

# Satellite Communications

SWE 425: Telecommunication  
Engineering with Lab  
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# Overview

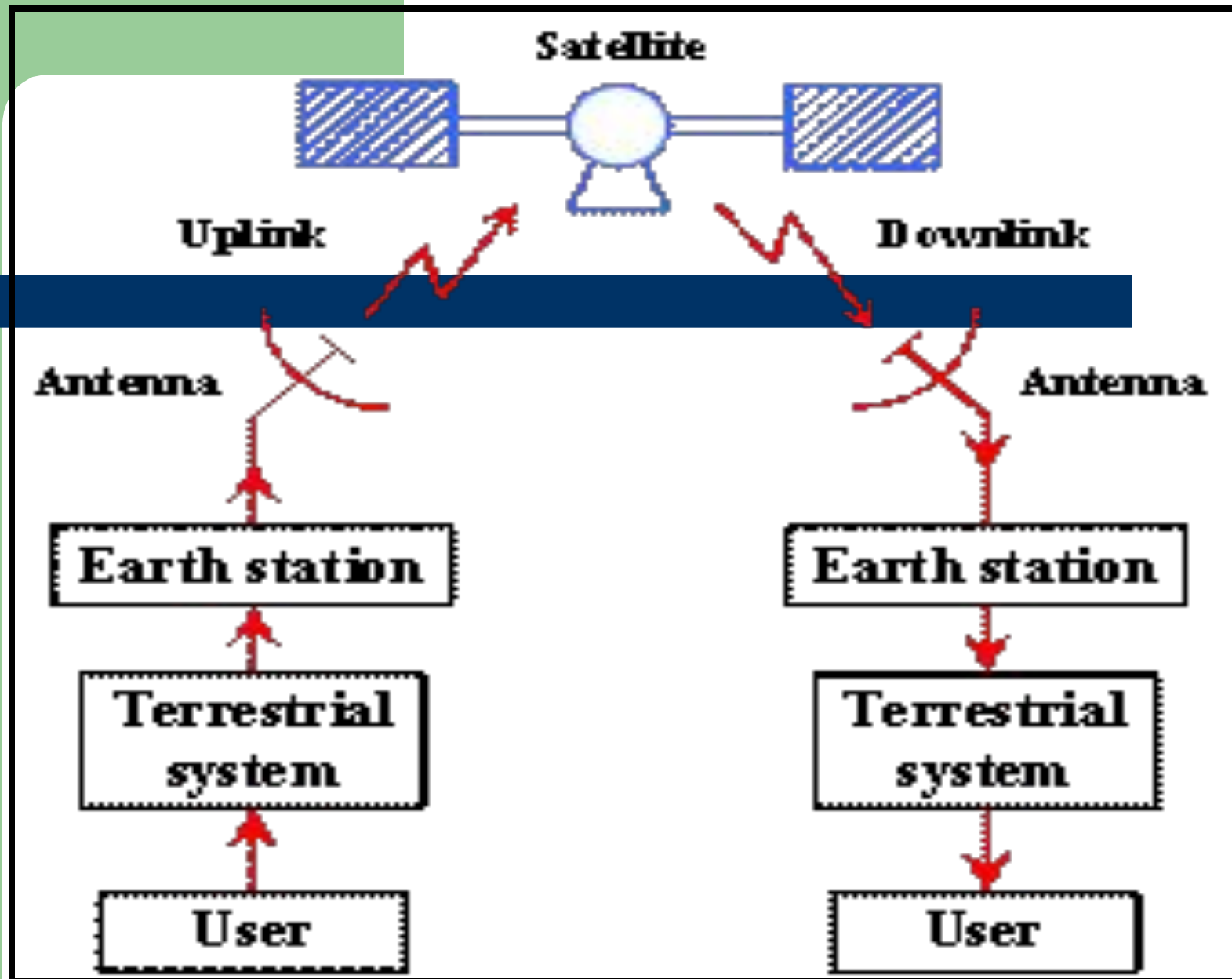
- Basics of Satellites
- Types of Satellites
- Capacity Allocation



An artificial body placed in orbit around the earth to collect information or for communication.

# Basics: How do Satellites Work

- Two Stations on Earth want to communicate through radio broadcast but are too far away to use conventional means.
- The two stations can use a satellite as a relay station for their communication
- One **Earth Station** sends a transmission to the satellite. This is called a **Uplink**.
- The satellite **Transponder** converts the signal and sends it down to the second earth station. This is called a **Downlink**.



# Basics: Advantages of Satellites

- The advantages of satellite communication over terrestrial communication are:
  - The coverage area of a satellite greatly exceeds that of a terrestrial system.
  - Transmission cost of a satellite is independent of the distance from the center of the coverage area.
  - Satellite to Satellite communication is very precise.
  - Higher Bandwidths are available for use.

# Basics: Disadvantages of Satellites

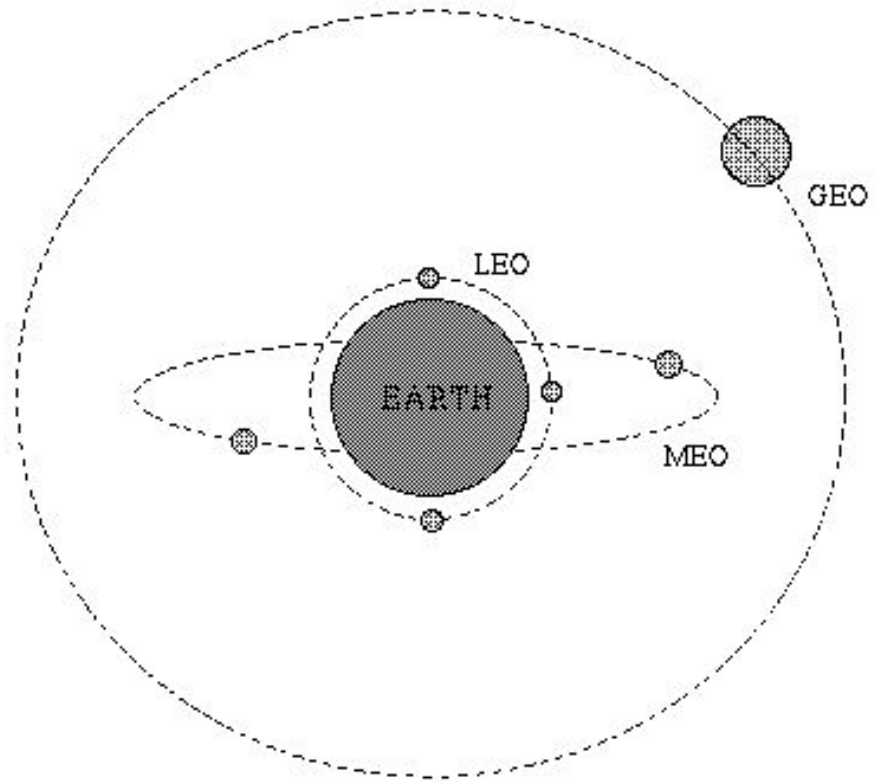
- The disadvantages of satellite communication:
  - Launching satellites into orbit is costly.
  - Satellite bandwidth is gradually becoming used up.
  - There is a larger propagation delay in satellite communication than in terrestrial communication.

# Basics: How Satellites are used

- Service Types
  - Fixed Service Satellites (FSS)
    - Example: Point to Point Communication
  - Broadcast Service Satellites (BSS)
    - Example: Satellite Television/Radio
    - Also called Direct Broadcast Service (DBS).
  - Mobile Service Satellites (MSS)
    - Example: Satellite Phones

# Types of Satellites

- Satellite Orbits
  - GEO
  - LEO
  - MEO
- Frequency Bands





# Geostationary Earth Orbit (GEO)

- These satellites are in orbit 35,863 km above the earth's surface along the equator.
- Objects in Geostationary orbit revolve around the earth at the same speed as the earth rotates. This means GEO satellites remain in the same position relative to the surface of earth.

# GEO (cont.)

- Advantages
  - A GEO satellite's distance from earth gives it a large coverage area, almost a fourth of the earth's surface.
  - GEO satellites have a 24 hour view of a particular area.
  - These factors make it ideal for satellite broadcast and other multipoint applications.

# GEO (cont.)

- Disadvantages
  - A GEO satellite's distance also cause it to have both a comparatively weak signal and a time delay in the signal, which is bad for point to point communication.
  - GEO satellites, centered above the equator, have difficulty broadcasting signals to near polar regions

# Low Earth Orbit (LEO)

- LEO satellites are much closer to the earth than GEO satellites, ranging from 500 to 1,500 km above the surface.
- LEO satellites don't stay in fixed position relative to the surface, and are only visible for 15 to 20 minutes each pass.
- A network of LEO satellites is necessary for LEO satellites to be useful

# LEO (cont.)

- Advantages
  - A LEO satellite's proximity to earth compared to a GEO satellite gives it a better signal strength and less of a time delay, which makes it better for point to point communication.
  - A LEO satellite's smaller area of coverage is less of a waste of bandwidth.

# LEO (cont.)

- Disadvantages
  - A network of LEO satellites is needed, which can be costly
  - LEO satellites have to compensate for Doppler shifts caused by their relative movement.
  - Atmospheric drag affects LEO satellites, causing gradual orbital deterioration.

# Medium Earth Orbit (MEO)

- A MEO satellite is in orbit somewhere between 8,000 km and 18,000 km above the earth's surface.
- MEO satellites are similar to LEO satellites in functionality.
- MEO satellites are visible for much longer periods of time than LEO satellites, usually between 2 to 8 hours.
- MEO satellites have a larger coverage area than LEO satellites.

# MEO (cont.)

- Advantage
  - A MEO satellite's longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network.
- Disadvantage
  - A MEO satellite's distance gives it a longer time delay and weaker signal than a LEO satellite, though not as bad as a GEO satellite.



# Frequency Bands

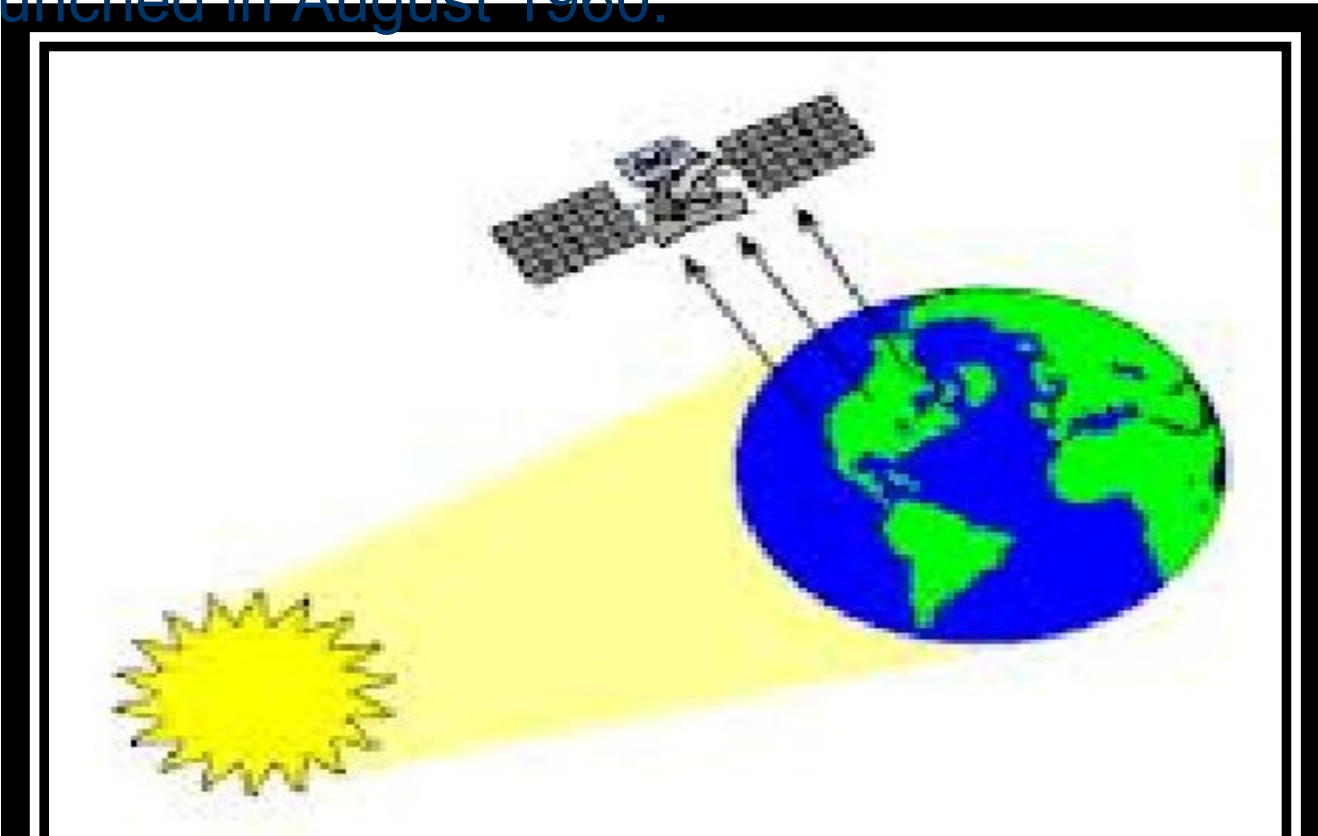
- Different kinds of satellites use different frequency bands.
  - L-Band: 1 to 2 GHz, used by MSS
  - S-Band: 2 to 4 GHz, used by MSS, NASA, deep space research
  - C-Band: 4 to 8 GHz, used by FSS
  - X-Band: 8 to 12.5 GHz, used by FSS and in terrestrial imaging, ex: military and meteorological satellites
  - Ku-Band: 12.5 to 18 GHz: used by FSS and BSS (DBS)
  - K-Band: 18 to 26.5 GHz: used by FSS and BSS
  - Ka-Band: 26.5 to 40 GHz: used by FSS

# Passive Satellites

- A satellite that only reflects signals from one Earth station to another, or from several Earth stations to several others.
- It reflect the incident electromagnetic radiation without any modification or amplification.
- It can't generate power, they simply reflect the incident power.

# Passive Satellites

- The first artificial passive satellite **Echo-I** of NASA was launched in August 1960.



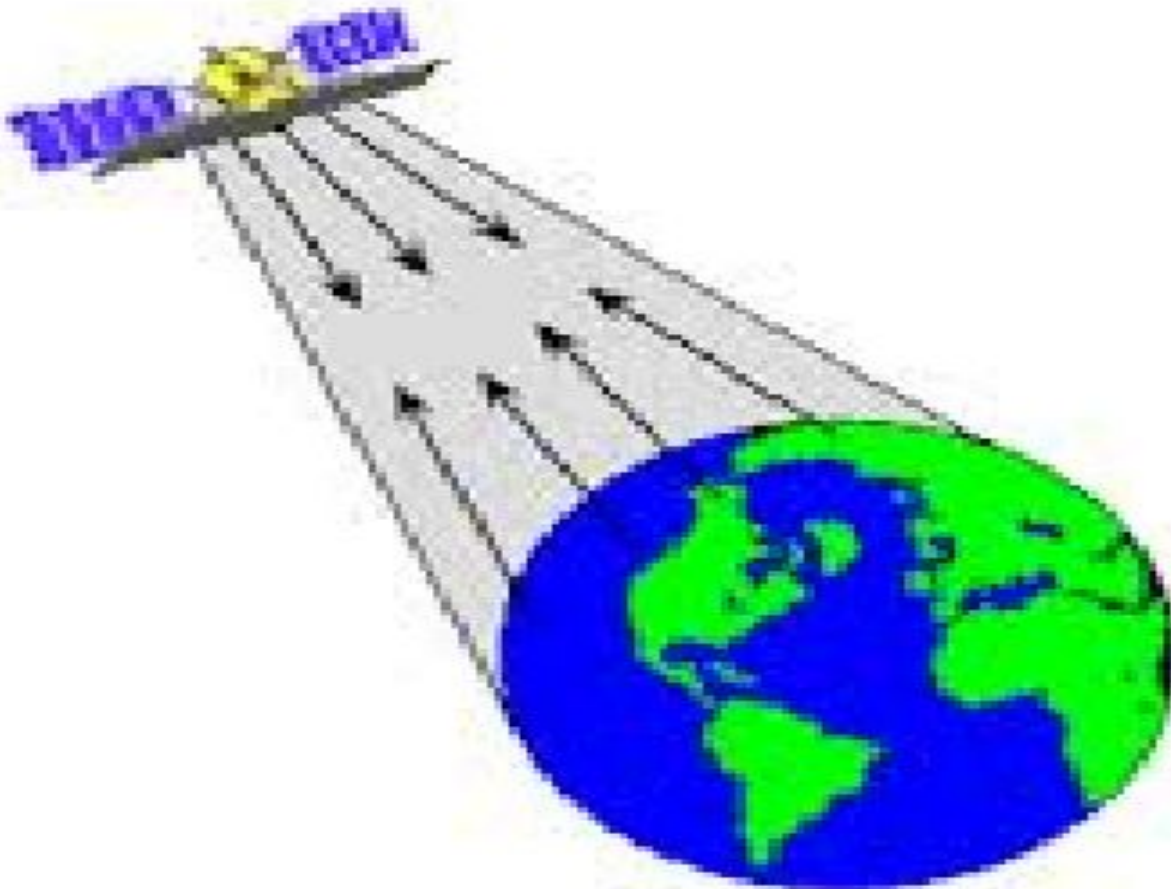
# Disadvantages

- Earth Stations required high power to transmit signals.
  - Large Earth Stations with tracking facilities were expensive.
  - A global system would have required a large number of passive satellites accessed randomly by different users.
  - Control of satellites not possible from ground.
- **The large attenuation of the signal while traveling the large distance between the transmitter and the receiver via the satellite was one of the most serious problems.**

# Active Satellites

- In active satellites, it amplify or modify and retransmit the signal from the earth.
- Satellites which can transmit power are called active satellite.
- **Have several advantages over the passive satellites.**
  - Require lower power earth station.
  - Less costly.
  - Not open to random use.
  - Directly controlled by operators from ground.

# Active Satellites



- World's first active satellite was **SCORE** (Satellite Communication by Orbiting Relay Equipment)

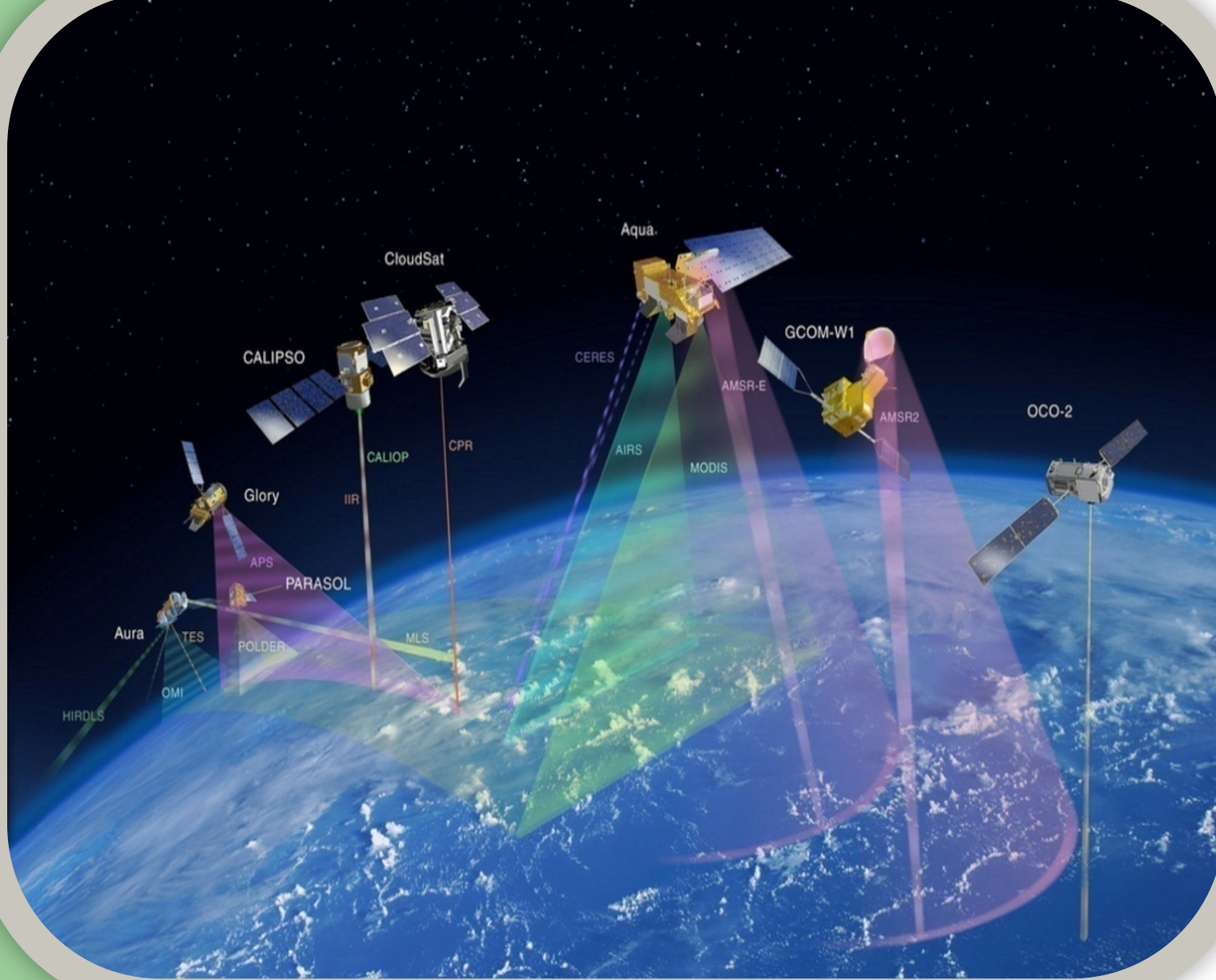
- Launched by US Air force in 1958.
- At orbital height of 110 to 900 miles.

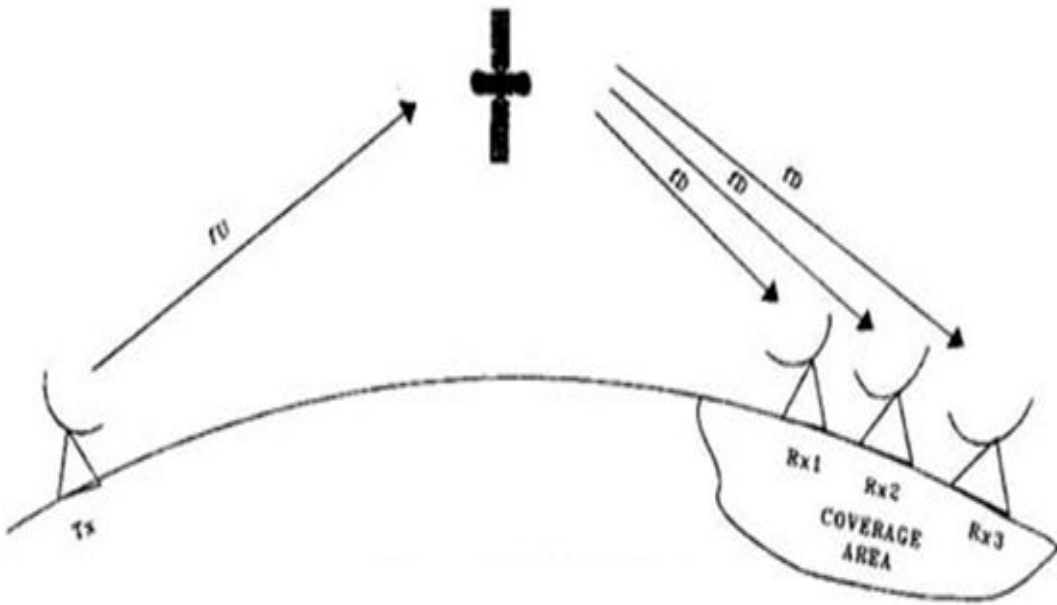
- The first fully active satellite was **Courier**
  - Launched into an orbit of 600 - 700 mile,
  - By Department of Defense in 1960.

# Disadvantages

- Requirement of larger and powerful rockets to launch heavier satellites in orbit.
- Requirement of on-board power supply.
- Interruption of service due to failure of electronics components



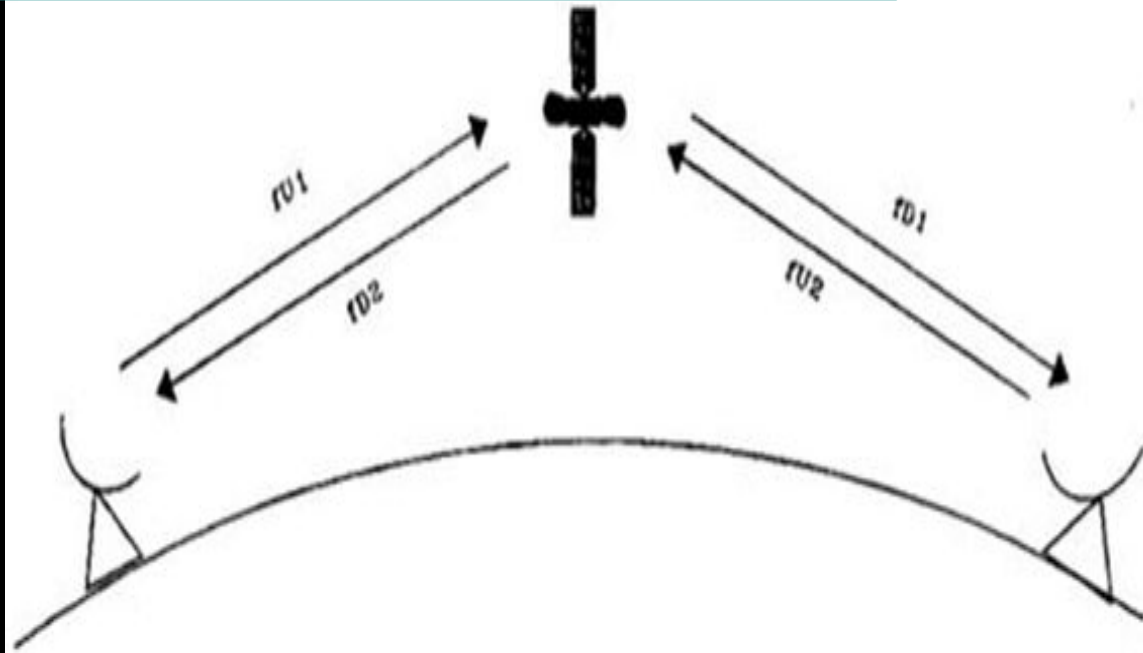




One way link

## Different Satellite Communications

Two way link



- **One-way satellite services are:**

- **Broadcast Satellite Service:** Radio, TV, Data broadcasting.

- **Safety services :** Search & Rescue, Disaster Warning
  - Radio Determination Satellite Service(Position location)
  - Standard frequency and time signal satellite service
  - Space Research Service.
  - Space operations service.
  - Earth Exploration Satellite Service.

- **Two-way satellite services are:**

- **Fixed Satellite Service:** Telephone, fax, high bit rate data etc.

- **Mobile Satellite Service:** Land mobile, Marine time mobile, Aero-mobile, personal communications.
- Satellite News Gathering.
- Inter Satellite Service.