at midnight on 31 December 2007 Agreed by IMO – MSC/Circ.1076. Successful closure Programme almost concluded Overseen throughout by IMSO.

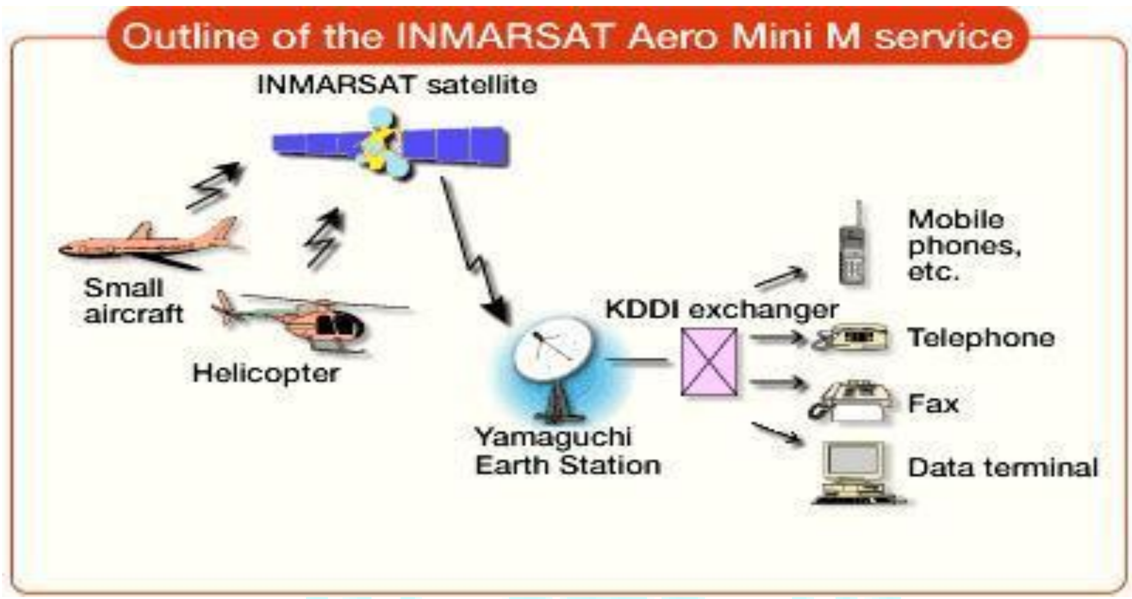


Fig 5.9 Outline of the INMARSAT

GMDSS services continue to be provided by:

- Inmarsat B, Inmarsat C/mini-C and Inmarsat Fleet F77
- Potential for GMDSS on Fleet Broadband being assessed

- The IMO Criteria for the Provision of Mobile Satellite Communications Systems in the Global Maritime Distress and Safety System (GMDSS).
- Amendments were proposed; potentially to make it simpler for other satellite systems to be approved.
- The original requirements remain and were approved by MSC 83
    - No dilution of standards
- Minor amendments only; replacement Resolution expected to be approved by the IMO 25th Assembly
- Inmarsat remains the sole, approved satcom provider for the GMDSS.

5.4.6 DIFFERENT SATELLITE ORBITS

An orbit is the path that a satellite follows as it revolves around Earth. Satellites orbits vary depending on:

1) Altitude 2) Inclination 3) Orbital Period

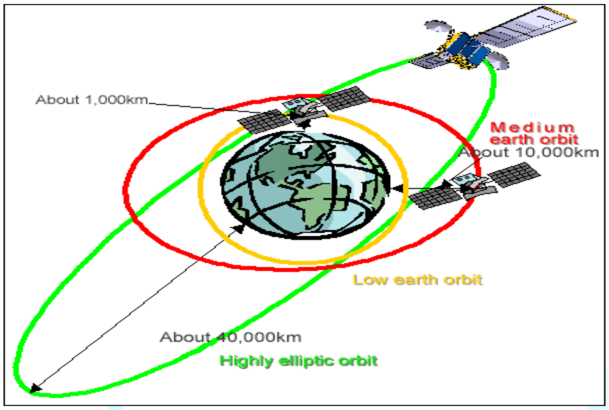


Fig 5.10 Satellite Orbits

Low Earth Orbit (LEO) Satellite Characteristics

- Circular/slightly elliptical orbit under 3000 km
- Orbit period ranges from 1.5 to 2 hours
- Diameter of coverage is about 8000 km
- Round-trip signal propagation delay less than 20 ms
- Maximum satellite visible time up to 20 min
- Used for Remote sensing satellites, altimeter satellites
- System must cope with large Doppler shifts
- Atmospheric drag results in orbital deterioration
- Low Earth Orbit satellites have a small area of coverage.
- The large majority of satellites are in low earth orbit
- The Iridium system utilizes LEO satellites (780km high)

Medium Earth Orbit (MEO) Satellite Characteristics

- Circular orbit at an altitude in the range of 6000 to 12,000 km
- Orbit period of 5 to 12 hours
- Diameter of coverage is 10,000 to 15,000 km
- Round trip signal propagation delay less than 80 ms
- Maximum satellite visible time is a few hours
- Used for GPS satellites (12 hr periods – twice a day)

Geostationary Earth Orbit (GEO) Satellite Characteristics

1. A satellite in a geostationary orbit appears to be stationary with respect to the earth.
2. Three conditions are required for an orbit to be stationary.
   - ♦ The satellite must travel eastward at the same rotational speed as the earth.
   - ♦ The orbit must be circular.
   - ♦ The inclination of the orbit must be 0.
3. The radius of the geostationary orbit=42164km.

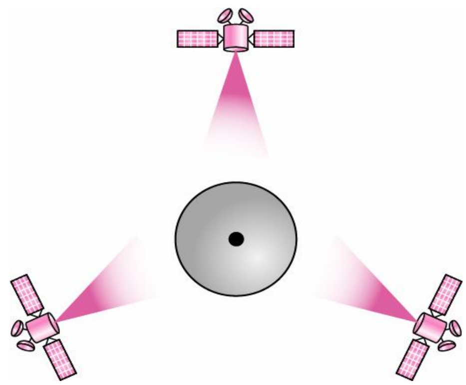


Fig 5.11 Satellites in Geosynchronous Orbit

Uses of Geostationary Orbits

Geostationary orbits are primarily used for two functions:

- Weather monitoring
- Telecommunications & Broadcasting
    - Commercial growth is focused on:
        - DTH TV (Direct To Home: Sky TV)
        - Phone, Fax, Video, Data services
        - Mobile Communications
        - VSAT & USAT
        - Digital Radio

Characteristics

- There is only one geostationary orbit possible around the earth Lying on the earth's equatorial plane. The satellite orbiting at the same speed as the rotational speed of the earth on its axis.
- They complete one orbit every 24 hours. This causes the satellite to appear stationary with respect to a point on the earth, allowing one satellite to provide continual coverage to a given area on the earth's surface
- One GEO satellite can cover approximately 1/3 of the world's surface. They are commonly used in communication systems
- User terminals do not have to track the satellite
- Only a few satellites can provide global coverage
- Maximum life-time (15 years or more)
- Above Van Allen Belt Radiation
- Often the lowest cost system and simplest in terms of tracking and high speed switching
- Altitudes of 36,000km
- The satellite needs 1 day to complete an orbit
  T = 86,000 sec (rounded), 86,000 sec = 1,433 min = 24hours (rounded)

Advantages of the GEO orbit

- No problem with frequency changes
- Tracking of the satellite is simplified
- High coverage area

Disadvantages of the GEO orbit

- Weak signal after traveling over 35,000 km
- Polar regions are poorly served
- Signal sending delay is substantial
- Large free space loss

Challenges of Geostationary (GEO) Orbit

- Transmission latency or delay of 250 millisecond to complete up/down link
- Satellite antennas must be of larger aperture size to concentrate power and to create narrower beams for frequency reuse
- Poor look angle elevations at higher latitudes

Comparison of Various Satellite Orbit

Features	GEO	MEO	LEO
Height (Km's)	36000	6000 - 12000	200 - 3000
Time per orbit (Hrs)	24	5 – 12	1.5
Speed (Km's / hr)	11000	19000	27000
Time Delay (ms)	250	80	10
Time in Site of Gateway	Always	2 – 4 hrs	< 15 min
Satellite for Global Coverage	3	10 – 12	50 - 70

5.4.7 SATELLITE NAVIGATIONAL SYSTEM

A **satellite Navigation** or **SATNAV** system is a system that uses satellites to provide autonomous geo-spatial positioning. It allows small electronic receivers to determine their location (Longitude, Latitude, and Altitude/Elevation) to high precision (within a few centimeters to meters) using time signals transmitted along a line of sight by radio from satellites.

The system can be used for providing position, navigation or for tracking the position of something fitted with a receiver (Satellite Tracking). The signals also allow the electronic receiver to calculate the current local time to high precision, which allows time synchronization. These uses are collectively known as Positioning, Navigation and Timing (**PNT**).

SATNAV systems operate independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the positioning information generated.

WORKING PRINCIPLE:

Satellite Navigation systems use a series of satellite placed in specific orbits around the earth to figure out where the receiver is located. The satellites transmit orbital and timing information. The receiver uses this information from several satellites to calculate its position. Commercial systems are accurate to a couple meters, but high end systems are accurate to a few centimeters.

TERMINOLOGY:

GPS (Global Positioning System) used to be an umbrella term for satellite navigation systems but now GPS is associated with the US owned NAVSTAR system. GNSS (Global Navigation Satellite System) is the umbrella term today for global systems, but only two global systems exist at this time. There are also regional satellite navigation systems, and regional satellite navigation systems that are in the infant stages of becoming global.

The Major satellite navigation systems are

- Two operational global satellite navigation systems exist in the world today (GPS and GLONASS)
- Two global satellite navigation systems are in development (Compass and Galileo)
- Three regional satellite navigation systems exist today (BeiDou, IRNSS and QZSS)

GPS

The NAVSTAR FPS system is composed of 24 satellites, and was created by the US department of defense; it can be accessed anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users worldwide and is freely accessible to anyone with a GPS receiver.

GLONASS

GLONASS is also composed of 24 satellites but was developed in the Soviet Union and is operated by the Russian aerospace defense forces. This SATNAV system is the only other navigational system in operation with global coverage and of comparable precision.

GALILEO (In Development)

GALILEO is a 30 satellite global navigation system currently being developed by the the European Union and European space agency, expected to be complete in 2019. One of the goals of this system is to provide a high precision positioning system for European nations that are independent from the Russian GLONASS, U.S, GPS, Indian IRNSS and Chinese Compass Systems.

COMPASS (In Development)

COMPASS is a global navigation system being developed by china that will consist of 35 satellites and is expected to be completed in 2020. It is the second generation of its regional BeiDou Satellite Navigation System (BDS), also known as BeiDou – 2.

QZSS

The Quasi Zenith Satellite System (QZSS) is a proposed three satellite regional time transfer and satellite based augmentation system for the global positioning system that would be receivable within japan and Australia.

BeiDou

The BeiDou Navigation satellite System (BDS) consists of two separate satellite constellations. The first is a limited test system known as BeiDou-1. BeiDou-1 consists of three satellite and offers limited coverage and applications. Its navigation services have been mainly for customers in china and neighboring regions. The second generation, BeiDou-2 (Compass), is a full scale global navigation system currently under construction.

IRNSS

The Indian regional Navigational Satellite System (IRNSS) is a regional satellite navigational system being developed by the Indian space research organization. When complete, it will be under control of the Indian government. IRNSS will provide standard service for civilian use and an encrypted restricted service for authorized users (Military)

5.5 RECEIVE-ONLY HOME TV SYSTEMS/ DIRECT BROADCAST SATELLITE

Planned broadcasting directly to home TV receivers takes place in the Ku (12-GHz) band. This service is known as direct broadcast satellite (DBS) service.

There is some variation in the frequency bands assigned to different geographic regions. In the Americas, for example, the down- link band is 12.2 to 12.7 GHz.

The comparatively large satellite receiving dishes [ranging in diameter from about 1.83 m (6 feet) to about 3 m (10 feet) in some locations, which may be seen in some “backyards” are used to receive downlink TV signals at C band (4GHz).

Originally such downlink signals were never intended for home reception but for network relay to commercial TV outlets (VHF and UHF TV broadcast stations and cable TV “head-end” studios)

Equipment is now marketed for home reception of C-band signals, and some manufacturers provide dual C-band/Ku-band equipment. A single mesh type reflector may be used which focuses the signals into a dual feed- horn, which has two separate outputs, one for the C-band signals and one for the Ku-band signals.

Much of television programming originates as first generation signals, also known as master broadcast quality signals.

These are transmitted via satellite in the C band to the network head- end stations, where they are retransmitted as compressed digital signals to cable and direct broadcast satellite providers.

- Another of the advantages, claimed for home C-band systems, is the larger number of satellites available for reception compared to what is available for direct broadcast satellite systems.
- Although many of the C-band transmissions are scrambled, there are free channels that can be received, and what are termed “wild feeds.”

- These are also free, but unannounced programs, of which details can be found in advance from various publications and Internet sources.
- C-band users can also subscribe to pay TV channels, and another advantage claimed is that subscription services are cheaper than DBS or cable because of the multiple-source programming available.
- The most widely advertised receiving system for C-band system appears to be 4DTV manufactured by Motorola.

This enables reception of:

- Free, analog signals and “wild feeds”
- Video Cipher ll plus subscription services
- Free Digi Cipher 2 services
- Subscription Digi Cipher 2 services

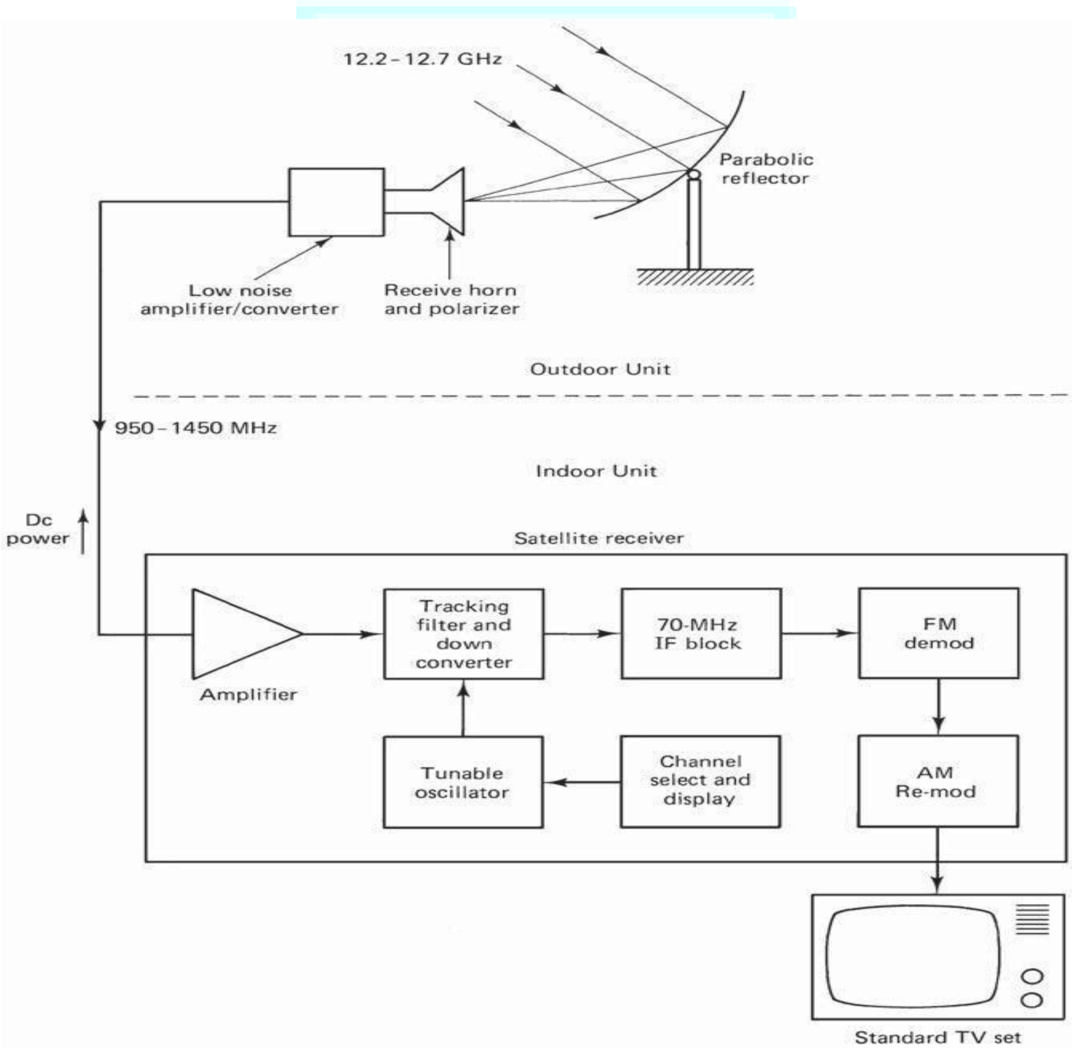


Fig 5.12 Home Terminal for DBS TV/FM reception.

THE OUTDOOR UNIT:

This consists of a receiving antenna feeding directly into a low-noise amplifier/converter combination. A parabolic reflector is generally used, with the receiving horn mounted at the focus. A common design is to have the focus directly in front of the reflector, but for better interference rejection, an offset feed may be used as shown.

Comparing the gain of a 3 m dish at 4 GHz with a 1 m dish at 12 GHz, the ratio D/l equals 40 in each case, so the gains will be about equal. Although the free-space losses are much higher at 12 GHz compared with 4 GHz.

The downlink frequency band of 12.2 to 12.7 GHz spans a range of 500 MHz, which accommodates 32 TV/FM channels, each of which is 24 MHz wide. Obviously, some overlap occurs between channels, but these are alternately polarized left-hand circular (LHC) and right-hand circular (RHC) or vertical/horizontal, to reduce interference to accept- able levels. This is referred to as polarization interleaving. A polarizer that may be switched to the desired polarization from the indoor control unit is required at the receiving horn.

The receiving horn feeds into a low-noise converter (LNC) or possibly a combination unit consisting of a low-noise amplifier (LNA) followed by a converter.

The combination is referred to as an LNB, for low-noise block. The LNB provides gain for the broadband 12 GHz signal and then converts the signal to a lower frequency range so that a low-cost coaxial cable can be used as feeder to the indoor unit.

THE INDOOR UNIT:

The signal fed to the indoor unit is normally a wideband signal covering the range 950 to 1450 MHz. This is amplified and passed to a tracking filter which selects the desired channel, as shown in Fig.

As previously mentioned, polarization interleaving is used, and only half the 32 channels will be present at the input of the indoor unit for any one setting of the antenna polarizer. This eases the job of the tracking filter, since alternate channels are well separated in frequency.

The selected channel is again down converted, this time from the 950- to 1450-MHz range to a fixed intermediate frequency, usually 70 MHz although other values in the very high frequency (VHF) range are also used.
The 70-MHz amplifier amplifies the signal up to the levels required for demodulation. A major difference between DBS TV and conventional TV is that with DBS, frequency modulation is used, whereas with conventional TV, amplitude modulation in the form of vestigial single side-band (VSSB) is used.

The 70 -MHz, FM intermediate frequency (IF) carrier therefore must be demodulated, and the baseband information used to generate a VSSB signal which is fed into one of the VHF/UHF channels of a standard TV set.

5.6 DIRECT TO HOME BROADCAST (DTH):

Direct to home technology refers to the satellite television broadcasting process which is actually intended for home reception. This technology is originally referred to as **direct broadcast satellite (DBS)** technology. The technology was developed for competing with the local cable TV distribution services by providing higher quality satellite signals with more number of channels.

In short, DTH refers to the reception of satellite signals on a TV with a personal dish in an individual home. The satellites that are used for this purpose is geostationary satellites. The satellites compress the signals digitally, encrypt them and then are beamed from high powered geostationary satellites. They are received by dishes that are given to the DTH consumers by DTH providers.

Though DBS and DTH present the same services to the consumers, there are some differences in the technical specifications. While DBS is used for transmitting signals from satellites at a particular frequency band [the band differs in each country], DTH is used for transmitting signals over a wide range of frequencies [normal frequencies including the KU and KA band]. The satellites used for the transmission of the DTH signals are not part of any international planned frequency band. DBS has changed its plans over the past few years so as to include new countries and also modify their mode of transmission from analog to digital. But DTH is more famous for its services in both the analog and digital services which includes both audio and video signals. The dishes used for this service is also very small in size. When it comes to commercial use, DBS is known for its service providing a group of free channels that are allowed for its targeted country.

DTH in India

India is one of the biggest DTH service providers in the world. The requirement is very high because of the high population and the increased number of viewers. The low cost of DTH when compared to other local cable providers is also one main reason for this substantial growth.

In India the DTH requirement is more than in any country as the population of viewers is at very high rate.

The first person who invented the technology for DTH war Sir Arthure Clarles Clarke, a british inventor in late 1946. The idea of DTH was first provided to India in 1996. But it was not approved then as there were concerns about national security. But the laws were changed by the year 2000 and thus DTH was allowed. Doordarshan was first to provide the service to the consumers from 1st of April, 2000.

According to the new rule, DTH providers are required to set up new stations within 12 months of getting the license. The cost of the license is almost $2.15 million in India with a validity of 10 years for renewal. The latest reports suggest that almost 25% of the total Indian population use this facility while others use local TV connections.

Some of the common DTH providers in India are

1. TATA Sky
2. BIG TV
3. Sun Direct DTH
4. Dish TV
5. Airtel DTH
6. Videocon DTH

Working of DTH

To know the working of DTH better, take a look at the diagram below.

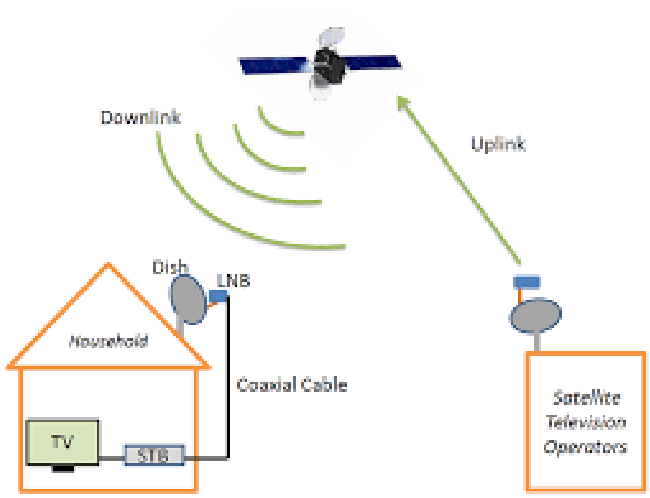


Figure DTH Service

For a DTH network to be transmitted and received, the following components are needed.

- Broadcasting Centre
- Satellites
- Encoders
- Multiplexers
- Modulators
- DTH receivers

It must be noted the channels that are broadcasted from the broadcasting centre hare not created by the DTH providers. The DTH providers pay other companies like HBO, Sony MAX and so on for the right to broadcast their channel to the DTH consumers through satellite. Thus the DTH provider acts as a mediator r broker between the consumers and the programme channels.

The broadcast centre is the main part of the whole system. It is from the broadcast station that the signals are sent to the satellites to be broadcasted. The broadcast station receives the signals from various program channels.

The satellite receives the signal from the broadcast centre and compresses the signals and makes them suitable for re-transmission to the ground.

The DTH providers give dish receivers for the viewers to receive the signal from the satellites. There may be one or multiple satellites that send the signals at the same time. The receiver receives the signal from them and is passed on to the Set Top Box [STB] receiver in the viewer's house.

The STB receiver changes the signal in a form suitable for our television and then passes it on to our TV. STB receiver consist of the following components

- Tuner
- Demodulator
- Decoder
- Microcontroller
- CAS System
- Amplifiers

Advantages of DTH Technology

- The main advantage is that this technology is equally beneficial to everyone. As the process is wireless, this system can be used in all remote or urban areas.
- High quality audio and video which are cost effective due to absence of mediators.
- Almost 4000 channels can be viewed along with 2000 radio channels. Thus the world's entire information including news and entertainment is available to you at home.
- As there are no mediators, a complaint can be directly expressed to the provider.
- With a single DTH service you will be able to use digital quality audio, video and also high speed broadband.
- It also offers interactive channels and program guides with customers having the choice to block out programming which they consider undesirable
- One of the great advantages of the cable industry has been the ability to provide local channels, but this handicap has been overcome by many DTH providers using other local channels or local feeds.

Disadvantages:

Among disadvantages, the biggest one is the capital cost that has to be borne initially. Since this involves setting up of a receiving apparatus at the subscribers end, the cost can be prohibitively high.

5.7 WORLD SPACE SERVICES:

World Space (Nasdaq: WRSP) is the world's only global media and entertainment company positioned to offer a satellite radio experience to consumers in more than 130 countries with five billion people, driving 300 million cars. World Space delivers the latest tunes, trends and information from around the world and around the corner.

World Space subscribers benefit from a unique combination of local programming, original World Space content and content from leading brands around the globe, including the BBC, CNN, Virgin Radio, NDTV and RFI. World Space's satellites cover two -thirds of the globe with six beams.

Each beam is capable of delivering up to 80 channels of high quality digital audio and multimedia programming directly to World Space Satellite Radios anytime and virtually anywhere in its coverage area. World Space is a pioneer of satellite-based digital radio services (DARS) and was instrumental in the development of the technology infrastructure used today by XM Satellite Radio.

Business Television (BTV) - Adaptations for Education:

Business television (BTV) is the production and distribution, via satellite, of video programs for closed user group audiences. It often has two-way audio interaction component made through a simple telephone line. It is being used by many industries including brokerage firms, pizza houses, car dealers and delivery services.

BTV is an increasingly popular method of information delivery for corporations and institutions. Private networks, account for about 70 percent of all BTV networks. It is estimated that by the mid- 1990s BTV has the potential to grow to a $1.6 billion market in North America with more and more Fortune 1,000 companies getting involved. The increase in use of BTV has been dramatic.

Institution updates, news, training, meetings and other events can be broadcast live to multiple locations. The expertise of the best instructors can be delivered to thousands of people without requiring trainers to go to the site. Information can be disseminated to all employees at once, not just a few at a time. Delivery to the workplace at low cost provides the access to training that has been denied lower level employees. It may be the key to re-training America's work force.

Television has been used to deliver training and information within businesses for more than 40 years. Its recent growth began with the introduction of the video cassette in the early 1970s. Even though most programming is produced for video cassette distribution, business is using BTV to provide efficient delivery of specialized programs via satellite.

The advent of smaller receiving stations - called very small aperture terminals (VSATs) has made private communication networks much more economical to operate. BTV has a number of tangible benefits, such as reducing travel, immediate delivery of time-critical messages, and eliminating cassette duplication and distribution hassles.

The programming on BTV networks is extremely cost-effective compared to seminar fees and downtime for travel. It is an excellent way to get solid and current information very fast. Some people prefer to attend seminars and conferences where they can read, see, hear and ask questions in person. BTV provides yet another piece of the education menu and is another way to provide professional development.

A key advantage is that its format allows viewers to interact with presenters by telephone, enabling viewers to become a part of the program. The satellite effectively places people in the same room, so that sales personnel in the field can learn about new products at the same time.

Speed of transmission may well be the competitive edge which some firms need as they introduce new products and services. BTV enables employees in many locations to focus on common problems or issues that might develop into crises without quick communication and resolution.

BTV networks transmit information every business day on a broad range of topics, and provide instructional courses on various products, market trends, selling and motivation. Networks give subscribers the tools to apply the information they have to real world situations.

5.8 GRAMSAT:

ISRO has come up with the concept of dedicated GRAMSAT satellites, keeping in mind the urgent need to eradicate illiteracy in the rural belt which is necessary for the all round development of the nation.

This Gramsat satellite is carrying six to eight high powered C -band transponders, which together with video compression techniques can disseminate regional and cultural specific audio-visual programmes of relevance in each of the regional languages through rebroadcast mode on an ordinary TV set.
The high power in C-band has enabled even remote area viewers outside the reach of the TV transmitters to receive programmers of their choice in a direct reception mode with a simple .dish antenna.

The salient features of GRAMSAT projects are:

- Its communications networks are at the state level connecting the state capital to districts, blocks and enabling a reach to villages.
- It is also providing computer connectivity data broadcasting, TV-broadcasting facilities having applications like e- governance, development information, teleconferencing, helping disaster management.
- Providing rural-education broadcasting.

However, the Gramsat projects have an appropriate combination of following activities.

- Interactive training at district and block levels employing suitable configuration
- Broadcasting services for rural development
- Computer interconnectivity and data exchange services
- Tele-health and tele-medicine services.