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Satellite Communication

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Satellite

Content:

1. Satellite
2. Advantages
3. Disadvantages
4. Evolution of Satellite
5. Application

Satellite:

Communications satellite is an orbiting artificial earth satellite which act as the active transmission relay.

This communication takes place between the earth stations through a satellite, then it is called as satellite communication.

Satellite use the electromagnetic waves as carrier signals.

Soviet Union had launched the world's first artificial satellite named, Sputnik 1 in 1957.

Satellite:

Satellite is required for :

Ground wave propagation –

Ground wave propagation is suitable for frequencies up to 30 MHz. This method of communication makes use of the earth troposphere.

Sky wave propagation –

The suitable bandwidth for this type of communication is between 30–40 MHz and it use earth ionospheric properties.

Satellite:

Satellite:

Advantages of Satellite communication:

1. Transmission cost
2. High Capacity
3. Low Error Rate
4. Diverse Network

Satellite:

Disadvantages of Satellite communication:

1. High cost of Launching process
2. High Propagation delay
3. Difficult maintenance
4. High Free space loss
5. Frequency congestion

Satellite:

Evolution of Satellite:

1. **Signal Communicating by Orbiting Relay Equipment (SCORE) -**

    Set first communications by artificial satellite

    Launched by the Air Force into a low orbit in December 1958.

    Maximum Message Length - 4 minutes

    Relay operated on a 150 MHz - Uplink and 108 MHz - Downlink.

    It is powered by battery only.

Satellite:

Evolution of Satellite:

2. **ECHO -**

   Initiate communication using Passive Techniques with ECHO satellite 1 and 2.

   It was launched by NASA in August 1960 and January 1964.

   They operated at frequencies from 162 MHz to 2390 MHz.

Satellite:

Evolution of Satellite:

3. **WESTFORD -**

    WESTFORD first successful launch is done by the U.S. Army in May 1963.

    It consist of tiny resonant copper dipoles dispersed in an orbit.

    ECHO and WESTFORD were the last passive technology satellite.

Satellite:

Evolution of Satellite:

4. **TELSTAR -**

    TELSTAR Satellites 1 and 2 launched by NASA for AT&T/Bell Telephone Laboratories in July 1962 and May 1963.

    They provide services like multichannel telephone, telegraph, facsimile, and television transmissions to stations.

    They were launched in low orbit and were the first active wideband communications satellites.

Satellite:

Evolution of Satellite:

5. **ATS-1 -**

   ATS-1 stands for APPLICATIONS TECHNOLOGY SATELLITE-1

   It was launched in December 1966.

   ATS-1 also contained a high-resolution camera which provide the the first photos of the full earth from orbit.

   It operated at C-band (6.3 GHz uplink, 4.1 GHz downlink), with two 25 MHz repeaters.

Satellite:

Evolution of Satellite:

6. ANIK-A -

ANIK A launched in November 1972 by NASA for Telesat Canada

Satellites was built by Hughes Aircraft Company.

It operated at C-band and had 12 transponders

The primary services provided were television distribution, SCPC (single channel per carrier) voice, and data services.

Satellite:

Evolution of Satellite:

7. **CTS -**

   CTS stands for communication technology Satellite.

   It was built by joint program of NASA and the Canadian Department of Communications.

   CTS was launched in January 1976, and operations ended in November 1979.

Satellite:

Applications of Satellite communication:

1. Radio broadcasting
2. Military applications and navigations
3. Remote sensing applications
4. Voice communications
5. TV broadcasting
6. Internet applications
7. Weather condition monitoring & Forecasting

Satellite-Network Characteristics

Content:

1. Types of Satellites
2. Satellite network topology
3. Types of links
4. Connectivity

Satellite - Network Characteristics:

Types of Satellites :

There are three different types of satellite systems:

1. International satellite communication system (INTELSAT)
2. Domestic satellite system (DOMSAT)
3. Search and rescue system (SARSAT)

Satellite - Network Characteristics:

Types of Satellites :

1. International satellite communication system (INTELSAT):

   The INTELSAT Organization was established in 1964 to handle the technical and administrative problems associated with a worldwide telecommunication system.

   It served the international regions such as Atlantic Ocean region (AOR), the Pacific Ocean Region (POR), and the Indian Ocean region (IOR).

Satellite - Network Characteristics:

Types of Satellites :

2. Domestic Satellite System (DOMSAT) :

   These Domestic satellites are used to provide various telecommunication services within a country.

   Services such as voice, data, and video transmission (T.V channels)

   Third party providers of satellite cell phones include Satcom Global, Roadpost Satcom, Online Satellite Communications, and others.

Satellite - Network Characteristics:

Types of Satellites :

3. Search and Rescue System (SARSAT) :

   SARSAT is a type of Polar orbiting satellites.

   Polar-orbiting satellites orbit the earth and it cover the north and south polar-regions.

   Polar satellites are used to provide environmental data, help to locate ships and aircrafts in distress conditions.

Satellite - Network Characteristics:

Satellite Network topology :

Satellite communication network use two type of topologies :

1. Meshed Network Topology :

   In this topology, every node in the network is able to communicate with the other node in the network.

   A meshed satellite network consist of a set of earth station that communicate with one another over satellite links.

Satellite - Network Characteristics:

Satellite Network topology :

Satellite communication network use two type of topologies :

2. Star Network Topology :

   In this topology, each node in the network can only communicate with the single central node.

   A star satellite network consists of earth stations which can communicate only with a central earth station called the hub.

Satellite - Network Characteristics:

Satellite Links:

Type of satellite links are:

1. Unidirectional :

   Stations and satellite can either receive or transmit at a same time.

2. Bidirectional :

   Satellite and earth station both transmit and receive at a same time.

Satellite - Network Characteristics:

Satellite Connectivity :

It determines the way in which nodes of a network are connected to each other.

Two level of satellite connectivity in satellite network are:

1. Connectivity at the service level
2. Connectivity required on board satellite

Satellite - Network Characteristics:

Satellite Connectivity :

1. Connectivity at the service level :

   It defines the type of connection required between CPE or network equipment, between satellite terminals - to provide services to end users.

2. Connectivity required on board the satellite :

   It defines how the satellite network resources are switched on board in order to meet the user requirement according to changing usage demand.

Satellite Terms & Frequency band

Content:

1. Satellite Terms
2. Frequency Band

Satellite Terms:

Relevant term in Satellite Communication:

1. **Footprint :** is the area on the Earth's surface where the signal strength is highest for the successful communications.
2. **Apogee :** refers to the farthest point of elliptical satellite orbit where satellites are deployed before releasing into circular orbit.
3. **Orbital period :** It is the time for satellite to complete one complete circle of its orbit.
4. **Azimuth :** is a horizontal rotation angle that a ground-based parabolic antenna is rotated through to connect to a specific satellite in a GEO.

Satellite Terms:

5. **Station keeping** : It is the small scale orbital adjustments for maintaining satellite's orbital position within geostationary arc.
6. **Spin Stabilization** : is used to keep the satellite in controlled position.
7. **Three-axis stabilization** : is used to maintain a fixed position of the satellite compared to the orbital track and the Earth's surface.
8. **Time standard :** of satellites usually utilizes Zulu Time i.e. Greenwich Meridian Time (GMT).

Satellite Terms:

9. **Threshold Extension :** refers to technique which applies to satellite television receivers in order to increase SNR.

10. **Turnaround frequency** : is calculated by subtracting the satellite translation frequency from the uplink transmit frequency.

    TF: Rx Frequency (T/R) = Tx Frequency – Translation Frequency.

11. **Slant Range :** is defined as length of the path between a communications satellite and the respective earth station.

12. **Average Satellite lifetime :** is 5–15 years except GEO satellites

Satellite Frequency Band:

Frequency Band used in satellite Communication

1. **High Frequency (HF):** refers to radio frequency range of 3–30 MHz.
2. **Very High Frequencies (VHF):** ranges between 30 and 300 MHz.
3. **L-Band:** refers to radio frequency range of 0.5–1.5 GHz.
4. **C Band:** refers to the RF band of about 4–8 GHz. The bands 4 to 6 GHz are typically used for satellite communications. Band 3.7–4.2 GHz (downlink) and 5.925–6425 GHz (uplink)
5. **Ka Band:** have frequency band of 18–31 GHz.

Satellite Frequency Band:

Frequency Band used in satellite Communication

6. **Ku Band**: have frequency band of about 10.9–17 GHz.
7. **Ultra-high Frequency (UHF)**: the HF band ranges is 300–3000 MHz.
8. **Superband**: have frequency range of 216–600 MHz.
9. **X-Band:** have frequency range of about 7–8 GHz.

Satellite Standardization

Content:

1. Satellite Standardization
2. Standardization Bodies

Satellite Standardization:

International bodies work together for the coordination of the satellite orbit and frequency utilization.

Frequency coordination is one of the key processes which control the RF interference between satellite systems or between terrestrial microwave systems.

Methods used for reducing interference are:

- Frequency Reuse Technique
- Assigning Varying Vertical and Horizontal Polarization

Satellite Standardization:

Organization for international standardization and regulation:

1. WRC
2. FCC
3. IFRB
4. ITU
5. INTERSPUTNIK
6. NTIA
7. TSS
8. PTT
9. OFTEL (OFCOM)
10. NAB
11. ITSO
12. INTELSAT
13. NASA
14. JAXA

Satellite Standardization:

WRC :

World radio conference

It is sponsored by ITU

Review and revise the radio regulations, radio frequency spectrum.

It also regulate the geostationary satellite orbit and non geostationary satellite orbits

Satellite Standardization:

FCC :

Federal Communication Commision

Control the national RF band allocation including satellite frequency.

IFRB :

International Frequency Registration Board

Regulate the use of frequencies and allocate satellite orbital location.

Satellite Standardization:

ITU :

International Telecommunication Union

It allocates global radio spectrum and satellite orbit.

It also develop technical standards to provide communication worldwide.

INTERSPUTNIK :

International organization for space communication

It provide global communication service via russian satellite network.

Satellite Standardization:

NTIA :

The National Telecommunication and Information Administration

It focus area are the government telecommunication policies, standard creations, radio spectrum allocation in USA.

TSS :

Telecommunication Standardization Sector

It is a organization of global telecommunication standard creation.

Satellite Standardization:

PTT :

Post Telephone and Telegraph Administration

It have power of regulating telecommunication services.

It responsible for postal mail, telegraph and telephone services.

OFTEL :

The office of Telecommunication of the United Kingdom Government

Now known as OFCOM (Office of Communication)

Regulate telecommunication services in UK

Satellite Standardization:

NAB :

National Association of Broadcaster

It improves the quality and profitability of broadcasting

ITSO :

International Telecommunication Satellite Organization

It ensure the availability of public telecommunication services including voice, data and video

Satellite Standardization:

INTELSAT :

The International Telecommunication Satellite Organization

It is a global provider of satellite services.

INTERSAT has a satellite , teleport and fiber infrastructure for transmission of video, data and voice services

NASA :

National Aeronautics and Space Administration

It administer the American Space Services

Satellite Standardization:

JAXA :

Japan Aerospace Exploration Agency

Perform basic research and development in aerospace field

NCTA :

National Cable Television Association

It a association for US Cable TV industry

It represent 200 cable program network

Satellite Standardization:

EBU :

European Broadcasting Union

It's a global alliance of public service media organization.

EBU operates EUROVISION and EURORADIO.

EUTELSAT :

European Telecommunication Satellite Organization

Provide satellite network for Europe and parts of North Africa and Middle East

Satellite Standardization:

ACTS :

Advanced Communication Technology Satellite

It is an experimental satellite project launched in 1993 by NASA

ISO :

International Standards Organization

It develop international standards and initiated in 1947

It work with the cooperation of CCITT

Satellite Communication System

Content:

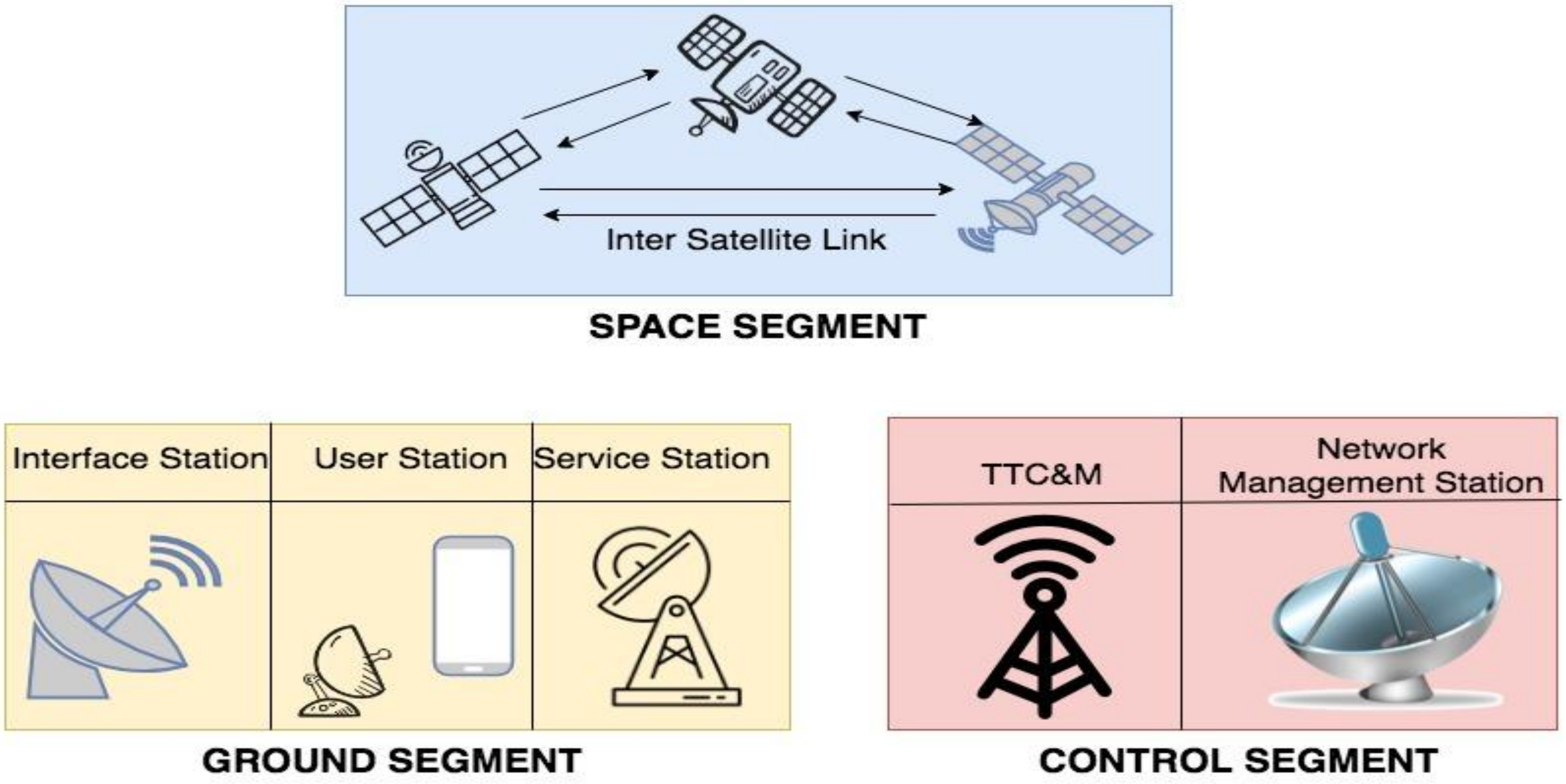
1. Satellite Communication System
2. Satellite Link Parameter
3. Types of Satellite services

Satellite Communication System:

Satellite system composed of three Segments:

1. **Space Segment** : consist of one or more active and spare satellites.
2. **Control Segment** : contain all ground facilities for the control and monitoring of the satellites and management of the traffic of satellite system.
3. **Ground Segment** : contain the traffic of earth stations.

Satellite Communication System:



Satellite Communication System:

Space Segment:

Space segment consist of Payload and Platform.

1. Payload :

   consist of receiving and transmitting antennas and all the electronic equipment.

2. Platform :

   consist of Attitude control subsystem, propulsion system, electric power supply, TTC and Thermal control structure.

Satellite Communication System:

Ground Segment:

Ground segment terminal consist of 3 types:

1. Fixed Terminal : access the satellite while remaining fixed at the ground.
2. Transportable Terminal : is a movable terminal but remain fixed while transmission.
3. Mobile Terminal : designed to communicate with satellite while in motion.

Satellite Communication System:

Control Segment:

Control segment terminal consist of 2 types:

1. TTC&M : Tracking , Telemetry , command and monitoring station provide management and control function to keep the satellite operating safely in orbit.
2. Network Management Station (NMS): used for non real time management function of the connection and associated resources allocated to a single satellite network.

Satellite Communication System:

Satellite Link Parameters :

Communication Satellite airlinks are:

1. Uplink - From earth station to satellite
2. Downlink - From satellite to the ground
3. Intersatellite Link - Link between satellites.

Satellite Communication System:

Space Radio Communication services:

- Fixed Satellite Service (FSS)
- Mobile Satellite Service (MSS)
- Broadcasting Satellite Service (BSS)
- Earth Exploration Satellite Service (EES)
- Space Research Service (SRS)
- Space Operation Service (SOS)
- Radiodetermination Satellite Service (RSS)
- Inter-Satellite Service (ISS)
- Amateur Satellite Service (ASS)

Satellite Subsystem- Satellite Bus Part 1

Content:

1. Satellite Subsystem
2. Satellite System Components
3. Satellite Bus
    - Physical Structure
    - Power subsystem
    - Attitude Control

Satellite Subsystem:

An operating communication satellites system consist of several elements.

These elements range from an orbital configuration of space component to ground based component.

Type of satellite system segment:

1. Space Segment - consist of orbiting satellite
2. Control Segment - contain controller to keep satellite in operation
3. Ground Segment - contain transmitting and receiving earth station

Satellite Subsystem:

Space Segment consist of two equipments :

1. Satellite Bus - also known as Platform
2. Payload

Satellite Subsystem:

Satellite Bus :

It include basic structure and satellite support system

its subsystems are

1. Physical Structure
2. Power Subsystem
3. Attitude and orbital control subsystem (AOCS)
4. Thermal control Subsystem
5. Command and telemetry system (TTC&M)

Satellite Subsystem:

Satellite Bus :

1. **Physical Structure:**

    Provide home to all the component of satellite.

    The shape of satellite depend on the method of stabilization.

    Orientation methods are: Spin stabilization and three axis or body stabilization.

    It is used to keep the satellite stable and pointing in desired direction.

    It include method to keep antennas properly oriented toward earth.

Satellite Subsystem:

Satellite Bus :

2. **Power Subsystem:**

Satellite use electrical power to operate.

Electrical power for operating equipment on satellite is obtained from solar cells.

The radiation on the satellite from the sun has an intensity averaging about - 1.4 kW/m^2

Solar cell operate at an efficiency of 20-25 % at beginning of life and degrade to 5-10 % at the end of life..

Satellite Subsystem:

Satellite Bus :

2. **Power Subsystem:**

   Spacecraft also carry storage batteries to provide power during launch and during eclipse period when sun blockage occur.

   Sealed nickel cadmium (Ni-Cd) and Nickel Hydrogen (NiH_2) batteries are used for satellite battery system

   Power conditioning Unit : is used to control battery charging and power regulation and monitoring.

Satellite Subsystem:

Satellite Bus :

3. **Attitude Control:**

Attitude of satellite refers to its orientation in space wrt earth.

Forces that affect the attitude of satellite are:

1. Gravitational force from the sun, moon and planets
2. Solar pressure acting on spacecraft body, solar panel and antenna
3. Earth magnetic field

Satellite Subsystem:

Satellite Bus :

3. **Attitude Control:**

   Orientation is monitored on the spacecraft by infrared horizon detectors.

   Four detectors are mainly used to establish a reference point which lies at the centre of the earth.

   A control signal is generated which activates attitude control device to restore proper orientation.

Satellite Subsystem- Satellite Bus Part 2

Content:

1. Satellite Bus
    a. Orbital Control
    b. Thermal Control
    c. Electric Propulsion Satellite
    d. TTC&M

Satellite Subsystem:

Satellite Bus :

4. **Orbital Control:**

   Orbital control is achieved by station keeping.

   It is a process required to maintain a satellite in its proper orbit location.

   Orbital control is usually maintained with the same thruster system as attitude control.

Satellite Subsystem:

Satellite Bus :

4. **Thermal Control:**

    The satellite thermal control system is used to control the large thermal gradient generated in the satellite.

    Heat is produced from thermal radiation from sun and many satellite equipments.

    Thermal control is done by removing or relocating the heat to provide a stable temperature environment.

Satellite Subsystem:

Satellite Bus :

4. **Thermal Control:**

Technique used to provide thermal control are:

1. Thermal Blanket
2. Thermal shields
3. Radiation Mirror
4. Heat Pumps
5. Thermal Heaters

Satellite Subsystem:

Satellite Bus :

5. **Electric Propulsion Satellite:**

   Satellite use electric powered spacecraft propulsion for its attitude and orbital control.

   Benefit of electric propulsion are:

   1. Spacecraft payload is increased due to reduced weight.
   2. Spacecraft launch cost also reduced due to reduced weight.

   Hydrogen, Helium and Ammonia are preferred propellent

Satellite Subsystem:

Satellite Bus :

5. **Electric Propulsion Satellite:**

   Basic means of thrust generation are:

   1. Electrostatic
   2. Electrothermal
   3. Electromagnetic

   The first US spacecraft bus to employ all electric propulsion was boeing 702SP, introduced in 2012.

Satellite Subsystem:

Satellite Bus :

6. **Tracking, Telemetry , Command and Monitoring:**

   TTC&M provide spacecraft management and control function to keep the satellite operating safely in orbit.

   Satellite TTC&M subsystem consist of:

   1. Antenna
   2. Command Receiver
   3. Tracking and Telemetry Transmitter
   4. Tracking Sensor

Satellite Subsystem:

Satellite Bus :

6. **Tracking, Telemetry , Command and Monitoring:**

   Satellite controlling and monitoring is accomplished through “monitors and keyboard interface”.

   Tracking - refer to determine the current orbit , position and movement of spacecraft.

   Telemetry - collect data from sensors of spacecraft and the relay this information to the ground.

   Command - is complementary function of telemetry.

Satellite Subsystem:

Satellite Bus :

6. **Tracking, Telemetry , Command and Monitoring:**

   Command system relay - specific control and operations information from the ground to the spacecraft and vice versa.

   It include commands like:

   1. Changes and correction in attitude control and orbital control.
   2. Antenna pointing and changes
   3. Transponder mode of operation
   4. Battery voltage

Satellite Subsystem-Payload

Content:

1. Payload
2. Transponder
3. Antennas

Satellite Subsystem:

Payload :

It is the equipment on the satellite that provide the service to operate the satellite.

It provide the relay connection between uplink and downlink.

Communication payload further divided into:

1. Transponder
2. Antenna Subsystem

Satellite Subsystem:

Payload :

1. **Transponder :**

    It is the series of components that provides the communication channels or links.

    These links are between the uplink signals received at the uplink antenna and the downlink signal transmitted by the downlink antenna.

    The transponders operate in a different frequency band.

    The number of transponders are doubled by using polarization frequency reuse.

Satellite Subsystem:

Payload :

1. **Transponder :**

   Consist of

   1. Duplexer
   2. Low Noise Amplifier (LNA)
   3. Carrier Processor
   4. Power Amplifier

Satellite Subsystem:

Payload :

1. **Transponder :**

   Type of satellite transponder configuration:

   1. Frequency Translation Transponder
   2. On board Processing Transponder

   On board processing satellites is more complex and expensive than frequency translation satellite

Satellite Subsystem:

Payload :

2. **Antenna :**

   Antennas in spacecraft are used to transmit and receive the RF signal.

   It is a critical part of satellite communication.

   It is essential element in increasing signal strength for long distance transmission.

Satellite Subsystem:

Payload :

2. **Antenna :**

   Parameters associated with antennas are:

   - **Operating Frequency** : Frequency bands and channels are defined by ITU.
   - **Radiation Patterns** : In frequency congestion period, it describe the capability of antenna to differentiate the unwanted signal.
   - **Gain** : measures antenna directivity and electrical efficiency

Satellite Subsystem:

Payload :

2. **Antenna :**

   Parameters associated with antennas are:

   - **Polarization**: about orientation of electric field that drive the signal (Horizontal or vertical).
   - **Inter Port isolation**: isolation of multi port antenna from each other.

Satellite Subsystem:

Payload :

2. **Antenna :**

   Parameters associated with antennas are:

   - **Cross Polar Discrimination**: Ability to maintain radiated or received polarization purity between horizontally and vertically polarized signals.
   - **Front to back ratio**: Ratio of signal strength transmitted in a forward direction to that transmitted in a backward direction.

Satellite Subsystem:

Payload :

2. **Antenna :**

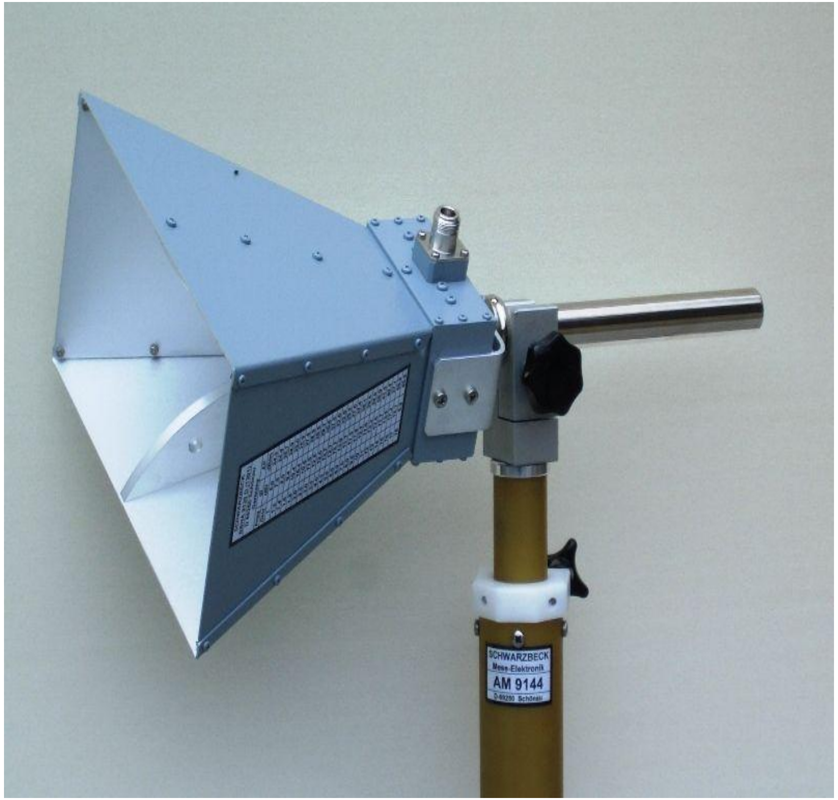
   Parameters associated with antennas are:

   - **VSWR**: indicates the value of mismatch between an antenna and feed-line connected to it.
   - **Half Power beamwidth** : refers to the peak effective radiated power of the main lobe.

Satellite Subsystem:

Horn Antenna:

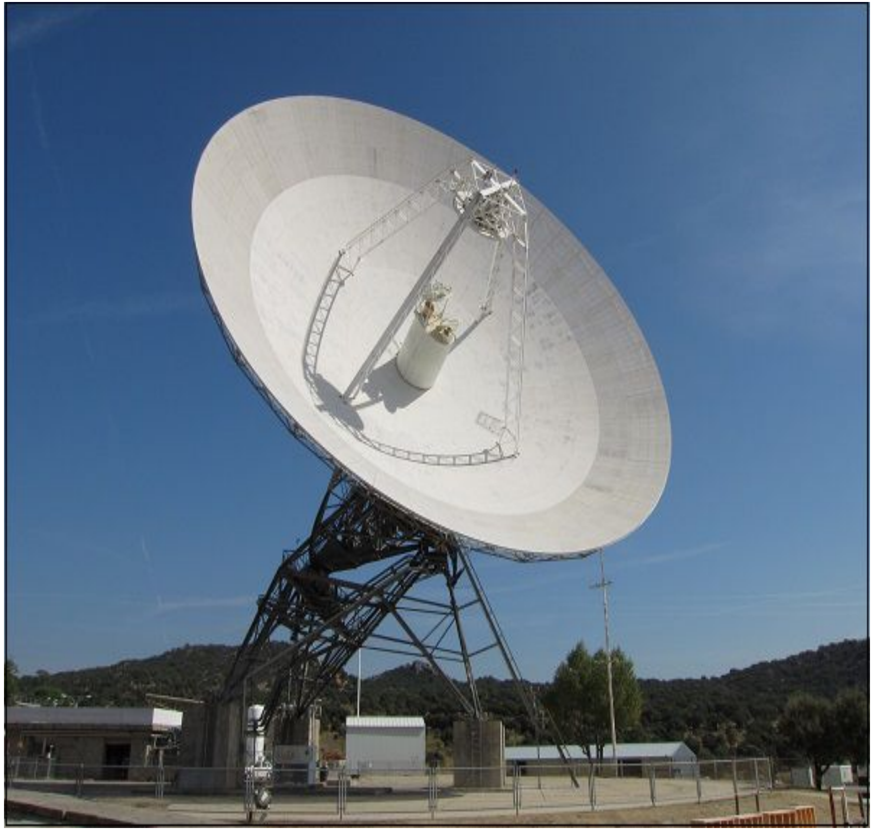
- Consist of flaring metal waveguide shaped like a horn.
- It direct radio waves in the form of beam.
- Commonly used at UHF.



Satellite Subsystem:

Parabolic Antenna:

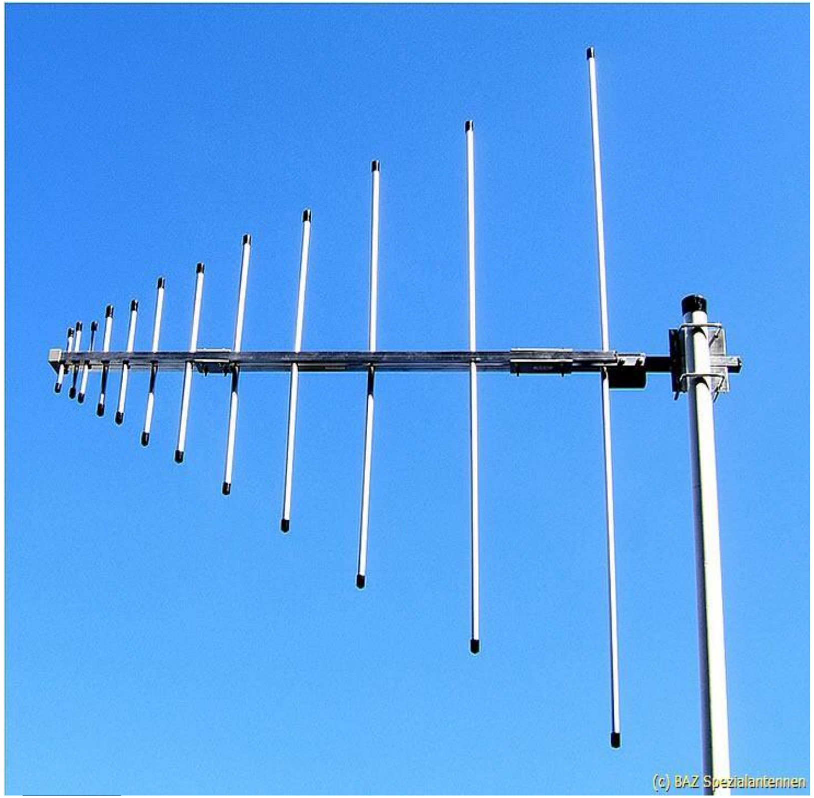
- Consist of curved surface with the cross-sectional wave of parabola.
- Well known as reflector antenna.
- Have high directivity.



Satellite Subsystem:

Dipole Antenna:

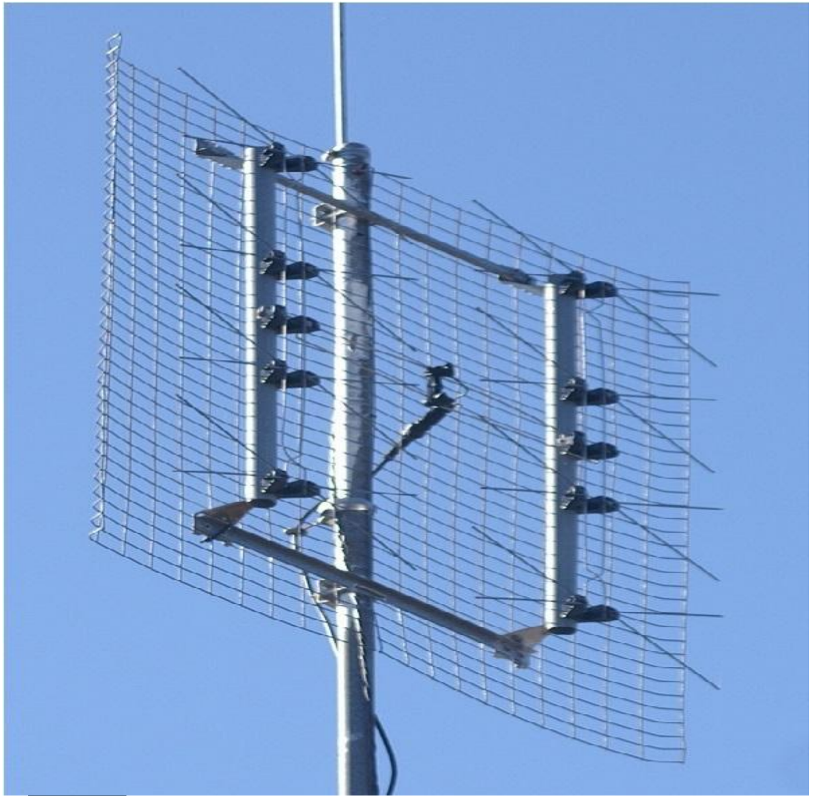
- Consist of two identical conductive elements such as metal wire and rods.
- Widely used antenna.



Satellite Subsystem:

Array Antenna:

- Multiple antennas are connected that worked as single antenna.
- It transmit and receive radio waves.
- Feedline is connected to provide power to each element.



Satellite Orbit Part 1

Content:

1. Orbital Location
2. Kepler's Law
3. Satellite Orbit

Satellite Orbit:

Orbital Location:

The orbital location of the satellite in communication system play a major role in determining the coverage and operational features of the services.

Satellite that orbit the earth are governed by the same laws of motion that controls the motions of the planets around the sun.

Satellite orbit determination is based on the laws of motion.

Satellite Orbit:

Orbital Location:

Forces acting on the satellite are : gravity force tends to pull the satellites in toward the earth, whereas its orbital velocity tends to pull the satellite away from the earth.

Gravitational force (Fin) and the Angular velocity force (Fout) represent as

$F_{in} = m(\mu/r^2)$ & $F_{out} = m(v^2/r)$

$F_{in} = F_{out}$ $v=(\mu/r)^{1/2}$

This result give the velocity require to maintain satellite at the orbit radius r.

Satellite Orbit:

Kepler's Law: Three Fundamental Principles

1. **Kepler's First Law :** applies to satellite orbit

   Stated as " The path followed by a satellite around the earth will be an ellipse , with the center of mass of earth as one of the two foci of the ellipse."

2. **Kepler's Second Law :**

   Stated as "for equal time interval, the satellite sweeps out equal areas in the orbital plane"

Satellite Orbit:

Kepler's Law: Three Fundamental Principles

3. **Kepler's Third Law :**

   Stated as "the square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies."

$$T^2 = [4\pi^2/\mu]\ a^3$$

Satellite Orbit:

Satellite Orbit:

1. **Geosynchronous Orbit (GSO or GEO)**

    The GSO orbit is the most popular orbit used for communications satellites.

    A GSO satellite is located in a circular orbit in the equatorial plane.

    The nominal distance of satellite from earth is 36,000 km.

    It remain at a stable point that means at a fixed location in the sky.

Satellite Orbit:

Satellite Orbit:

2. **Low Earth Orbit (LEO):**

   LEO is a circular orbit nominally 100 to 400 nautical miles above the earth.

   The delay is low i.e. ~10 ms.

   The satellite moves across the sky, and the ground station actively track the satellite to maintain communications.

   The satellites provide the broadband data services efficiently.

Satellite Orbit:

Satellite Orbit:

3. **Medium Earth Orbit (MEO):**

   In MEO, the satellite is in a higher circular orbit – 1000 to 3000 nautical miles.

   It is used as navigation satellites such as the GPS constellation.

   The delay values of the radio transmission are longer than in the case of LEO.

Satellite Orbit:

Satellite Orbit:

4. **High Earth Orbit (HEO):**

    HEO is the non-circular orbit referred as non-geosynchronous orbit, NGSO, satellites.

    It operates with in an elliptical orbit:

    - Maximum altitude (apogee) similar to the GSO.
    - Minimum altitude (perigee) similar to the LEO.

    The HEO, used for special applications where coverage of high latitude locations is required.

Satellite Orbit Part 2

Content:

1. Orbital Parameters
2. Commonly used Orbit

Satellite Orbit:

Orbital parameters:

1. **Apogee** : It is the point in orbit which is farthest from the earth.
2. **Perigee** : It is the point in orbit which is closest to the earth.
3. **Line of apsides** : It is the line joining the perigee and apogee through the center of the earth.
4. **Ascending Nodes** : It is the point where the orbit crosses the equatorial plane , going from south to north.
5. **Line of Nodes** : It is the line joining the ascending and descending nodes through the center of the earth.

Satellite Orbit:

6. **Eccentricity** : It is the measurement of the circularity of the orbit.
7. **Inclination Angle** : It is the angle between the orbital plane and the earth's equatorial plane.
8. **Prograde Orbit** : An orbit in which the satellite moves in the same direction as the earth rotation in called prograde orbit. The inclination angle is between 0 to 90 degree.
9. **Retrograde Orbit** : An orbit in which the satellite moves in opposite direction as the earth rotation. The inclination angle is between 90 to 180 degree

Satellite Orbit:

Most commonly used Orbit:

1. GEO :

   Geostationary is the ideal orbit

   A perfect orbit is one where eccentricity is equal to zero and inclination angle is equal to 0 degree

   This orbit cannot be achieved for real artificial satellites because many other forces are also acting on the satellite beside earth gravity.

Satellite Orbit:

Most commonly used Orbit:

2. **GSO :**

   Geosynchronous orbit is the all real orbit where inclination angle is not equal to 0.

   Most of the satellites operate in this orbit with fixed slant path.

   It also require less ground station tracking.

   In GSO orbit, 2 or 3 satellites provide the global coverage.

Satellite Orbit:

Most commonly used Orbit:

3. **LEO :**

LEO characteristics that are important for communication application:

1. Earth satellite links are very short which lead to lower path loss.
2. Propagation Delay is also less because of shorter path distance.
3. With proper inclination, LEO can cover high latitude location including polar areas.

Satellite Orbit:

Most commonly used Orbit:

3. **LEO :**

   Disadvantages:

   1. LEO satellites has restricted operations period.
   2. For global area coverage, multiple satellites are installed in LEO robit.
   3. The LEO orbit satellites are basically used for mobile application.
   4. LEO satellites are much smaller and require significantly less energy to insert into orbit.

Satellite Orbit:

Most commonly used Orbit:

4. **MEO :**

MEO is the orbit where satellite is placed in between the LEO and GEO at the altitude of 10,000 to 20,000 km.

Features of MEO are:

1. Repeatable ground traces for recurring ground coverage.
2. Relectable number of revolutions per day
3. Adequate relative earth motion to allow accurate and precise position measurements.

Satellite Orbit:

Most commonly used Orbit:

5. **HEO :**

   It is used to provide coverage to high latitude areas not reachable by GSO.

   The HEO orbit is used as communication satellite

   Molniya orbit has a perigee altitude of about 1000 Km and an apogee altitude of nearly 40,000 Km

   The eccentricity is about 0.722 and inclination angle is 63.4 degree

Satellite Orbit:

Most commonly used Orbit:

6. **Polar Orbit :**

    It is a circular orbit with an inclination near 90 degree.

    It is useful for sensing and data gathering services.

    It scan the entire globe on a periodic cycle.

    Each day the orbit shifted about 160 km west on the equator returning to its original position after 18 days and 252 revolution.

Perturbation of Orbit

Content:

1. Perturbation
2. Effect on GEO
3. Orbital Control procedure
4. Station keeping box
5. Correction Cycle
6. Termination of Station Keeping

Perturbation:

Perturbation of the orbit is due to various forces that act on satellite

These forces are other than the force of attraction of the central, spherical and homogeneous body.

The forces are like :

1. The non-spherical component of terrestrial attraction.
2. The sun and the moon force of attraction
3. Pressure produce by Solar radiation
4. Aerodynamic Drag
5. Motor Thrust

Perturbation:

Effect of Perturbation on geostationary satellites:

It cause the displacement of satellite in the east west plane wrt nominal position.

It also cause displacement in the north south direction wrt the equatorial plane.

This displacement is defined by longitude of satellite station.

This indicate that satellite is no longer perfectly geostationary.

Perturbation:

Orbit Correction Procedure:

1. Adjusting position and velocity of the satellite.
2. Monitoring the effect of non zero eccentricity and inclination value
3. Maintaining satellite position with the help of Station Keeping box

Perturbation:

Station Keeping Box:

Station keeping box represents the maximum permitted values of the outing of the satellite in longitude and latitude.

This box is used to maintain the satellite position stationary wrt the earth and to occupy well defined position on the equator.

The Radiocommunication regulation impose a station keeping accuracy of +/- 0.1 degree in longitude for fixed and broadcast service satellite.

Perturbation:

Cost of Station Keeping:

The budget for correcting long term drift is as follow:

1. 43 - 48 m/s per year for North-South control
2. 1 - 5 m/s per year for East-West control

The total cost depend on

1. Date of start of station keeping
2. Longitude of station
3. Dimension of station keeping window

Perturbation:

Correction Cycle:

The strategies are made to control the perturbation.

Its main aim is to minimise the amount of consumption of propellent which is used to generate the required velocity increment.

A typical correction cycle is of 14 days which include north-south and east-west corrections.

Perturbation:

Correction Cycle:

The correction cycle include following procedure:

1. Inclination correction at the start of the cycle
2. Measurement and restoration of the orbit
3. Eccentricity and drift correction
4. Verification of the result of the corrections
5. Natural progression of the orbit

Perturbation:

Station Keeping termination:

Satellite station keeping is possible due to propellants which are stored in reservoirs.

When the propellent is consumed, station keeping is no longer provided and the satellite drifts under the effect of various perturbation

A special procedure is adapted which aims to remove satellite from the geostationary orbit at the end of its lifetimes

Satellite Signaling

Content:

1. Transmission
2. Digital Baseband Signal
3. Baseband Signal Formatting
4. Digital Modulation
5. Channel Coding
6. Coded Modulation

Satellite Signaling:

Transmission:

The fundamental element of communication satellite is Radio Frequency or free space link.

It impact the design and performance of communication of satellite.

Important parameters used for RF links are:

- Transmitter Power and Received Power
- Transmit antenna gain and Receive antenna gain
- Path distance

Satellite Signaling:

Digital Baseband signal:

Baseband signal belongs to the original frequency range of a transmission signal before it is converted or modulated to a different frequency range.

Various Baseband signals that are used in satellite communication are :

1. Digital telephone signal
2. Sound signal
3. Television signal
4. Data and multimedia signal

Satellite Signaling:

Baseband Signal Formatting:

The formatting of baseband signal is done by encryption and scrambling the RF signals.

1. **Encryption :**

    Encryption is used to prevent unauthorised exploiting or tampering of data signal.

    Encryption consist of confidentiality and authenticity.

Satellite Signaling:

Baseband Signal Formatting:

1. **Encryption :**

   Encryption is done using two techniques in satellite communication:

   - Online Encryption (Stream Ciphering) -

     Encryption is done bit by bit

   - Encryption by Block (Block Ciphering) -

     Encryption is done block by block

Satellite Signaling:

Baseband Signal Formatting:

2. **Scrambling :**

   A scrambler is a device which is used to manipulates the data stream before transmitting.

   Descrambler is used to reverse the manipulations at the receiving side.

   Scrambling is widely used in satellite, radio relay communications and PSTN modems.

Satellite Signaling:

Modulation in satellite communication system:

Modulation : is a process of superimposing the information of a modulating signal on a carrier signal.

This is done by varying the characteristic of carrier signal according to the modulating signal.

Phase modulation or phase shift keying (PSK) is widely used for satellite links.

Demodulation : is the process of separating information from a modulated carrier wave.

Satellite Signaling:

Modulation in satellite communication system:

The modulation formats used in satellite communications are:

1. Differential Phase Shift Keying (DPSK)
2. Quadrature Phase Shift Keying (QPSK)
3. M-ary Phase Shift Keying (MPSK)
4. Minimum Shift Keying (MSK)
5. Quadrature Amplitude Modulation (QAM)

Satellite Signaling:

Channel Coding:

Channel coding is used to add redundant bits to the information bits.

These redundant bits are used at the receiver to detect and correct errors.

Two type of encoding techniques are used :

1. Convolutional Encoding
2. Block Encoding

Satellite Signaling:

Coded Modulation:

Coded modulation is a technique where FEC and modulation are merged into one process.

There are two main classes of coded modulation:

- Trellis coded modulation (TCM) where convolutional encoding is implemented
- Block coded modulation (BCM) using block encoding

Satellite-
Multiple Access Techniques

Content:

1. Multiple Access Techniques
2. Secondary access techniques
3. FDMA
4. TDMA
5. CDMA

Multiple Access Techniques:

Satellite Multiple Access Techniques :

used to allow a large number of ground station to share the allocated spectrum in the most efficient manner.

The important components used in a multiple access process are satellite transponders and user ground terminals.

The goal of the Multiple access process is

- to allow the satellite network to respond to high and limited demand period accordingly
- to use resources efficiently to provide high performance throughout

Multiple Access Techniques:

The Satellite System Multiple Access (MA) Methods are

1. Frequency Division Multiple Access (FDMA)
2. Time Division Multiple Access (TDMA)
3. Code Division Multiple Access (CDMA)

Secondary Access Techniques are :

1. Demand Assigned Multiple Access (DAMA)
2. Space Division Multiple Access (SDMA)
3. Satellite Switched TDMA (SS-TDMA)
4. Multi-frequency TDMA (MF TDMA)

Multiple Access Techniques:

Secondary Access Techniques:

1. Demand Assigned Multiple Access (DAMA) :

   Is a demand assigned networks which changes the signal configuration dynamically according to the change in user demands.

2. Space Division Multiple Access (SDMA) :

   refers to the capability to assign users to spatially separated physical links like different antenna beams, cells, sectored antennas etc.

Multiple Access Techniques:

Secondary Access Techniques:

3. Satellite Switched TDMA (SS-TDMA) :

    a form of TDMA in which circuit switching is used to dynamically change the channel assignments.

4. Multi-frequency TDMA (MF TDMA) :

    is technique used to combines both FDMA and TDMA.

    It is used to improve capacity and performance for broadband satellite communications networks.

Multiple Access Techniques:

Satellite Multiple Access Techniques :

1. **FDMA :**

    Each station is assigned a specific frequency band for uplink

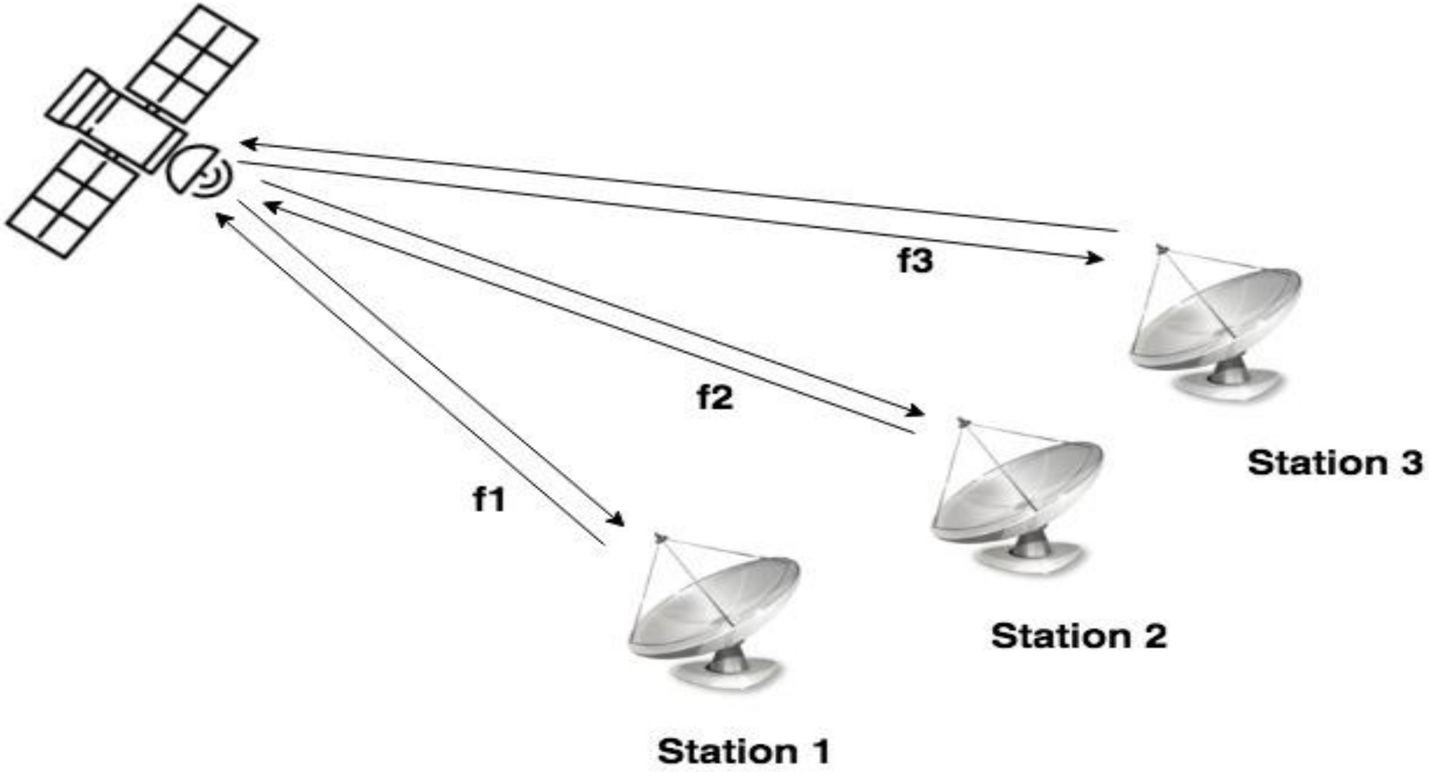
    All stations receive total spectrum on downlink

    FDMA are used for analog and digital transmission.

    FDMA is most useful for applications that require full time channel like video distribution.

    It is less expensive to implement than other access techniques

Multiple Access Technique - FDMA:



Multiple Access Techniques:

Satellite Multiple Access Techniques :

1. **FDMA:**

   PCM/TDM/PSK/FDMA :

   PCM/TDM (pulse code modulation/time division multiplexed) application are used for voice communication.

   PCM/SCPC/PSK/FDMA :

   It a popular digital baseband SCPC system used for data and voice applications. No signal multiplexing is involved.

Multiple Access Techniques:

Satellite Multiple Access Techniques :

2. **TDMA :**

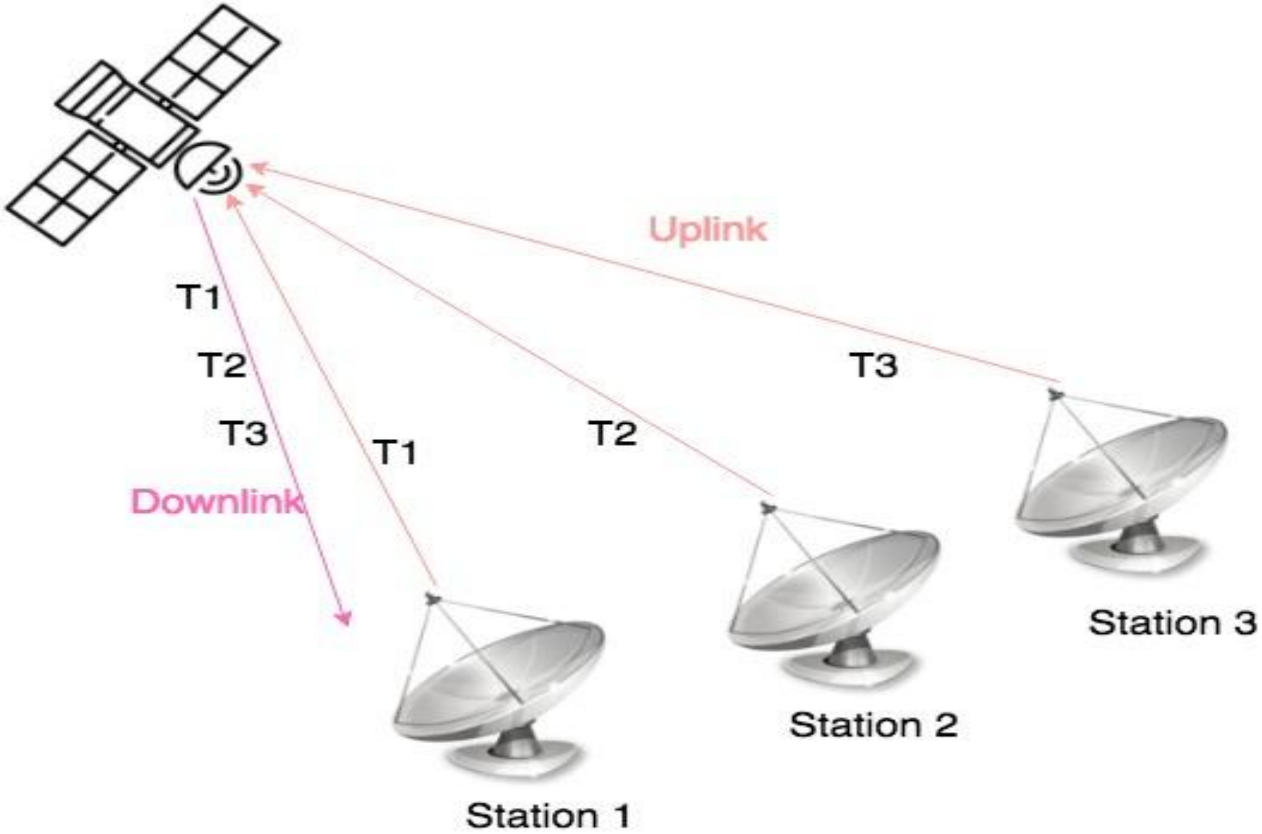
   Each station is assigned a specific uplink time slot for packet

   Downlink transmission is interleaved set of all packets from all ground stations

   TDMA is mostly used for digital transmission.

   A reference station is used to establish the synchronization to reference clock and provide burst time operational data to the network.

Multiple Access Technique - TDMA:



Multiple Access Techniques:

Satellite Multiple Access Techniques :

2. **TDMA :**

PCM/TDM/PSK/TDMA :

This type of TDMA network structure consists of PCM based baseband formatting, TDM source combining, and QPSK or BPSK modulation.

Satellite Switched TDMA :

SS/TDMA consists of a rapid reconfiguration of antenna beams on-board the satellite.

Multiple Access Techniques:

Satellite Multiple Access Techniques :

3. **CDMA :**

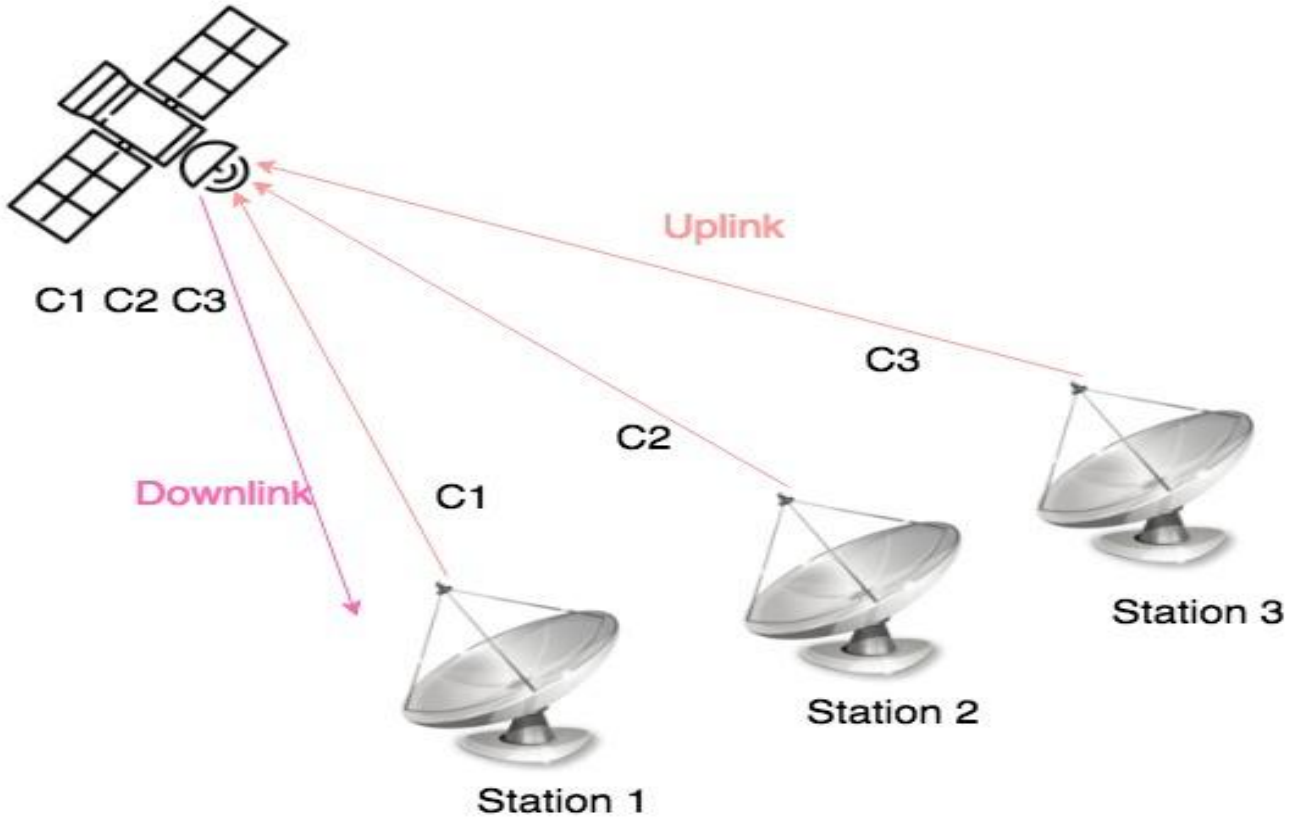
   A hybrid combination of FDMA and TDMA.

   Each uplink station is assigned time slot and frequency band in coded sequence.

   Downlink receiver must know code to detect the original signal.

   It is also known as SSMA (Spread Spectrum Multiple Access)

Multiple Access Technique - CDMA:



Multiple Access Techniques:

Satellite Multiple Access Techniques :

3. **CDMA :**

Direct Sequence Spread Spectrum (DS-SS):

DSSS is a spread spectrum technique where original data signal is multiplied with a pseudo random noise spreading code.

Frequency Hopping Spread Spectrum (FH-SS)

FHSS is a method of transmitting signals by rapidly switching a carrier among various frequency channels, using a PN sequence

Satellite - Propagation Delays & Noise

Content:

1. Propagation Delays
2. System Noise
3. Signal Loss

Satellite- Propagation Delays:

Propagation Delays:

Propagation delay is the amount of time taken by signal to travel from the sender to the receiver.

It is computed as the ratio between the link length and the propagation speed.

The delays built up from sending user terminal to destination user terminal.

Satellite- Propagation Delays:

Propagation Delays:

Type of propagation delays in satellite communication system are:

1. Delay in terrestrial network
2. Propagation Delay over satellite link
3. Baseband signal processing time
4. Protocol induced delay

Satellite- Propagation Delays:

Propagation Delays:

1. Delay in terrestrial network :

   The delay in terrestrial network include switching and propagation time. t (ms) = 12 + 0.004 * Distance (km)

2. Propagation Delay over satellite link :

   It is denoted by $t = R/c$

   R = Range from the transmission to the receiving equipment.

   c = Speed of light (3*10^8 m/s)

Satellite- Propagation Delays:

Propagation Delays:

3. Baseband Signal processing time :

   This delay is the result from baseband signal processing in the earth station and on board regenerative satellite.

   It also occur in the buffering process associated with switching and multiple access.

4. Protocol Induced delay:

   Error Free delivery of data packet using ARQ also induce the delay.

Satellite- Noise:

System Noise:

The addition of undesired power or signal into satellite link along the signal path produce signal noise.

There are many source of noise in communication system such as amplifier, mixers, upconverters, downconverters, switches , combiners and multiplexers.

Noise is also produced by the atmospheric condition.

Satellite- Noise:

System Noise:

- **Radio Noise** :

  The Source of radio noise are the receiver front end, receiver antenna , connecting elements between them, noise entering from the free space path.

- **Thermal noise** :

  It is the major contributor of noise.

  It is caused by the thermal motion of electrons in the various devices at receiver end.

Satellite- Noise:

System Noise:

Noise is produced by:

1. **Active device :**

   Active devices in satellite communication system are amplifier and other components that are used to increase the signal level.

2. **Passive device :**

   Passive devices in satellite communication are waveguide, cables, diplexers, switches.

Satellite- Noise:

System Noise:

Noise is produced by:

3. **Receiver Antenna Noise:**

Noise in antenna system induced in 2 ways:

- From physical antenna structure - in the form of antenna losses
- From radio path - introduced due to natural or human induced sources.

Satellite- Signal Loss:

Signal loss : occurs due to various causes:

1. Attenuation of signal due to atmosphere
2. Losses in the transmitting and receiving equipment
3. Depointing losses
4. Polarisation mismatch losses.

Satellite- Signal Loss:

Signal loss :

1. **Attenuation of signal due to atmosphere**

   The attenuation of waves in the atmosphere is due to the presence of gaseous components in the troposphere, rain, clouds, snow, ice and the ionosphere

2. **Losses in the transmitting and receiving equipment**

   The feeder loss occur between the transmitter and the antenna at transmitting end and between the antenna and the receiver at receiving end.

Satellite- Signal Loss:

Signal loss :

3. **Depointing losses**

   This signal loss occur due to imperfect alignment of the transmitting and receiving antennas.

   Due to this loss the antenna gain reduces with respect to the maximum gain on transmission and on reception, called depointing loss.

Satellite- Signal Loss:

Signal loss :

4. **Polarisation mismatch losses.**

   The polarisation mismatch loss occur when the receiving antenna is not oriented with the polarisation of the received wave.

Satellite-
Radio Waves

Content:

1. Radio Wave
2. Modes of Propagation
3. Propagation Techniques

Satellite- Radio Waves:

Radio Waves:

The frequency of the radio wave is a critical factor in carrying space communication.

A radio wave propagate from the Earth's surface to outer space using high frequency.

Ionosphere is the ionized region extending from about 15 km to roughly 400 km above the surface.

Satellite- Radio Waves:

Type of Radio Wave Propagation Modes:

1. **Ground Wave Propagation :**

    Frequency used : Below ionospheric penetration frequency

    Wave Propagate along the earth's surface.

    Used for broadcasting and communication services such as AM broadcast band, amateur radio , radio navigation and land mobile service

Satellite- Radio Waves:

Type of Radio Wave Propagation Modes:

2. **Terrestrial Propagation Mode :**

   Frequency used : Below 300 MHz

   Wave Propagate toward and return from the ionosphere.

   Used for commercial FM and VHF television band, aeronautical and marine mobile services.

Satellite- Radio Waves:

Type of Radio Wave Propagation Modes:

3. **Troposphere or Forward Scattered Wave :**

   Frequency used : Above 30 MHz and upto 3 GHz

   It is generated by scattering of energy from refractive index of troposphere.

   Used for long distance communication.

Satellite- Radio Waves:

Type of Radio Wave Propagation Modes:

4. **Direct Propagation Mode :**

   Frequency used : above ionospheric penetration frequency.

   Wave Propagate as line of sight propagation.

   Used for terrestrial radio relay communication and broadcasting services.

Satellite- Radio Waves:

Radio Wave Propagation Mechanism:

1. **Absorption** : is a reduction in the amplitude of a radio wave.
2. **Scattering** : is a process in which the energy of a radio wave is dispersed in other direction
3. **Refraction** : is a change in the direction of propagation of a radio wave
4. **Diffraction** : is a change in the direction of propagation of a radio wave
5. **Multipath** : propagation condition occur in transmitted radio wave while reaching the receiving antenna by two or more propagation paths.

Satellite- Radio Waves:

Radio Wave Propagation Mechanism:

6. **Fading** : is the variation of the amplitude of a radio wave.
7. **Scintillation** : occurred as rapid fluctuations of the amplitude and the phase of a radio wave with respect to time.
8. **Frequency Dispersion** : is the change in the frequency and phase components across the bandwidth of a radio wave. It is caused by a dispersive medium.

Satellite- Radio Waves:

Radio Noise :

Radio noise are introduced into the transmission path of a satellite communications system from both natural and human-induced sources.

Natural source are of two type :

1. Terrestrial Origin
2. Extra-Terrestrial Origin

Satellite- Radio Waves:

Radio Noise :

Natural Terrestrial sources include:

- Emissions from atmospheric gases
- Emissions from hydrometeors
- Radiation from lightning discharges
- Re-radiation from the ground
- Obstructions within the antenna beam

Radio Noise :

Natural Extra Terrestrial sources include:

- Cosmic background radiation
- Solar and lunar radiation
- Radiation from celestial radio sources

Satellite- Radio Waves:

Radio Noise :

Human induced sources include:

1. Unintended radiation from electrical machinery etc
2. Power transmission lines
3. Internal combustion engine ignition
4. Emission from other communication systems

Satellite-
Propagation Below 3 GHz

Content:

1. Ionosphere
2. Propagation Below 3 GHz

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

Ionosphere :

Is the region of ionized gas or plasma.

It extends from about 400 km to 2000 km above 15 km Earth’s surface.

The ionosphere is ionized by solar radiation in the ultraviolet and x-ray frequency range and contains free electrons and positive ions.

The ionosphere consists of several layers or regions of varying ion density. By increasing altitude, these layers are known as the D, E, and F layers

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

Satellite Communication Applications operate in the frequency band below 3 GHz are:

- Satellite cellular mobile user link
- Command and telemetry links supporting satellite operations
- Deep space communications
- Specialized services requiring wide directivity ground antennas

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

1. Ionospheric Scintillation:

    It consists of rapid fluctuations of the amplitude and phase of a radio wave.

    These fluctuations are caused by electron density irregularities in the ionosphere.

    The ionospheric scintillation cause forward scattering and diffraction of radio wave.

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

2. Polarization Rotation :

   It refers to a rotation of the polarization sense of a radio wave.

   It is caused by the interaction of a radio wave with electrons in the ionosphere, in the presence of the Earth’s magnetic field.

   This effect is also known as the Faraday Effect.

   It affect the VHF space communications systems which are using linear polarization.

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

3. Group Delay :

   It is the reduction in the propagation velocity of a radio wave.

   It is caused by the presence of free electrons in the propagation path.

   The group velocity of a radio wave is retarded (slowed down) which interns increase the travel time.

   This delay extremely critical for radio navigation or satellite ranging links.

Satellite- Propagation < 3 GHz:

Propagation Below 3GHz:

4. Dispersion:

    The radio wave with a significant bandwidth when propagates through the ionosphere, the propagation delay occur.

    The propagation delay is a function of frequency which interns introduces dispersion.

    The effect of dispersion introduce distortion into broadband signals, and systems at VHF and UHF.

Satellite-
Propagation Above 3 GHz

Content:

1. Propagation Above 3 GHz
2. Rain Attenuation
3. Gaseous Attenuation
4. Cloud Attenuation
5. Depolarization
6. Troposphere Scintillation

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

Satellite applications which operate in these frequency bands include:

- Fixed Satellite Service (FSS) user links
- Broadcast Satellite Service (BSS) downlink user links
- BSS and Mobile Satellite Service (MSS) feeder links
- Deep space communications, and
- Military communications links

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

1. Rain Attenuation :

    Rain Attenuation is a reduction in the transmitted signal amplitude.

    Raindrops absorb and scatter radio wave energy which result in rain attenuation.

    This effect degrade the reliability and performance of the communications link.

    The non-spherical structure of raindrops also change the polarization characteristics of the signal, which results in rain depolarization.

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

2. Gaseous Attenuation :

    Atmospheric gases affect radio communications by adding atmospheric noise to the link.

    Signal degradation depend on frequency, temperature, pressure, and water vapor concentration.

    This effect cause by gaseous constituents to the radio wave is molecular absorption, which results from the reduction in signal amplitude of the signal.

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

3. Cloud Attenuation :

   Clouds are water droplets with 100% relative humidity.

   High-level clouds, such as cirrus, are composed of ice crystals.

   They do not contribute to radio wave attenuation but can cause depolarization effects.

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

4. Depolarization :

    Depolarization refers to a change in the polarization characteristics of a radio wave.

    It is caused by hydrometeor in the path and multipath propagation.

    A depolarized radio wave will have alter polarization state

    This result in interference or crosstalk between the two orthogonally polarized channels.

Satellite- Propagation > 3 GHz:

Propagation Above 3 GHz:

5. Troposphere Scintillation :

   Tropospheric scintillation is produced by refractive index fluctuations.

   It is caused by high humidity gradients and temperature inversion layers.

   Scintillation effects are produced in both the ionosphere and in the troposphere.

Satellite-
Installation & Launching

Content:

1. Installation of Satellite
2. Launching of Satellite

Installation and Launching:

Installation of satellite:

Installation of satellite in orbit means - positioning the satellite in its nominal orbit from a launching site on the surface of the earth.

A launch vehicle have various propulsion systems that is used to inject the satellite into an intermediate orbit called the transfer orbit.

The procedure called Hohmann transfer is followed - which enables the satellite to move from a low altitude circular orbit to a higher altitude circular orbit.

Installation and Launching:

Launching of satellite:

The process of placing the satellite in a proper orbit is known as launching process.

During this process, satellite operations are controlled from earth stations.

Four stages in launching a satellite are:

1. First Stage – The first stage of launch consists of vehicle that contain rockets and fuel for lifting the satellite from ground.

Installation and Launching:

Launching of satellite:

Four stages in launching a satellite are:

2. Second Stage – The second stage of launch vehicle contains smaller rockets.
3. Third Stage – The third (upper) stage of the launch vehicle is connected to the satellite fairing.
4. Fourth Stage – When satellite reached out of Earth's atmosphere then it get separated from the upper stage of launch vehicle, Then, the satellite will go to a “transfer orbit”.

Installation and Launching:

Launching of satellite:

The launch window specifies the time periods during which satellite is launched:

1. It enable determination of the attitude with the required accuracy
2. It avoid the saturation of the sensors or disappearance of references during the apogee manoeuvres
3. Ensure an electric power supply
4. Guarantee Thermal Control
5. During Critical phases, align the radio visibility of the control station with satellite.

Satellite-Launch Vehicle

Content:

1. Type of Satellite Launch Vehicle
2. Launching Cost

Satellite Launch Vehicle:

Satellite Launch Vehicle:

Satellite launch vehicles are used to launch the satellites into a particular orbit according to the requirement.

Launchers or Launch vehicles are used to carry spacecraft to space.

Types of satellite launch vehicles are:

1. Expendable Launch Vehicles (ELV)
2. Reusable Launch Vehicles (RLV)

Satellite Launch Vehicle:

Satellite Launch Vehicle:

1. **Expendable Launch Vehicles:**

    ELV get destroyed after leaving the satellites in space.

    The ELV contains three stages.

    First and second stages of ELV raise the satellite to an about 50 miles and 100 miles.

    Third stage of ELV places the satellite in transfer orbit.

Satellite Launch Vehicle:

Satellite Launch Vehicle:

1. **Expendable Launch Vehicles:**

   Example of ELV :

   1. Ariane 5
   2. Zenit
   3. Vega
   4. Delta 2

Satellite Launch Vehicle:

Satellite Launch Vehicle:

2. **Reusable launch vehicles:**

   RLV is used multiple times for launching satellites.

   This type of launch vehicles is used to return back to earth after leaving the satellite in space.

   When the space shuttle reaches to an elevation of 150 to 200 miles satellite is ejected from the cargo bay.

Satellite Launch Vehicle:

Satellite Launch Vehicle:

2. **Reusable launch vehicles:**

   After this, the third stage of space shuttle gets fired and places the satellite into a transfer orbit.

   Finally, the space shuttle will return back to earth for reuse.

Satellite Launch Vehicle:

Satellite Launch Vehicle:

2. **Reusable launch vehicles:**

The launchers in development are

1. Silver Dart from PlanetSpace (USA)
2. Falcon 9 from SpaceX (USA)
3. K-1 from Kistler Aerospace (USA)
4. Hopper from ESA (Europe)
5. Avatar RLV from ISRO (India)

Satellite Launch Vehicle:

Satellite Launching cost:

The cost of launching a satellite depends on the:

1. Type of service provided
2. The performance of the launcher
3. The commercial policy of the organisation which sells the service.

Approximately 100 million Euros are spend for a launch capacity of the order of 5000 kg at take-off .

Satellite-
Space Environment

Content:

1. Space environment
2. Type of environmental effects
3. Environment during installation
4. Environment during Launching

Satellite - Space Environment:

The space environment affects the design and operation of the satellite during its lifetime in orbit.

The following space conditions affect the operation of satellite:

- Absence of atmosphere (vacuum)
- Gravitational and magnetic fields
- Meteorites and debris
- Radiation sources and sinks
- High energy particles.

Satellite - Space Environment:

The effects of the environment on the satellite during the launch period are:

- Mechanical - consisting of forces and torques which are exerted on the satellite and modify its orbit and attitude
- Thermal - resulting from radiation from the sun and earth absorbed by the satellite and energy radiated towards cold space
- Degradation of materials - due to radiation and high energy particles.

Satellite - Space Environment:

1. **Mechanical Environment :**

- Gravitational Force :

  The gravitational field of earth is asymmetries, due to the non-spherical and inhomogeneous nature of earth.

  This cause perturbations of the orbit.

- Magnetic Force :

  This cause negligible changes to the satellite operation and design.

Satellite - Space Environment:

1. **Mechanical Environment :**

- Solar Radiation Pressure :

  This torque causes a drift of the orientation of the north–south axis of the satellite

- Meteorites and other space particle :

  The cloud of meteorites (scrap material, rocks, pebbles etc) present in space have density that becomes lower as the altitude increases.

  This also affect the satellite during launch period.

Satellite - Space Environment:

2. **Thermal Environment :**
    - Solar Radiation
    - Earth Radiation
3. **Degradation of material :**
    - Cosmic radiation
    - Solar wind
    - Van Allen Belts

Satellite - Space Environment:

Environment during installation is divided into 2 phase :

1. The launch phase :

   up to injection into the transfer orbit with a duration of tens of minutes

2. The transfer phase :

   during which the satellite describes the elliptical orbits. This transfer phase lasts for several tens of hours.

Satellite - Space Environment:

Environmental effects during launching :

- Aerodynamic Heating : A fairing protects the satellite from aerodynamic heating as it passes through the dense layers of the atmosphere.
- Longitudinal and transverse accelerations and vibrations : originate at the launcher during ignition of the motors and during propulsion phases.
- High Acoustic noise : originate under the fairing while passing through the atmosphere.

Satellite - Space Environment:

Environmental effects in the transfer orbit :

Satellite in the transfer orbit experience difficulty in attaining Spin-stabilization and other satellite configuration such as operational configuration.

The effect in transfer orbit are:

- Thermal effects
- Atmospheric drag
- Braking effect

Satellite-Reliability

Content:

1. Reliability
2. Availability
3. Quality assurance of satellite system

Satellite - Reliability:

Reliability of a Satellite system :

It is defined by the probability of correct operation of the system during a its lifetime.

The reliability of a complete satellite communication system depends on

- The Satellite
- The Ground Stations.

Satellite - Reliability:

Availability of the Satellite system :

It is the ratio of the actual period of correct operation of the system to the required period of correct operation.

The availability of a complete satellite communications system depends on:

- Probability of successful launching
- The replacement time and
- The number of operational and back-up satellites

Satellite - Reliability:

Quality assurance of satellite system :

Quality assurance is necessary for security and reliability of satellite system.

The main elements of a quality assurance programme are:

1. Checking a quality of the pre-project studies and definition
2. Testing quality at the design level
3. Testing quality at the model testing level
4. Quality of supplies

Satellite - Reliability:

Quality assurance of satellite system :

5. Quality of manufacture
6. Quality of testing
7. Control of Configuration
8. Non-conformity, failures, exemptions

HTS Satellite

Content:

1. HTS satellite
2. Satellite HTS and 5G

HTS Satellite:

HTS Satellite :

The communication satellite that provide a significant increase in capacity, by a factor of 20 or more are known as high-throughput satellite, or HTS.

- Meet demand of higher data rate
- Provide new application accessibility with cost effective connectivity
- Provide maritime communication
- Provide new in-flight connectivity (IFC) solutions

HTS Satellite:

HTS Satellite :

HTS satellite use multi beam antennas to provide large coverage to service area.

Benefits:

1. Frequency reuse
2. Higher EIRP on the transmit side
3. Higher G/T on the receiver side.

HTS Satellite:

HTS Satellite :

HTS Ground Terminals -

1. High capacity beams bandwidth (>100 MHz), with associated higher data rates
2. Feeder link terminals support multiple spot beams
3. Deploy fade mitigation techniques for high rain fade avoidance

HTS Satellite:

HTS Satellite :

Example of HTS satellite are:

- **Ka-Sat** –
  - launched December 2010 (Eutelsat KA-Sat 9A)
  - Built for Eutelsat
  - location 9o East, lifetime 15 years
  - 82 Ka-band spot beams, 250 km footprint, 10 gateways
  - 70 Gbps total throughput

HTS Satellite:

HTS Satellite :

Example of HTS satellite are:

- **ViaSat-1** –
  - Launched October 2011
  - Built by Space Systems Loral
  - Position 1150 West, lifetime 12 years
  - 56 Ka-band transponders
  - 72 spot beams, coverage CONUS, Alaska, Hawaii, and Canada
  - 140 Gbps total throughput capacity

HTS Satellite:

GBBF Technology:

Ground-based beam forming (GBBF) systems is used in 4G HTS.

This technology used to alter the coverage and the beam shape.

Benefits of GBBF technology:

- Faster and lower cost satellite deployment
- Ability to coordinate frequency use and remove interference for mass numbers of subscribers
- Refocusing of satellite capacity to the areas of greatest need.

HTS Satellite:

Satellite HTS and 5G:

Terrestrial cellular mobile networks evolved to a several generations of technology.

But these generation does not contained a use of satellite communication.

The satellite is used to provide the backhaul services for long distance and intercontinental connections.

But now, the HTS satellite systems will play a major role in 5G networks.

HTS Satellite:

Satellite HTS and 5G:

5G network implementation include :

- Software Defined Radio Access Technologies (RATs)
- Cognitive radios
- High Altitude stratospheric platform stations (HAPS)
- Machine to machine (M2M) communications
- Internet of Things (IoT)
- Increased screen resolution (i.e., 4K, UHD) and video downloading
- Cloud Computing

DVB Satellite

Content:

1. DVB satellite
2. Transmission system
3. Modulation Technique
4. DVB-S2

DVB Satellite:

It stands for Digital Video Broadcasting

Satellite (DVB-S) is the original DVB standard for Satellite Television

It development period is from 1993 to 1997.

The first commercial application was by Galaxy in Australia.

DVB-S is used in both Multiple Channel Per Carrier (MCPC) and Single channel per carrier (SCPC) modes for Broadcast Network.

DVB Satellite:

Most of the broadcasters,service providers, equipment and chip manufacturers worked together to define a digital video broadcasting (DVB) standard.

Types of DVB according to services services are:

1. DVB-T for terrestrial digital TV
2. DVB-C for cable
3. DVB-S for satellite
4. DVB-RCS for the return channel
5. DVB-S2 (the second generation of DVB-S)
6. DVB-H for handheld terminals
7. DVB-SH for satellite handheld terminals

DVB Satellite:

Transmission system of DVB:

The transmission system consists of the functional block of equipment.

These equipment are used to transport baseband TV signals in the format of the MPEG-2 transport stream over the satellite channel.

The transmission system of DVB use this processes:

- Multiplexing and randomisation for energy dispersal
- Outer coding and Inner Coding
- Convolutional interleaving
- Baseband Modulation

DVB Satellite:

Modulation technique used by DVB-S:

The DVB-S uses QPSK modulation.

The concatenation of signal is done using convolutional and Reed Solomon channel codes.

This method is adopted by most satellite operators worldwide for television and data broadcasting services.

The first publication of the DVB-S standard was done in 1994

DVB Satellite:

DVB-S2 :

Main features of DVB S2 are:

- New channel coding schemes achieve a capacity gain in the order of 30%
- Variable coding and modulation (VCM) provide different levels of error protection to different service components
- Extended flexibility that cope with other input data formats without significant complexity increase.

DVB Satellite:

DVB-S2 :

DVB-S2 is designed to support a wide range of broadband satellite applications such as:

- Broadcast Services (BS)
- Interactive service (IS)
- Digital TV Contribution and Satellite News Gathering (DTVC/DSNG)
- Professional Services (PS):

All service components are time division multiplexed (TDM) on a single digital carrier.

Satellite System - GPS

Content:

1. GPS and Telemetry
2. GPS satellite History
3. GPS satellite Architecture
4. Frequency band
5. Other Positioning Satellites

Satellite System - GPS:

Due to the advancement in technology, the importance of location based services has increased rapidly.

The initial deployment of GPS was done in 1990s.

In mobile communications network various applications utilizes location based services by combining the location information of satellite and cellular systems.

Telecom services also require high-precision clock information.

Satellite System - GPS:

GPS Satellite History :

America was the first to deploy the satellite for the location services called GPS (Global Positioning System).

The basic idea of GPS is to provide location and time for the receivers around globe regardless weather conditions.

USA develop this satellite more for military purposes.

The first fully operational stage of GPS, with 24 satellites and 3 spare satellites, was reached in 1994.

Satellite System - GPS:

GPS Satellite Architecture :

The Global Positioning System is based on the GPS satellites

These Satellites constantly send messages from their orbit to Earth.

The GPS receivers calculate their position by timing these signals.

This provide the accurate position of the user system.

The architecture of GPS contains three segments: space segment (SS), control segment (CS), and user segment (US)

Satellite System - GPS:

GPS Satellite Architecture :

- Space Segment :
  - It contains 24–32 satellites located in Medium Earth Orbit (MEO).
- Control segment :
  - It contains MCS and OCS.
- User segment :
  - It contains users using secure GPS Precise Positioning Service.

Satellite System - GPS:

GPS Satellite Frequency Band :

The GPS satellite system is based on CDMA spread-spectrum technique.

In CDMA spread spectrum technique, the low bit rate data transmission is encoded with a high-rate Pseudo-Random Noise (PRN) sequence.

GPS receivers know the PRN codes of different satellites and able to decode the transmitted data.

- The P code rate is 10.23 Mcps - Military use only (1.575 GHz L1 band)
- The C/A code rate is 1.023 Mcps for the civilian use (1.2276 GHz L2 band)

Satellite System - GPS:

Other Positioning System :

1. GALILEO
2. BeiDou / COMPASS
3. GLONASS
4. QZSS
5. IRNSS

Satellite System - Telemetry

Content:

1. Weather Satellite
2. Meteorological Satellites
3. Military Satellites

Satellite System - Telemetry:

Weather Satellites :

Weather satellites are used for observing Earth's climate.

Weather satellites are of two type :

1. Polar Orbiting Satellite - coverage to entire earth asynchronously
2. Geostationary Satellite - coverage to particular localized area spots

This satellite observe cloud systems , ash from active volcanoes and the status of the ozone layer and cycles of the severe weather conditions due to El Nino weather system.

Satellite System - Telemetry:

Weather Satellites :

1. Geostationary weather Satellites

   These satellites are orbiting at the level of the Equator with altitude of 35880 km or 22300 miles.

   This provide constant information of the status of the complete hemisphere by utilizing both visible-light and infrared sensors.

   It deliver the daily weather forecast pictures for local television news and newspapers.

Satellite System - Telemetry:

Weather Satellites :

2. Polar Orbiting weather Satellites

   These satellites are located at an altitude of 850 km or 530 miles.

   These satellites move via North and South Poles and are able to monitor any location on Earth by viewing the spots twice per day with the same light conditions.

   Polar orbiting satellites are closer to Earth that why they are able to provide higher quality imaging of earth environment.

Satellite System - Telemetry:

Meteorological Satellites :

These satellite have capability to observe deeper weather condition on earth.

It include forest fires, status of air pollution, snow and ice, ocean currents, and development of vegetation, among other visual aspects.

Example of meteorological satellites is the European ENVISAT.

Weather and meteorological satellites working is based on visible and infrared light.

Satellite System - Telemetry:

Military Satellite :

Military satellite are used to gather intelligence information around the earth.

It is used for secured and closed communications.

The example of US military satellite - Milstar (Military Strategic and Tactical Relay)

Milstar is a set of communication satellites in geostationary orbit.

Satellite Generations

Content:

1. Satellite Communication technology
2. Technology Generation

Satellite Generations:

Satellite Communication Technology Generations :

First generation satellite :

Use C-band links in geosynchronous orbit.

The satellite payload had 12 to 24 transponders, each with 70 to 120 MHz bandwidths

Satellites operates with fixed beam full earth coverage antennas.

Analog signals are used for transmissions

Satellite Generations:

Satellite Communication Technology Generations :

Second generation satellite :

- Implement digital communication technology using Ku-band operations.
- The first on-board processing transponders were deployed.
- Satellite capacity improved due to the use of high power solid-state transmitters
- The satellite coverage area data rate is increased by using shaped beam antenna and steerable spot beam.

Satellite Generations:

Satellite Communication Technology Generations :

Third generation satellite :

Introduce Ka-band which increase the number of transponders and satellite capacity at the global level.

The frequency reuse is possible with deployment of multi-beam technology.

The great enhancement is possible with full digital link communications which add high capacity options as well.

Satellite Generations:

Satellite Communication Technology Generations :

Fourth generation satellite :

Frequency band used are Ku-band and Ka-band

Satellite have large capacity payloads with several hundred transponders and extensive multi-beam and steerable beam antenna arrays.

These satellite are known as Broadband satellite.

Satellite - Applications

Content:

1. Aeronautical Mobility Service
2. Maritime Satellite Service
3. Transportable system

Satellite Applications:

Aeronautical Mobility Service : provided by satellite

- IFC - In Flight Communication - use L band and Ku band
- Broadband Internet Connectivity
- In- Flight Entertainment and Communication (IFEC)

Satellite Applications:

Four major technologies providing IFC are :

1. ATG
2. Satellite L Band
3. Satellite Ku Band
4. Satellite Ka Band

Satellite Applications:

Four major technologies providing IFC are :

1. **AGT :**

   Use ground tower to provide connection path with aircraft

   Service coverage is limited to particular land masses

   Service is less expensive as compared to the service from satellite communication.

   Used in North America using Gogo as a key provider.

Satellite Applications:

Four major technologies providing IFC are :

2. **Satellite L Band :**

   MSS based approach use L band satellite technologies to provide IFC.

   It was basically designed for cockpit communication services on business and military aircraft

   Now it used for passenger communication

   Inmarsat and Iridium are the two satellite

Satellite Applications:

Four major technologies providing IFC are :

3. **Satellite Ku Band :**

   Satellite Ku band provide coverage in North Atlantic corridor like in the United States, Europe, part of Asia, and the Middle East.

   Examples are ViaSat's Yonder service with Ku-band connectivity to the business jet market

   Row 44 operates over the Hughes Ku-band network

Satellite Applications:

Four major technologies providing IFC are :

4. **Satellite Ka Band :**

   It use higher bandwidth and smaller antenna

   This technology face more problem from rainfade than Ku band satellite.

   Example : ViaSat operates Ka-band aeronautical services in North America through Exede in the Air service.

Satellite Applications:

Maritime Satellite Service:

Satellite are used to improve operational productivity.

It also support crew connectivity to family and friends.

Maritime Services offered by satellite are :

- Download of latest chart updates
- Engine monitoring and weather-routing applications

Information is collected from centralized source, and distribute in real time to all the ships, vessels, Yachts.

Satellite Applications:

Maritime Satellite Service:

	Satellite	HTS infrastructure	Band	Area Focus
1.	Inmarsat	Global Xpress	Ka	Worldwide
2.	Intelsat	Epic	Ku, Ka	Northern Hemisphere
3.	O3b	8 spacecraft constellation	Ka	Worldwide
4.	Telenor	Thor 7	Ka	Europe area
5.	Telesat	Vantage	Ku	Caribbean and Europe area

Satellite Applications:

HTS/Ka-Band Transportable System:

Transportable systems is used for military, news gathering, and sporting events.

The Ka HTS satellite use an IP service to stream content via an Internet-based VPN to the intranet of the content aggregator.