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Unit-V
Satellite Services and Applications

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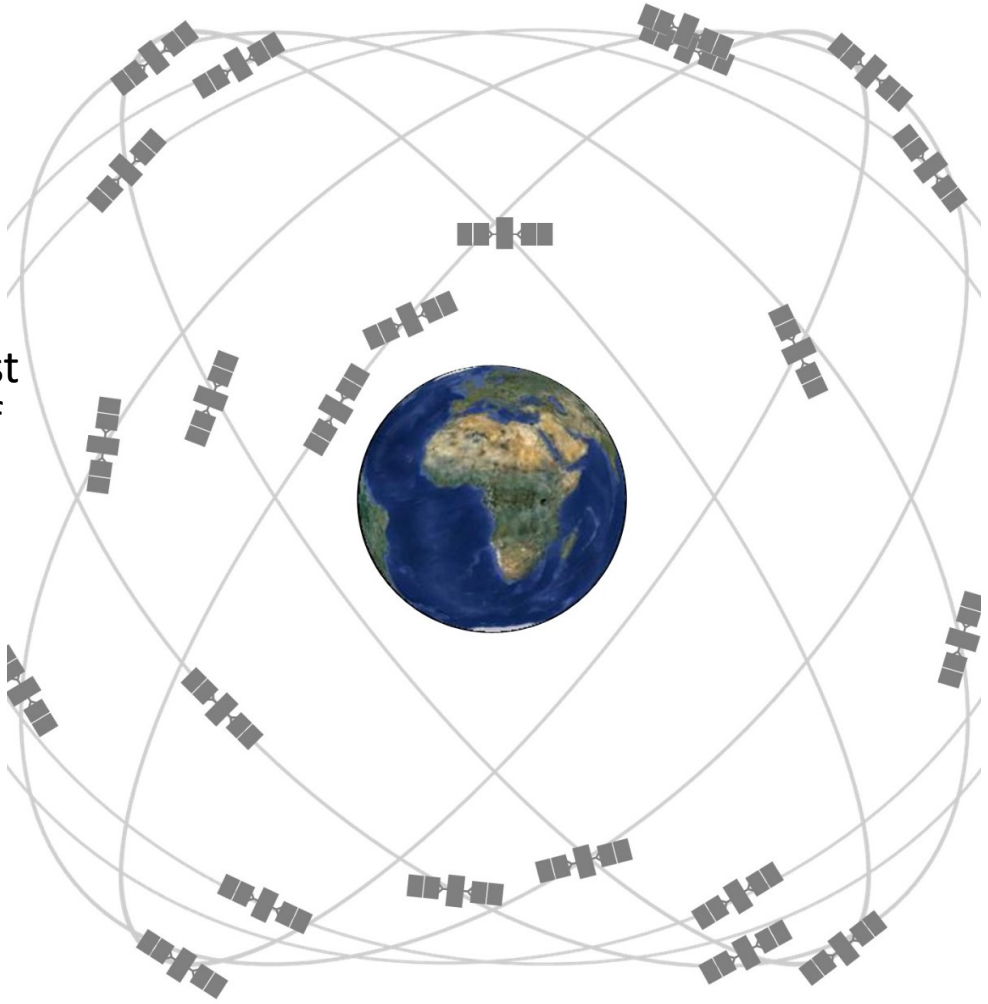
Space Segment

- The GPS space segment consists of a constellation of satellites transmitting radio signals to users.
- The United States is committed to maintaining the availability of at least 24 operational GPS satellites, 95% of the time.
- To ensure this commitment, the U.S. Space Force has been flying 31 operational GPS satellites for well over a decade.



Constellation Arrangement

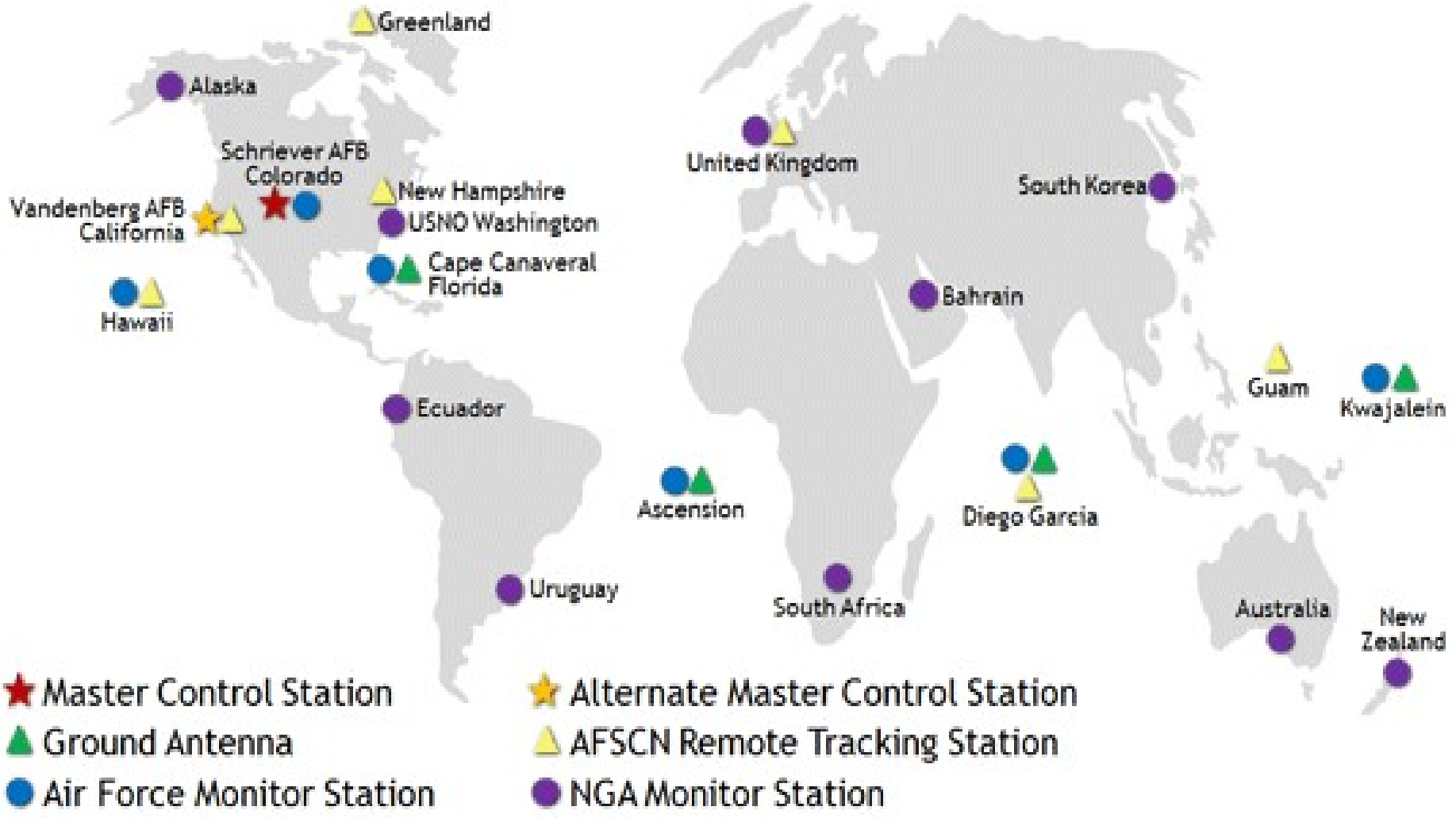
- GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day.
- The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures users to view at least four satellites from virtually any point on the planet.
- The Space Force normally flies more than 24 GPS satellites to maintain coverage whenever the baseline satellites are serviced or decommissioned. The extra satellites may increase GPS performance but are not considered part of the core constellation.

GPS System

- The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services.
- GPS is a satellite-based radio navigation system.
- This system consists of three segments:
  1. **Space segment**
  2. **Control segment**
  3. **User segment**
- It has created the revolution in navigation and position location.

Control Segment

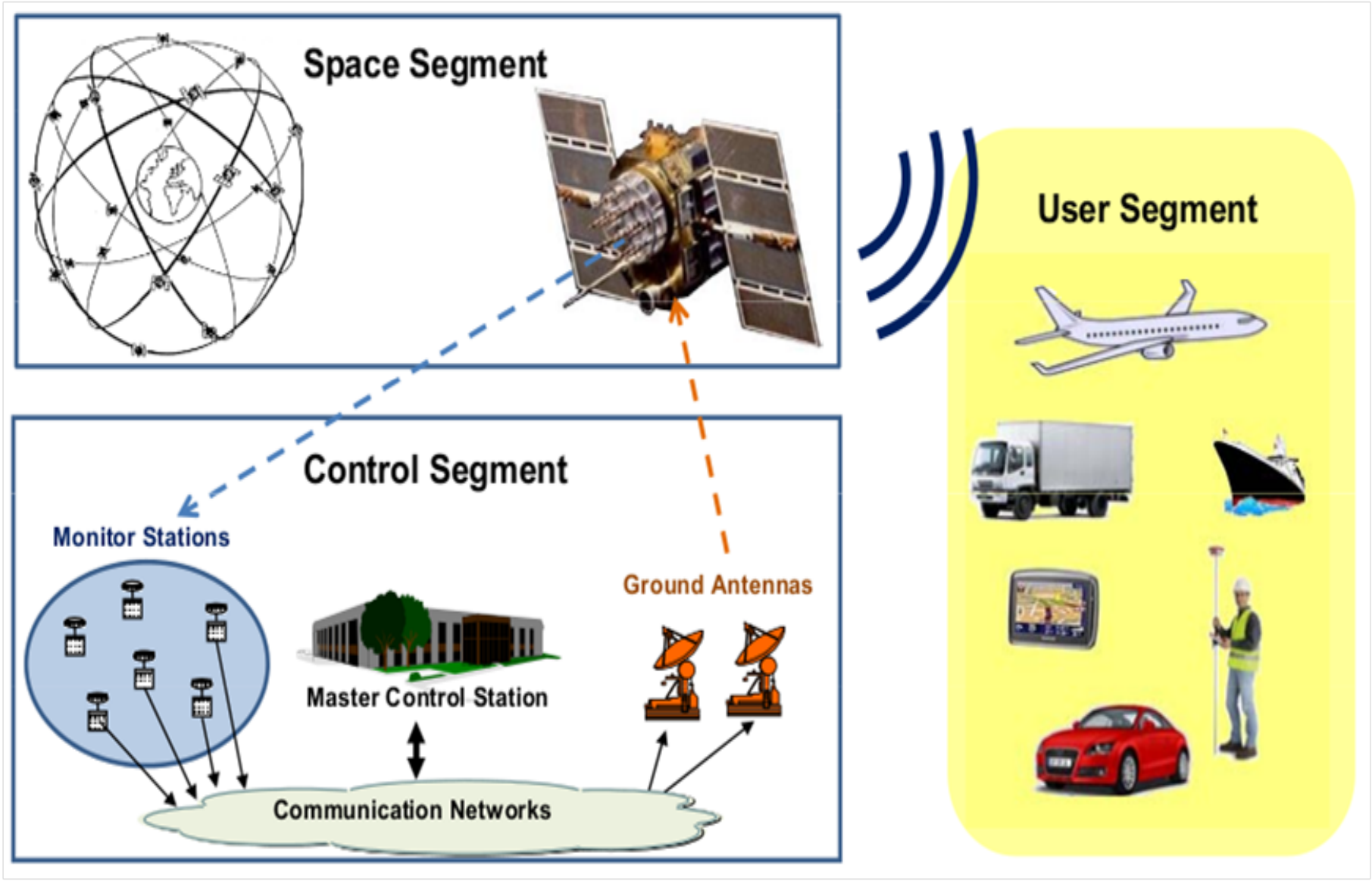
- The GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation.
- The current Operational Control Segment (OCS) includes a master control station, an alternate master control station, 11 command and control antennas, and 16 monitoring sites.


Greenland
Alaska
Schriever AFB
Colorado
Vandenberg AFB
California
New Hampshire
USNO Washington
Cape Canaveral
Florida
Hawaii
Ecuador
Uruguay
United Kingdom
South Korea
Bahrain
Guam
Kwajalein
Ascension
Diego Garcia
South Africa
Australia
New
Zealand
Master Control Station
Alternate Master Control Station
Ground Antenna
AFSCN Remote Tracking Station
Air Force Monitor Station
NGA Monitor Station

User Segment

- The User unit is the term given to all GPS receivers like mobile phones, laptops, PC or any other device.
- The devices receives the signals from the GPS satellites and determines how far away it is from each satellite.

GPS System


Space Segment
Control Segment
Monitor Stations
Master Control Station
Ground Antennas
Communication Networks
User Segment

Global Positioning System (GPS) Working

- The three elements of Global Positioning System work in unison resulting in accurate and reliable operation of the positioning system
- GPS positioning is based on "**Trilateration Principle**" which determines the position by measuring distances to points at known coordinates.
- Trilateration requires three ranges to three known points at a minimum but Global Positioning System requires four "Pseudo ranges" to four satellites.
- Hence the positioning system uses two main factors in determining the position:
  1. **Position of the Receiver (User) using Trilateration Principle**
  2. **Pseudorange Calculation**

Position of the Receiver using the Trilateration Principle

- To calculate the 2-D position (latitude and longitude) of a point of interest or track movement, a GPS receiver must be locked on to the signal of at least three satellites.
- A single satellite tracks a general location of the point of interest on the Earth's surface.
- This location information is spread over a large area.
- Data from a second satellite, when added to this information, allows the Global Positioning System to narrow the location.
- This will be the point where the two areas of satellite data overlap.
- Adding data from a third satellite provides more accurate position of the point.

- The distance is measured using the equation:

Distance = Travel Time X Speed of Light

- Where Travel Time is the time taken by the signals to reach the receiver, which travels at the speed of light and the distance measured helps to locate the point of interest (User) on the face of Earth.
- The fourth satellite is used to re-confirm and enhance the position of the point of interest(Receiver).
- The receiver determines the 3-D position (latitude, longitude, and altitude) of the point of interest with the information from the fourth satellite.
- Precision increases with an increase in the number of satellites in the vicinity.

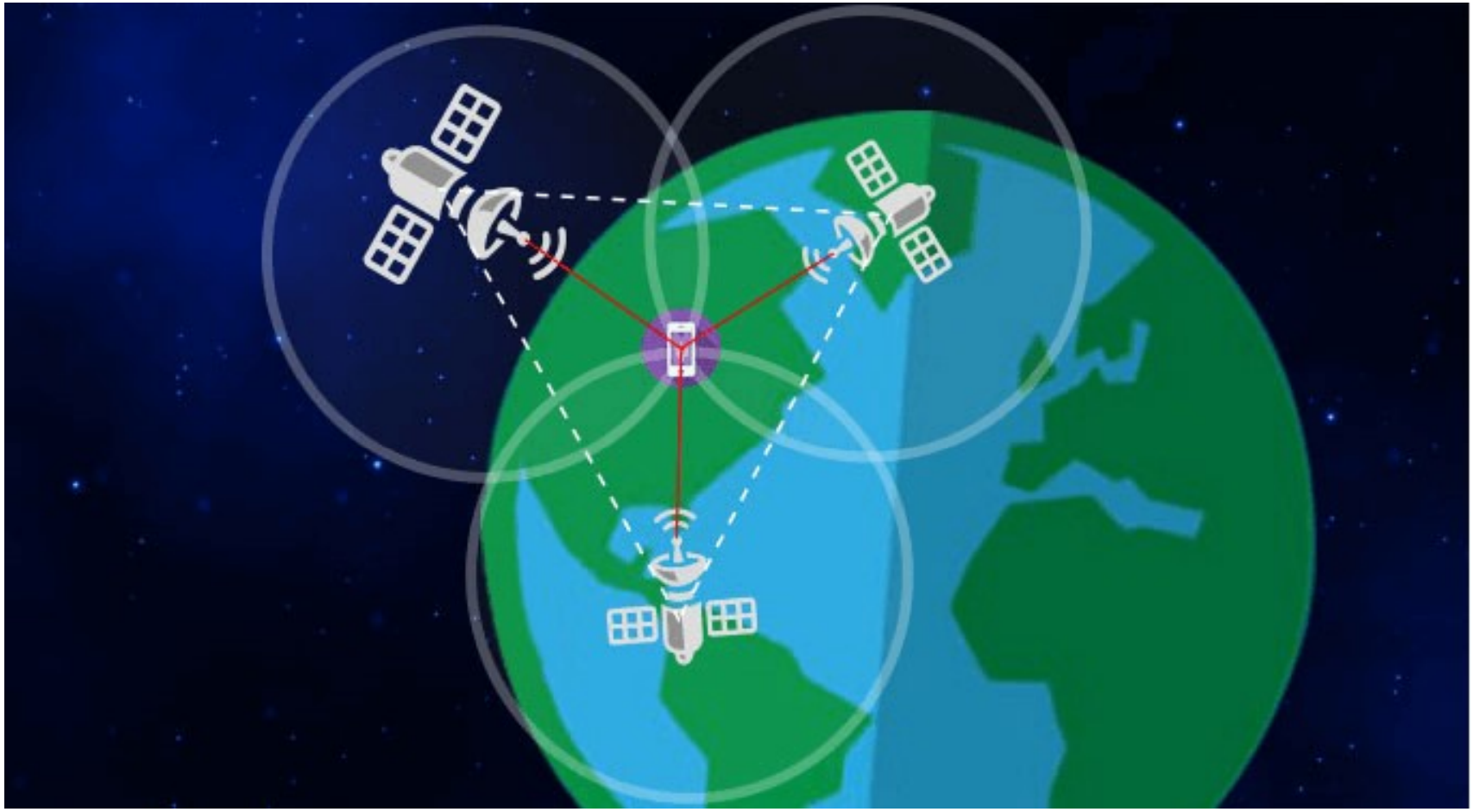


Fig: Trilateration Principle

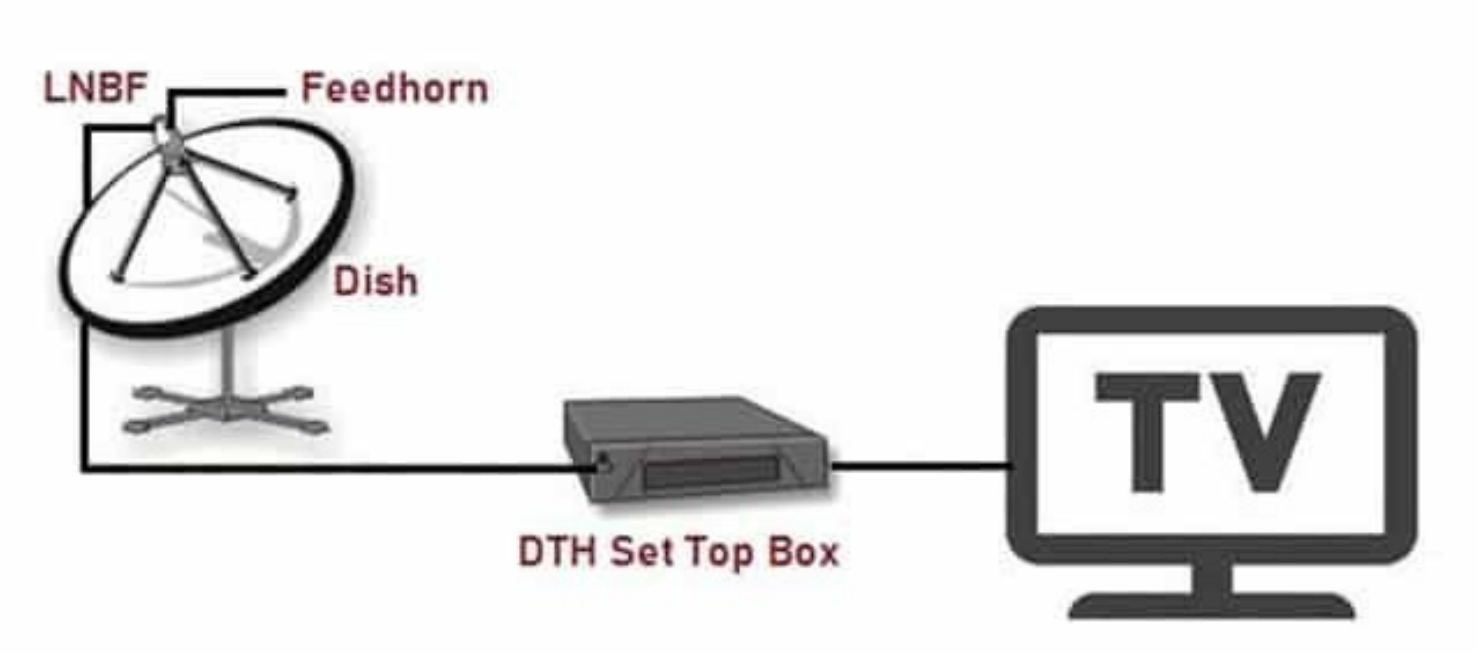
Direct to Home

- Direct-to-home to home technology refers to the satellite television broadcasting process which is actually intended for home reception.
- This technology was originally referred to as direct broadcast satellite (DBS) technology.
- The technology was developed to compete 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.

Direct to Home

- Direct to Home Technology provides better picture and sound quality. It also offers services like internet access, video conferencing and email.
- HDTV (High Definition TV) and 3D TV are the enhanced features of this Technology. It also has options to record/rewind/pause live TV.
- DTH (Direct to Home) System consists of the following components:
- Dish Antenna
- LNBF (Low Noise Block Down Converter plus Feedhorn)
- Coaxial Cable
- Set Top Box

Direct to Home



Direct to Home

- The architecture of Direct to Home System includes:
- Satellite
- Broadcasting Centre
- Multiplexer
- Modulator
- Encoder
- DTH Receiver

Direct to Home

Satellite

- A Geo-Stationary Satellite plays an important role in the direct-to-home system. Satellites have a much larger “line of sight” range as they are higher in the sky than TV antennas. It transmits the signals to the DTH Antenna.

Broadcasting centre

- The Broadcast Centre is the central hub of the system. The television provider receives signals here from various programming sources and then beams a broadcast signal to satellites that are in Geostationary orbit.
- The satellites receive the signals from the broadcasting station and rebroadcast them to the ground.

Direct to Home

Multiplexer

- Multiplexer is a device that transmits the information of many channels in one channel. It is a part of the broadcasting center.
- In the Broadcasting Centre, the Multiplexer compresses all the frequency signals into one single channel & and transmits it to the Geo-Stationary satellite. It sends the single channel to the Modulator.

Modulator

- Modulation is a process in which the information signal is imposed on a carrier signal that is of high strength. The Modulator modulates the signals and sends to the Encoder.

Direct to Home

Encoder

- The Encoder encodes the signals to transmit the signals. The satellite sends the signals to the DTH Antenna which further transmits them to the Set Top Box.

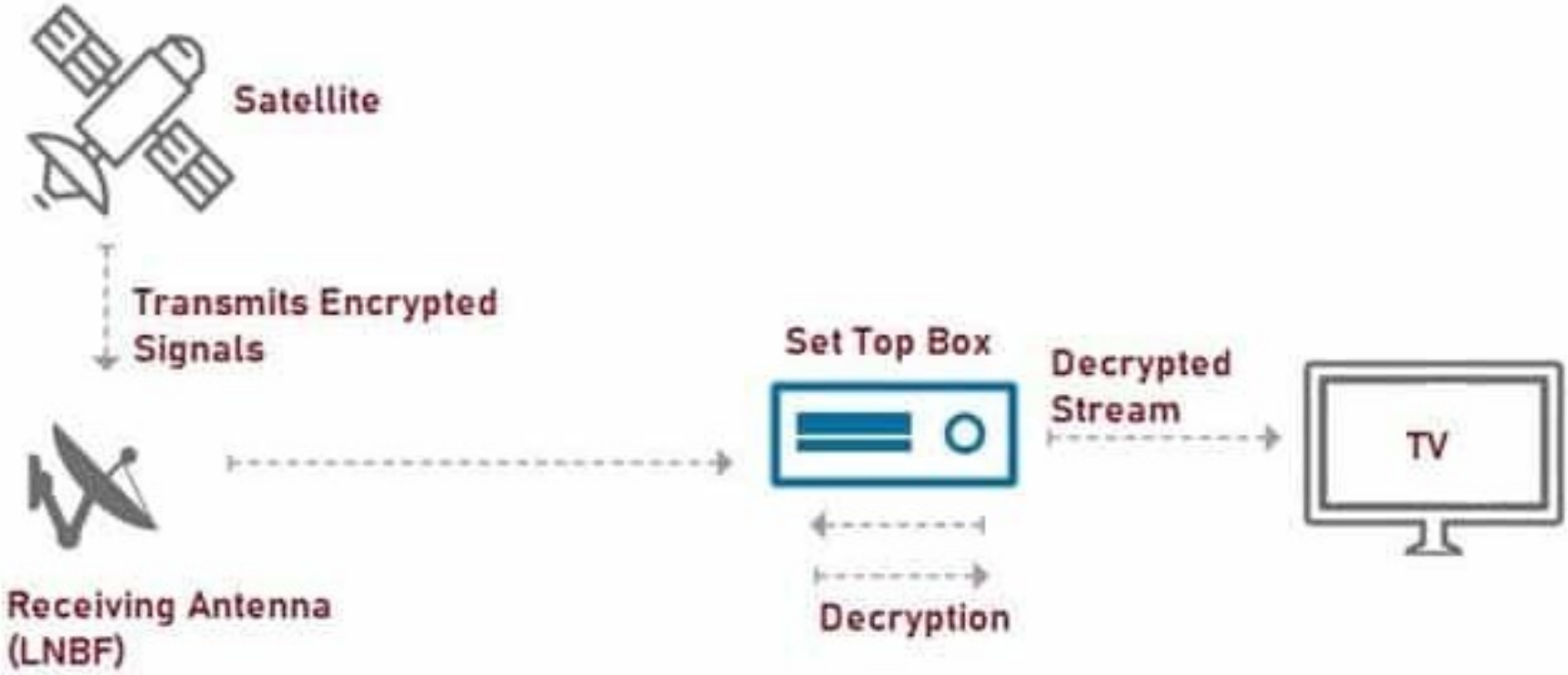
DTH Receiver

- The receiver is the end component in the entire DTH System. It decodes or descrambles the encrypted signal. For unlocking the signal, it needs the proper decoder chip for that programming package. The service provider can communicate with that chip with the help of a satellite signal to make the required operations to its decoding program.

Direct to Home

- The Satellites which are located approximately 35700 km above the Earth's surface transmit signals to the Broadcast stations on the Earth's Surface. The Broadcast Centre receives the signals and Transponder on the satellite helps establish a Communication channel between Transmitting and Receiving Units. Satellite rebroadcasts the signals which are encoded.
- The Encoder converts the data, audio, and video signals into the digital format and these signals are combined by the multiplexer. There will be a small Dish Antenna and Set Top Box at the user end to Receive, Decode, and view numerous channels.

Direct to Home



Direct to Home

The advantages of DTH Technology include:

- Greater service coverage.
- More channels.
- Better signal quality.
- Multiple language options.
- Pay only for the channels and services that the user wants.
- Applications such as Parental Lock, Pre-booked Pay-Per-View and Impulse Pay-Per-View.

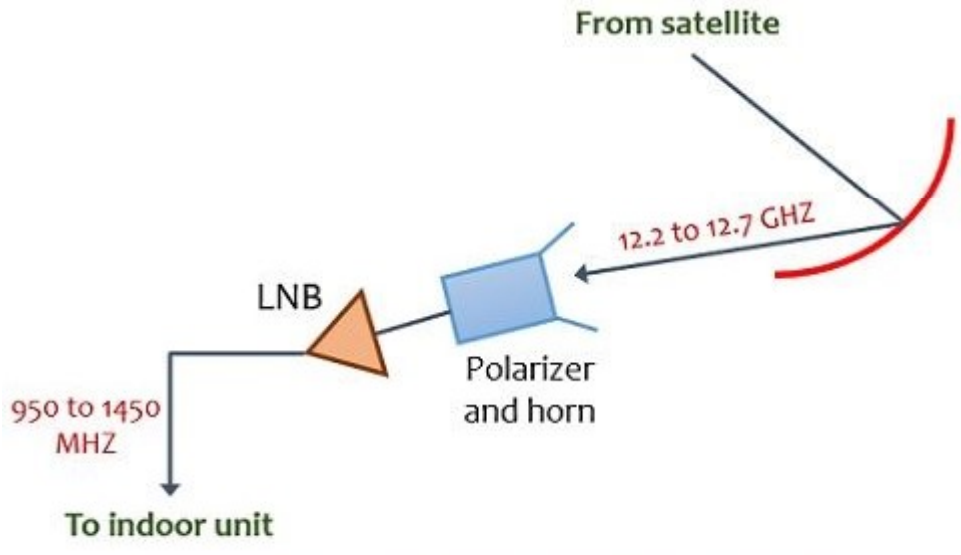
Direct to Home

The disadvantages of DTH Technology include:

- One of the major problems for the subscribers of Direct To Home service is unable to view any channel during heavy rains due to weak signals.
- Changing service provider is not easy as the user has to pay additional cost to buy new Set Top Box from new service provider.

(TVRO and DBS)

Home Receiver – Outdoor unit



Schematic of Outdoor Unit

Home Receiver

- The home receiver consists of two units—an outdoor unit and an indoor unit.

Outdoor Unit

- The downlink signal, covering the frequency range of 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 downconverter.
- A low-noise amplifier is used to **amplify very low-power signals without significantly degrading their signal-to-noise ratio**. They increase the amplitude of weak RF signals, which assists in processing as part of a receiver circuit.

Home Receiver

- The downconverter 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.
- The antenna usually works with an offset feed.
- It is important that the antenna have an unobstructed view of the satellite cluster to which it is aligned.
- The size of the antenna is a compromise among many factors but typically is around 18 in. (46 cm) in diameter. A small antenna is desirable for a number of reasons.

Out Door Unit

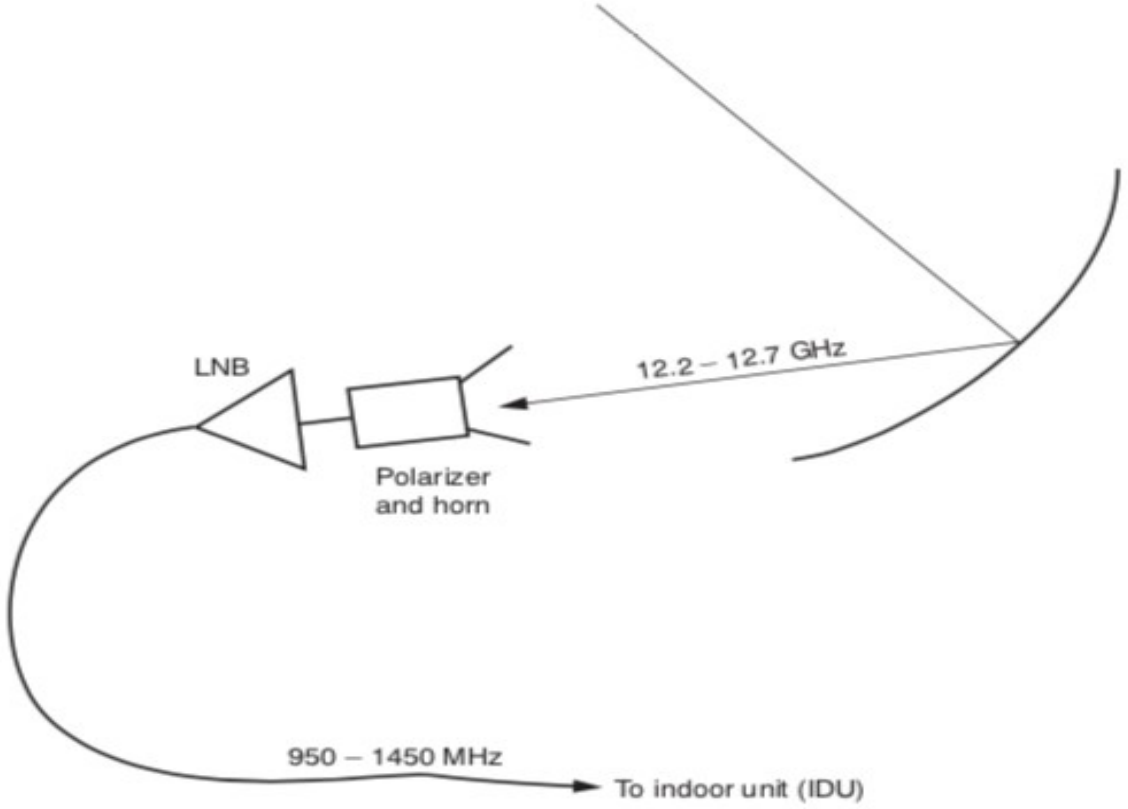
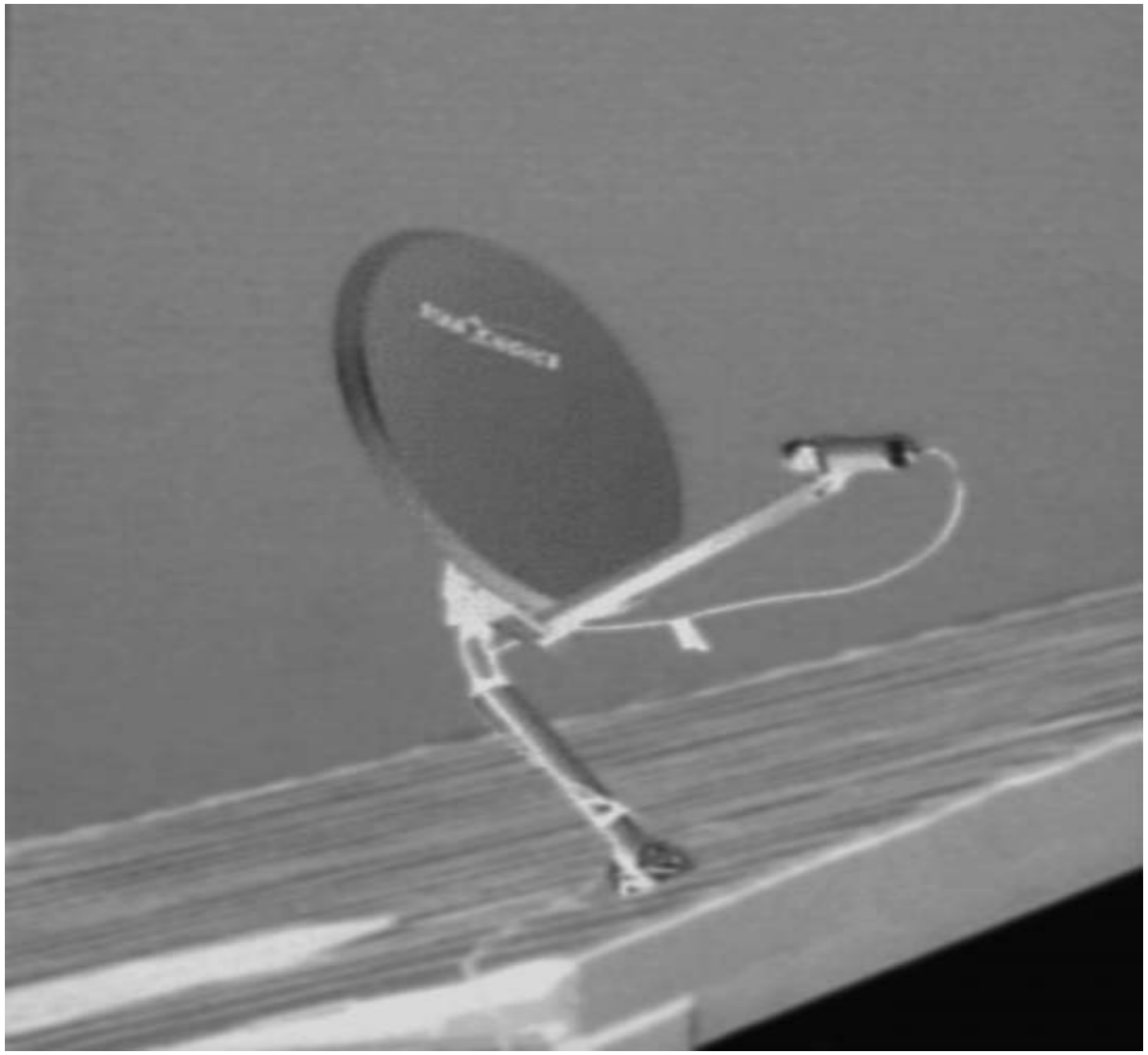


Figure 16.5 Block schematic for the outdoor unit (ODU).

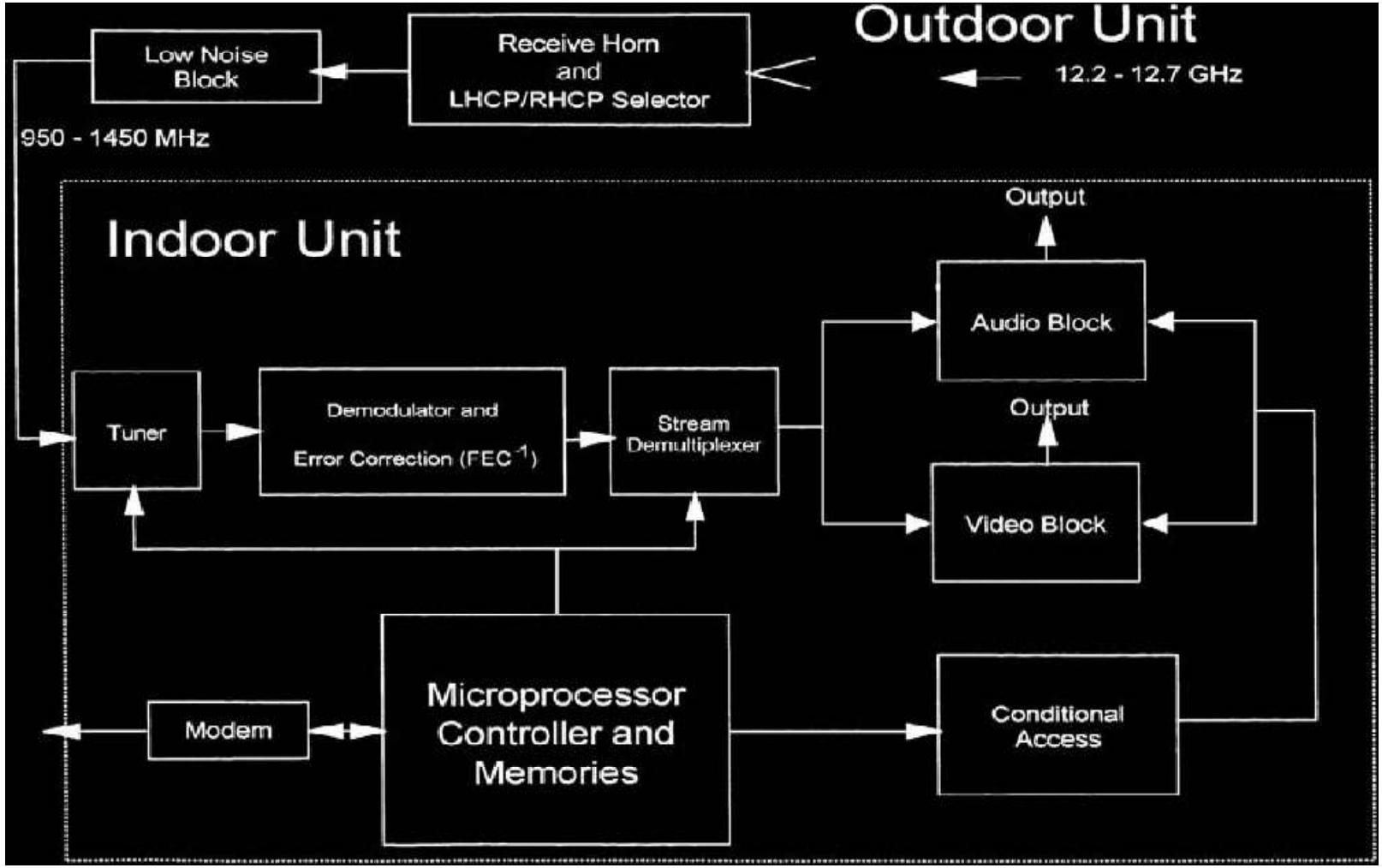
Out Door Unit



Home Receiver Indoor Unit

- 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, and the QPSK modulation is converted to a bit stream. Error correction is carried out in the decoder block labelled FEC.

Home Receiver Indoor Unit



- The demultiplexer following the FEC block separates the individual programs, which are then stored in buffer memories for further processing (not shown in the diagram).
- This further processing would include such things as conditional access, viewing history of *pay-per-view* (PPV) usage, and connection through a modem to the service provider (for PPV billing purposes).

Satellite Mobile Services

- Although countries in the developed world are well served by global communications, there remain large areas and population groups that have very limited access to telecommunications services.
- Developing a telephone network on the ground, whether wired or cellular, is time-consuming and expensive.
- Once satellites are deployed in orbit, they can provide wide area service for telephone, facsimile, and Internet, on an as-needed basis, without the need for extensive ground facilities.
- Most of the systems that offer telephone services provide the users with dual-mode phones that operate to GSM standards.

MSAT

- Mobile Satellite : **a satellite-based mobile telephony service developed by the National Research Council of Canada**
- This system has two geostationary satellites, MSAT-1 and MSAT-2, which provide services across North and Central America, northern South America, the Caribbean, Hawaii, and in coastal waters.
- The system is operated by Mobile Satellite Ventures (MSV).
- A variety of services are offered, including tracking and managing trucking fleets, wire- less phone, data and fax, dispatch radio services, and differential GPS.
- L-band frequencies are used for the satellite services, the downlink band being 1530 to 1559 MHz, and the uplink, 1631.5 to 1660.5 MHz.

Download speeds from GPRS to 5G compared

GENERATION NETWORK	TECHNOLOGY TYPE	TYPICAL DOWNLOAD SPEED (MEGABITS PER SECOND)	MAX DOWNLOAD SPEED (MBPS)
2G	GPRS	<0.1	0.1
	Edge	0.1	0.3
3G	3G (Basic)	0.1	0.3
	HSPA	1.5	7.2
	HSPA+	4	21
	DC-HSPA+	8	42
4G	LTE Category 4	15	150
4G+	LTE-Advanced Cat6	30	300
	LTE-Advanced Cat9	45	450
	LTE-Advanced Cat12	60	600
	LTE-Advanced Cat16	90	979
5G	5G	150-200	1,000-10,000 (1 to 10 gigabits per second)

SOURCE: HTTPS://KENSTECHTIPS.COM/INDEX.PHP/DOWNLOAD-SPEEDS-2G-3G-AND-4G-ACTUAL-MEANING

VSAT

- VSAT stands for *very small aperture terminal* system.
- Distinguishing feature : 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
- Usually reserved for private networks, mostly providing two-way communications facilities.
- Typical user groups include banking and financial institutions, airline and hotel booking agencies, and large retail stores with geographically dispersed outlets.

- VSATs offer various advantages, like wide geographical area coverage, high reliability, low cost, independence from terrestrial communication infrastructure, flexible network configurations, etc
- However, VSATs suffer from a major problem of delay between transmission and reception of data (around 250 ms) due to the use of GEO satellites.

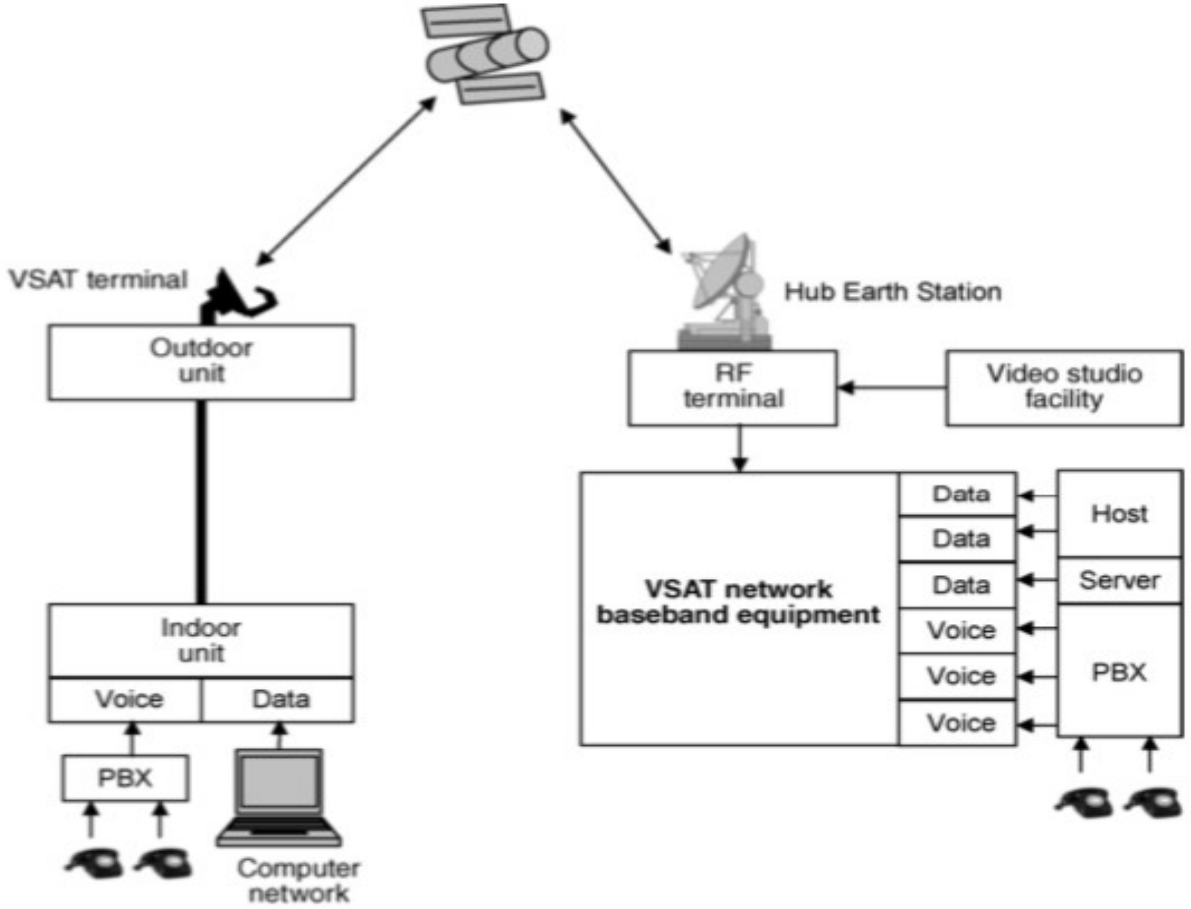


Figure 10.10 A typical VSAT network

- The ground segment of a typical VSAT network consists of a high performance hub Earth station and a large number of low performance terminals, referred to as VSATs.
- The space segment comprises of GEO satellites acting as communication links between the hub station and the VSAT terminals.
- VSATs employ a **high performance central station** so that the various remote stations can be simpler and smaller in design, thus enabling the VSAT networks to be extremely economical and flexible.

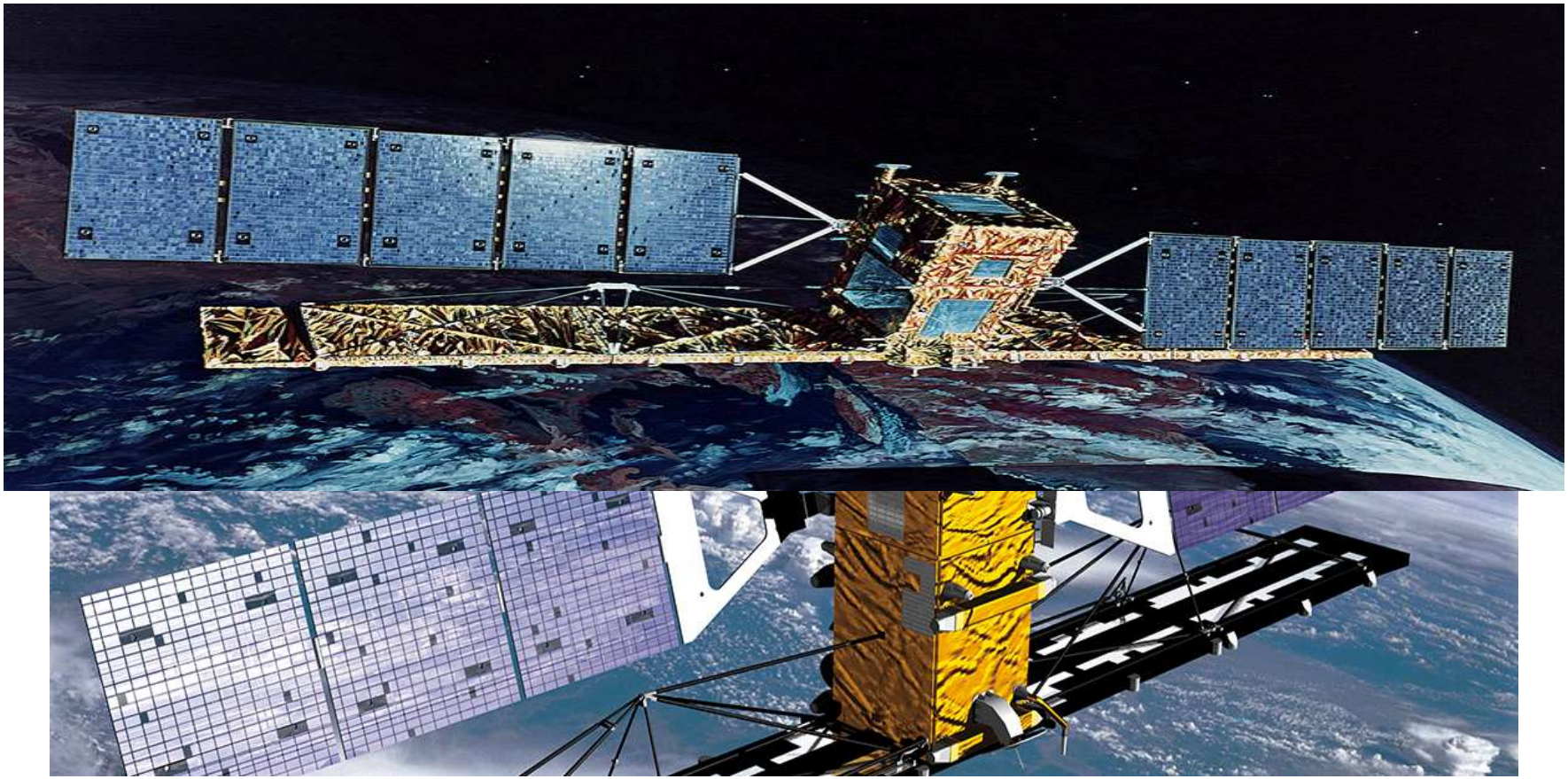
- The hub station is usually a large, high performance Earth station comprising an outdoor antenna (with a diameter of between 6 to 9 metres) for transmission.
- VSAT terminals are smaller and simpler in design as compared to the hub centre and comprise an outdoor antenna (0.5 to 2.4 m in diameter)
- Most VSAT systems operate in the Ku band with the antenna diameter of the Earth stations being as small as 1 to 2 m.

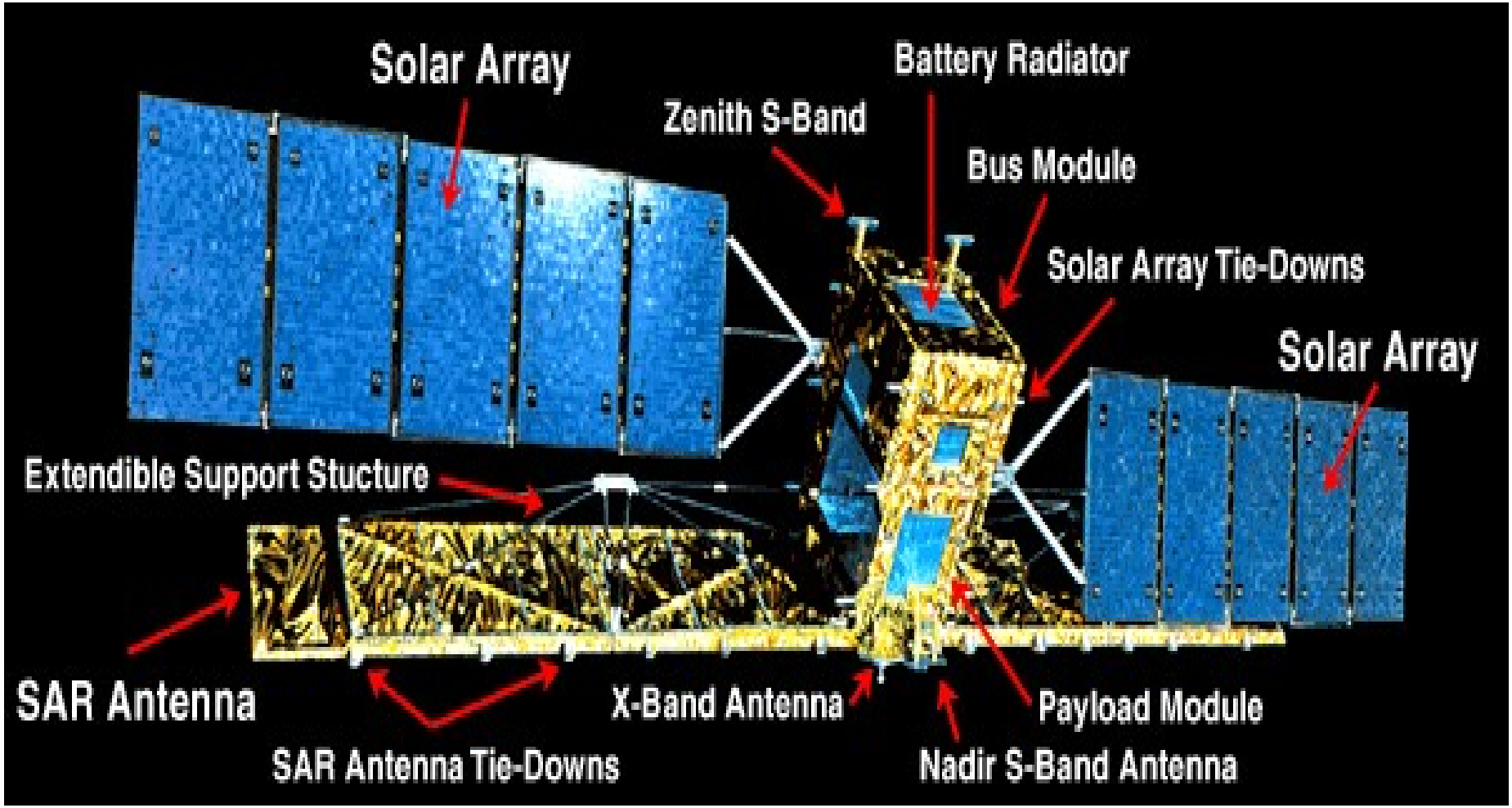
RADARSAT

- Radarsat is an earth-resources remote-sensing satellite, which is part of the Canadian space program.
- Radarsat-1 was launched on November 4, 1995, and Radarsat-2 is scheduled for launch in 2006.
- The Radarsat satellites are planned to fly in a low-earth near-circular orbit.
- The Radarsat orbit is sun synchronous.

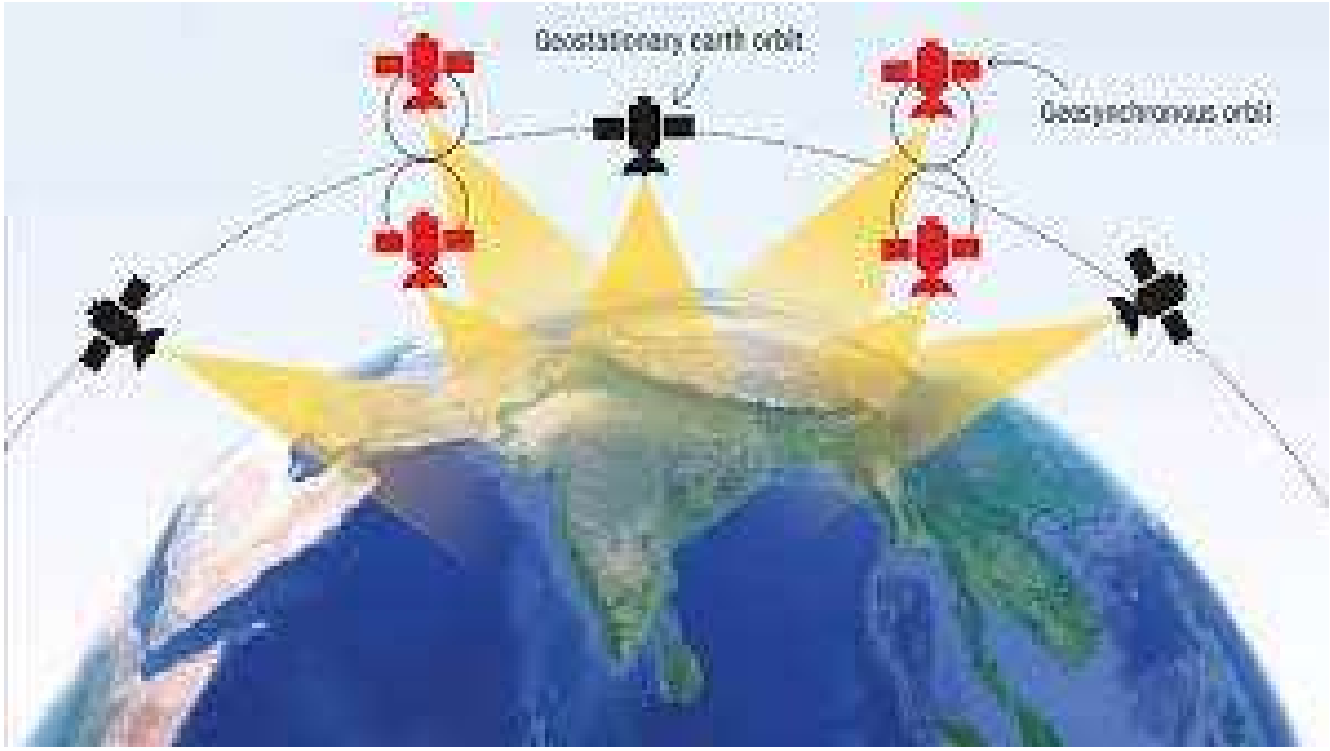
The applications seen for Radarsat are:

- Ocean feature mapping
- Oil pollution monitoring
- Sea ice mapping (including dynamics)
- Iceberg detection
- Crop monitoring
- Forest management
- Geological mapping (including stereo SAR)
- Topographic mapping




Solar Array
Battery Radiator
Zenith S-Band
Bus Module
Solar Array Tie-Downs
Solar Array
Extendible Support Stucture
SAR Antenna
X-Band Antenna
Payload Module
SAR Antenna Tie-Downs
Nadir S-Band Antenna

IRNSS



IRNSS

- Indian Regional Navigation Satellite System
- Intended to provide un- interrupted navigation services including a standard positioning service for civilian use and an encrypted service for authorized users.
- The system is designed to provide real time position, navigation and time services on 24 × 7 basis to users on a variety of platforms.
- It is designed to offer position accuracy of better than 10 m over India and the region extending up to 1500 km around India.

- Full constellation of IRNSS comprises seven satellites.
- Three of these satellites will be placed in geostationary equatorial orbit with locations at 34◦E, 83◦E and 131.5◦E.
- Another two satellites will be placed in geosynchronous orbit at an equatorial inclination of 29◦ and equator crossings at 55◦E and 111.5◦E.
- The remaining two satellites are planned as spares. The first of the seven satellites, called IRNSS-1A, was launched onboard PSLV-C22 on 1 July 2013.
- The ground segment of the IRNSS constellation consists of a master control centre (MCC), ranging

Satellite Structures and Materials

- The *mechanical structural subsystem* provides the framework for mounting other subsystems of the satellite and also an interface between the satellite and the launch vehicle.
- The mechanical structure weighs between 7 and 10% of the total mass of the satellite at launch
- It performs three main functions namely:

1. It links the satellite to the launcher and thus acts as an interface between the two.

2. It acts as a support for all the electronic equipment carried by the satellite.

3. It serves as a protective screen against energetic radiation, dust and micrometeorites in space.

Design Considerations

- The space environment generates many other potentially dangerous effects.
- The satellite must be protected from collision with micrometeorites, space junk and charged particles floating in space.
- The material used to cover the outside of a satellite should also be resistant to puncture by these fast travelling particles.
- The structural subsystem also plays an important role in ensuring reliable operation in space of certain processes such as separation of the satellite from the launcher, deployment and orientation of solar panels, precise pointing of satellite antennas, operation of rotating parts and so on.

Structures

- The design of satellite structure is dependent on many factors.
- Some of the most important factors are placement of components and the material properties of components.
- The design approach that is followed generally is the following: first system engineering team prepares a Configuration Layout and Mass Budget and structures team analyses it and decides the parameters like the material of satellite body and thickness of the material.
- The analysis is given to Systems engineering team and if there is some flaw in the system, Systems engineering team prepares a modified configuration layout.
- This iterative process is followed till a design satisfying both system engineering and structural requirements is obtained.
- The various parameters that can be changed by structural subsystem are material properties of structure, geometric parameters like thickness of the structure and joining mechanisms.