Tishk International University
Applied Science Faculty
IT Department

Wireless Networking

Lecture 4: Satellite Systems

4th Grade – Fall Semester

Instructor: Alaa Ghazi

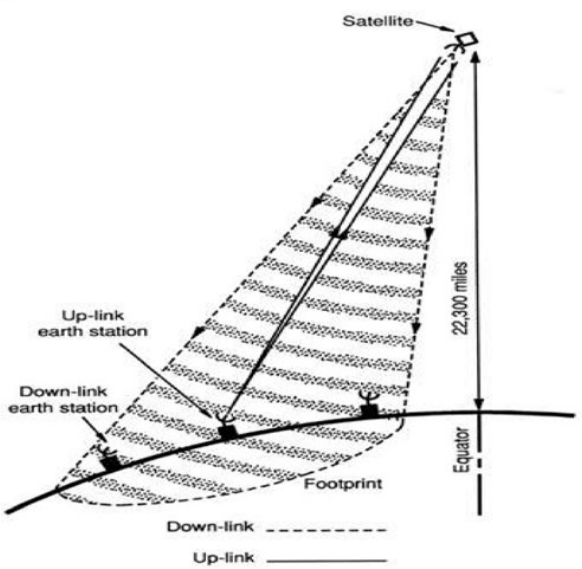
Lecture 4
Satellite Systems

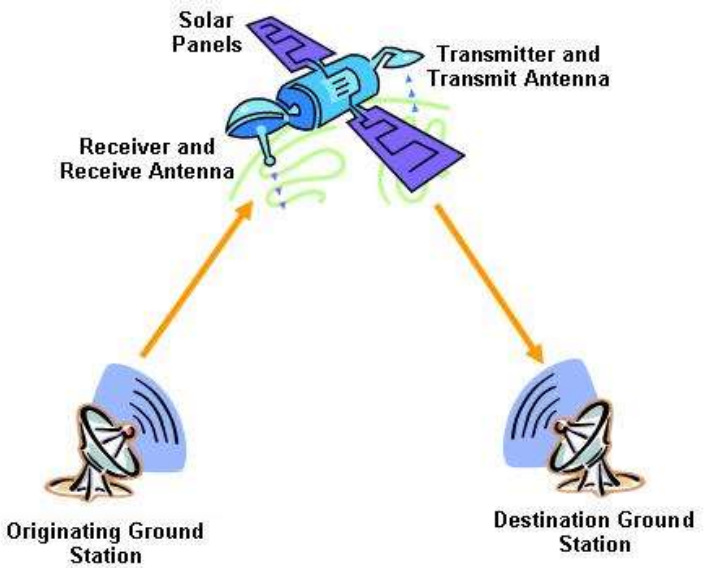
Topics

1. Introduction to Satellites
2. How do Satellites work?
3. Satellite vs. Ground Communication
4. Satellite Footprint
5. Satellites Types by Bands
6. Satellites Types by Orbits
7. Satellites Applications
8. How does GPS work?
9. What is a VSAT ?

1. Introduction to Satellites

- A **Communications Satellite** is an artificial object that relays and amplifies radio telecommunications signals via a transponder; it creates a communication channel between a source transmitter and a receiver at different locations on Earth.
- Communications satellites are used for television, telephone, radio, Internet, and military applications
- A satellite travels in a special path, called its **orbit**.





2. 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** transmits the signals to the satellite. **Up link frequency** is the frequency at which Ground Station is communicating with Satellite.
- The satellite **Transponder** converts the signal and sends it down to the second earth station. This frequency is called a **Downlink frequency.**
- The area which receives a signal of useful strength from the satellite is known as the **satellite's footprint.**

3. Satellite vs. Ground Communication

Advantages

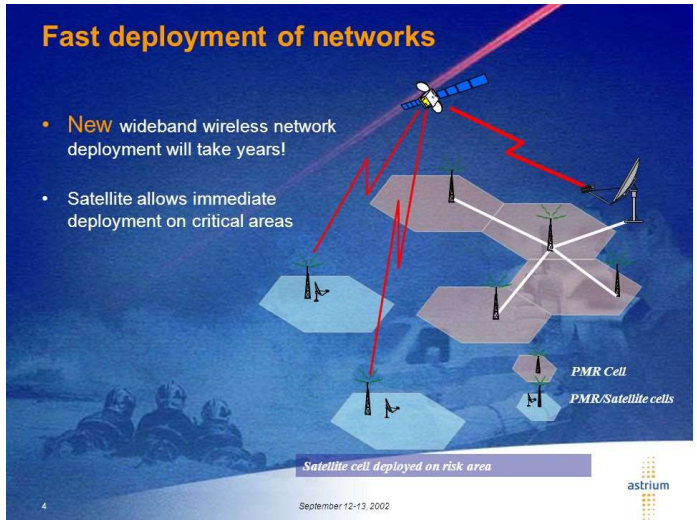
The advantages of satellite communication over Ground communication are:

- Greater coverage area
- Transmission cost is independent on the distance

Disadvantages

The disadvantages of satellite communication are:

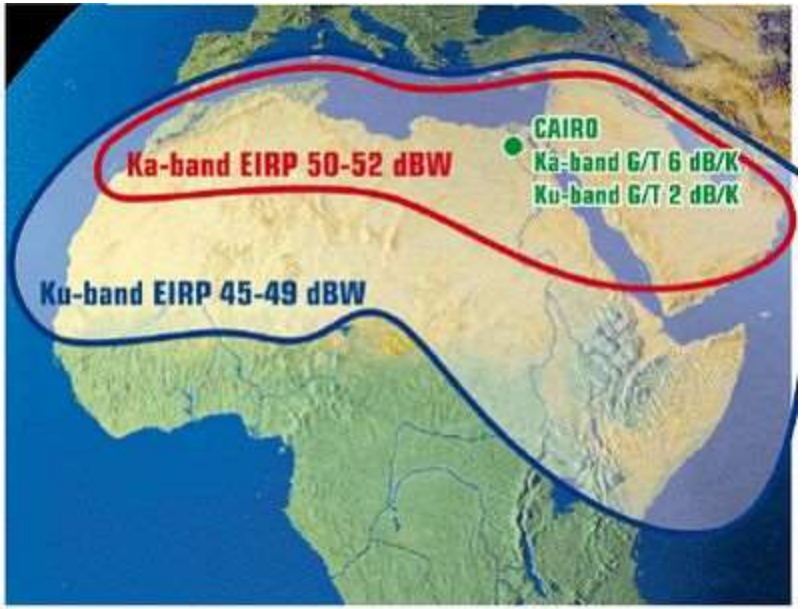
- Launching Cost is too high
- Larger propagation delay

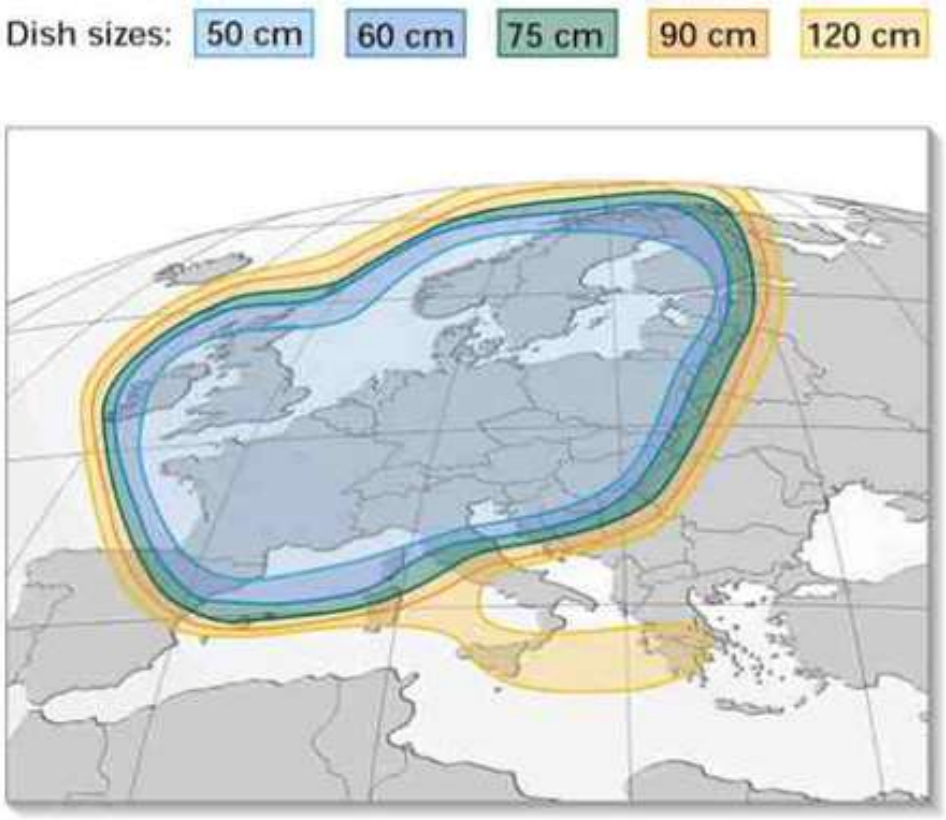


4. Satellite Footprint

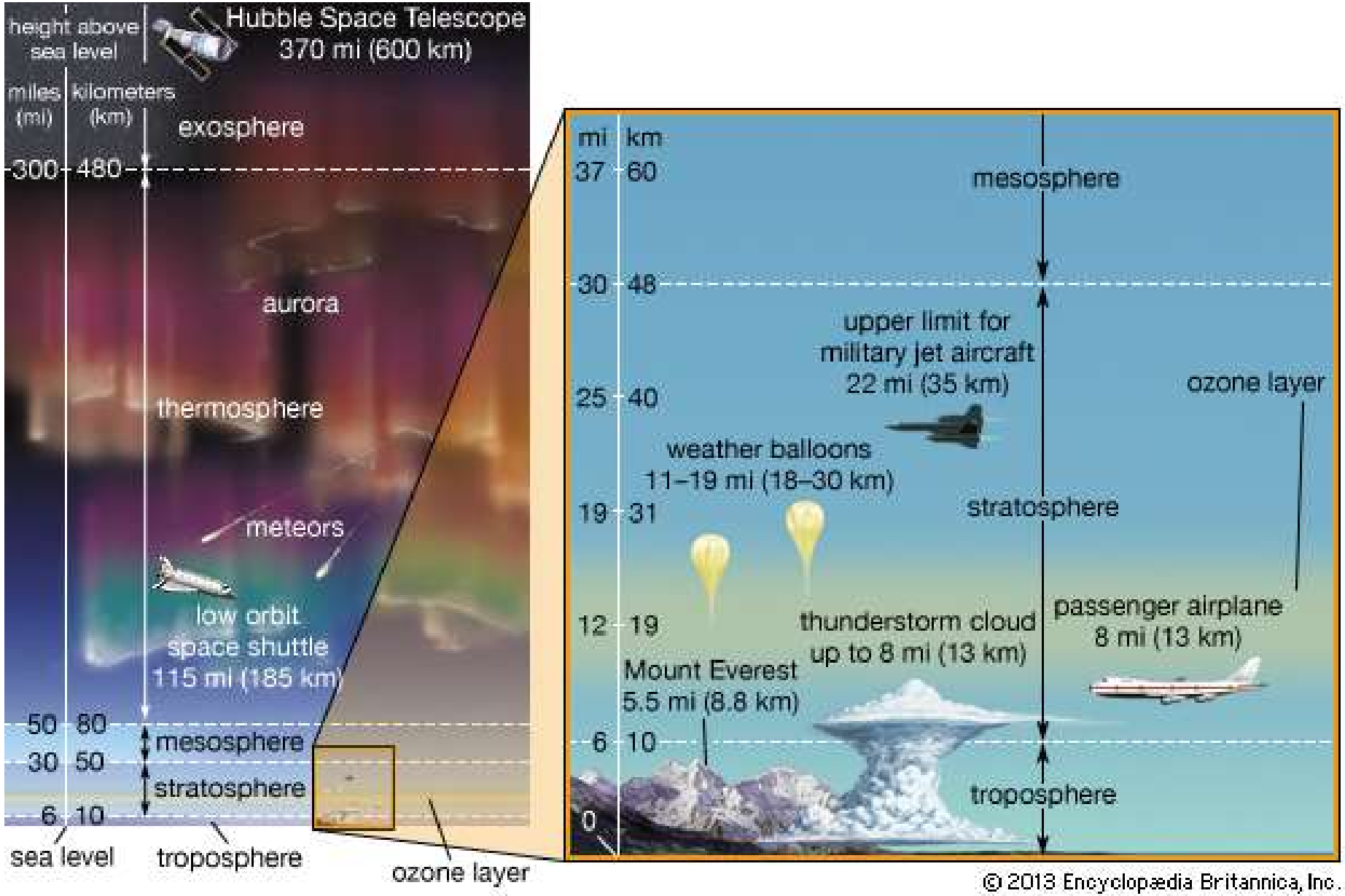
Satellite Footprint: is the ground area that Satellite covers.

In geostationary orbit, communications satellites have direct line-of sight to almost half the earth - a large "footprint" which is a major advantage.

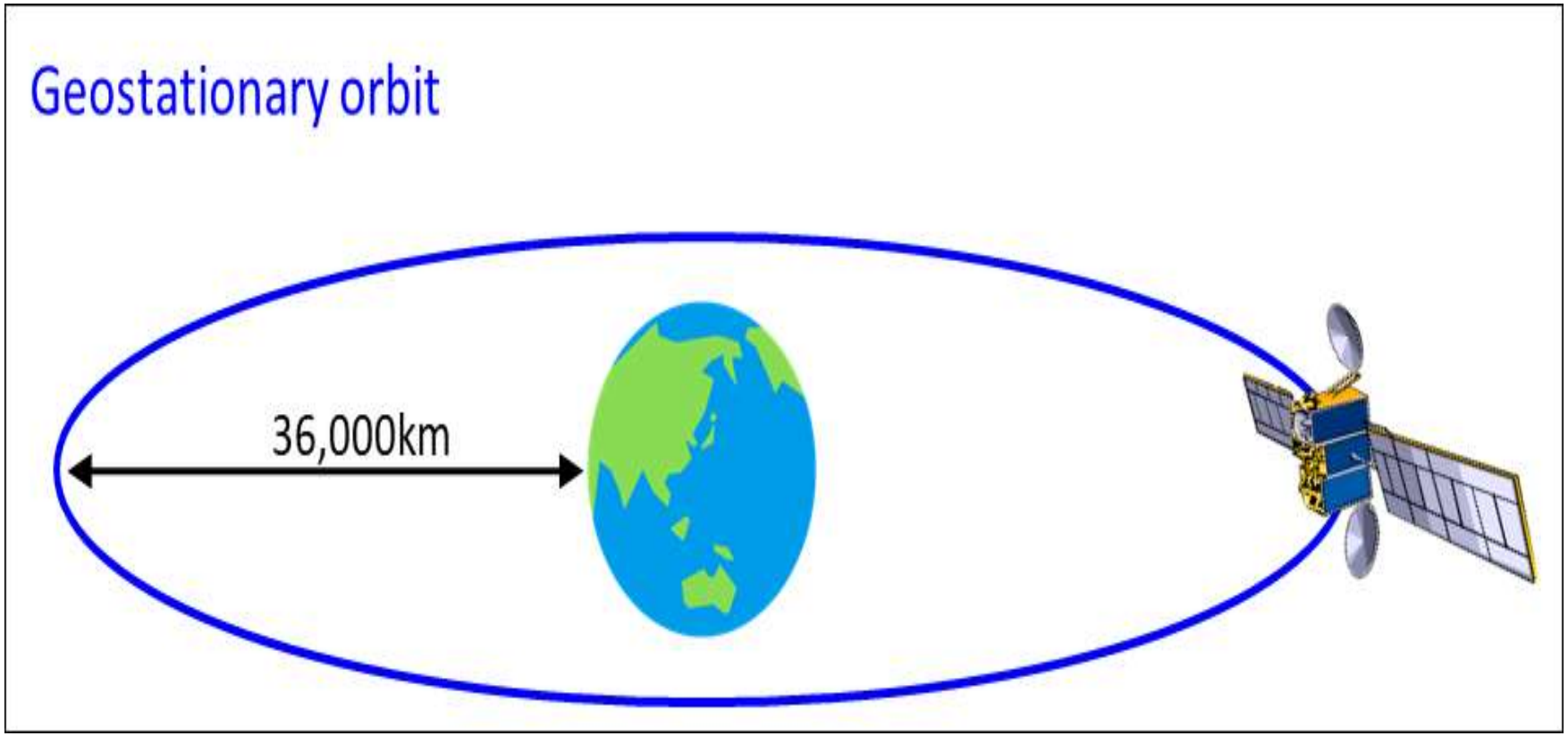




Heights of Space Objects



Height of Geo-Stationary Satellite

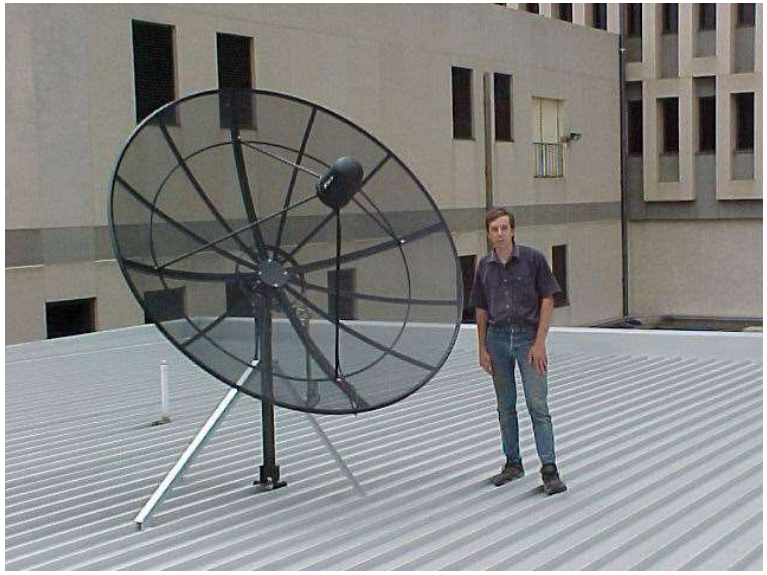


5. Satellites Types by Bands

- The three most commonly used satellite frequency bands are:
  - C-band
  - Ku-band
  - Ka-band
- C-band and Ku-band are the two most common frequency spectrums used by today's satellites.
- There is an inverse relationship between frequency and wavelength--when frequency increases, wavelength decreases and vice versa.
- As wavelength increases (and frequency decreases), larger antennas (satellite dishes) are necessary to gather the signal.

C -Band

- C-band satellite transmissions occupy the 4 to 8 GHz frequency range.
- These relatively low frequencies translate to larger wavelengths than Ku-band or Ka-band.
- These larger wavelengths of the C-band mean that a larger satellite antenna is required to gather the minimum signal strength, and therefore the minimum size of an average C-band antenna is approximately 2-3 meters in diameter.



Ku - Band

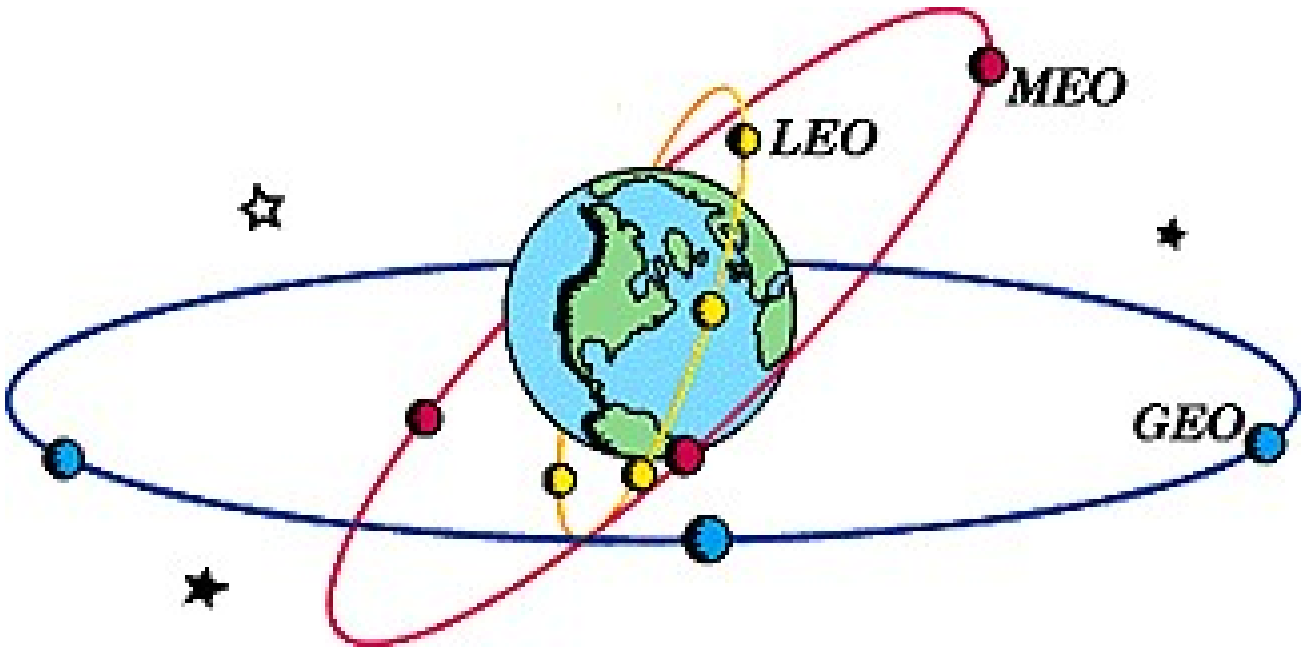
- Ku-band satellite transmissions occupy the 11 to 17 GHz frequency range.
- These relatively high frequency transmissions correspond to shorter wavelengths and therefore a smaller antenna can be used to receive the minimum signal strength.

Ka - Band

- Ka-band satellite transmissions occupy the 20 to 30 GHz frequency range.
- These very high frequency transmissions mean very small wavelengths and smaller diameter antennas than Ku-band and C-band.
- The Antenna Diameter can range from 74 cm to 120 cm

6. Satellites Types by Orbits

- LEO (Low Earth Orbit)
- MEO (Medium Earth Orbit)
- GEO (Geostationary Earth Orbit)



Low Earth Orbit (LEO) Satellites

- A low Earth orbit (LEO) is an orbit with an altitude between 160 to 2,000 Kms.
- At 160 km, one revolution takes approximately 90 minutes.
- The majority of satellites, have been in LEO.
- **Earth observation satellites** and **spy satellites** use LEO

Advantages:

- Better signal strength
- Short propagation delays (10 – 15 msec)
- Low transmission power
- Low price

Disadvantages:

- A network of LEO satellites is needed, which can be costly
- Small coverage spot
- High system complexity

Medium Earth Orbit (MEO) Satellites

- MEO is in the region of space around the Earth between 2,000 to 36,000 Kms.
- Used for **GPS**, **communication**, and **space environment science**.
- Average orbital period of 12 hours, as used, for example, by the **(GPS)**.

Advantages:

- Larger coverage than LEO.
- Fewer are needed than a LEO network.

Disadvantages:

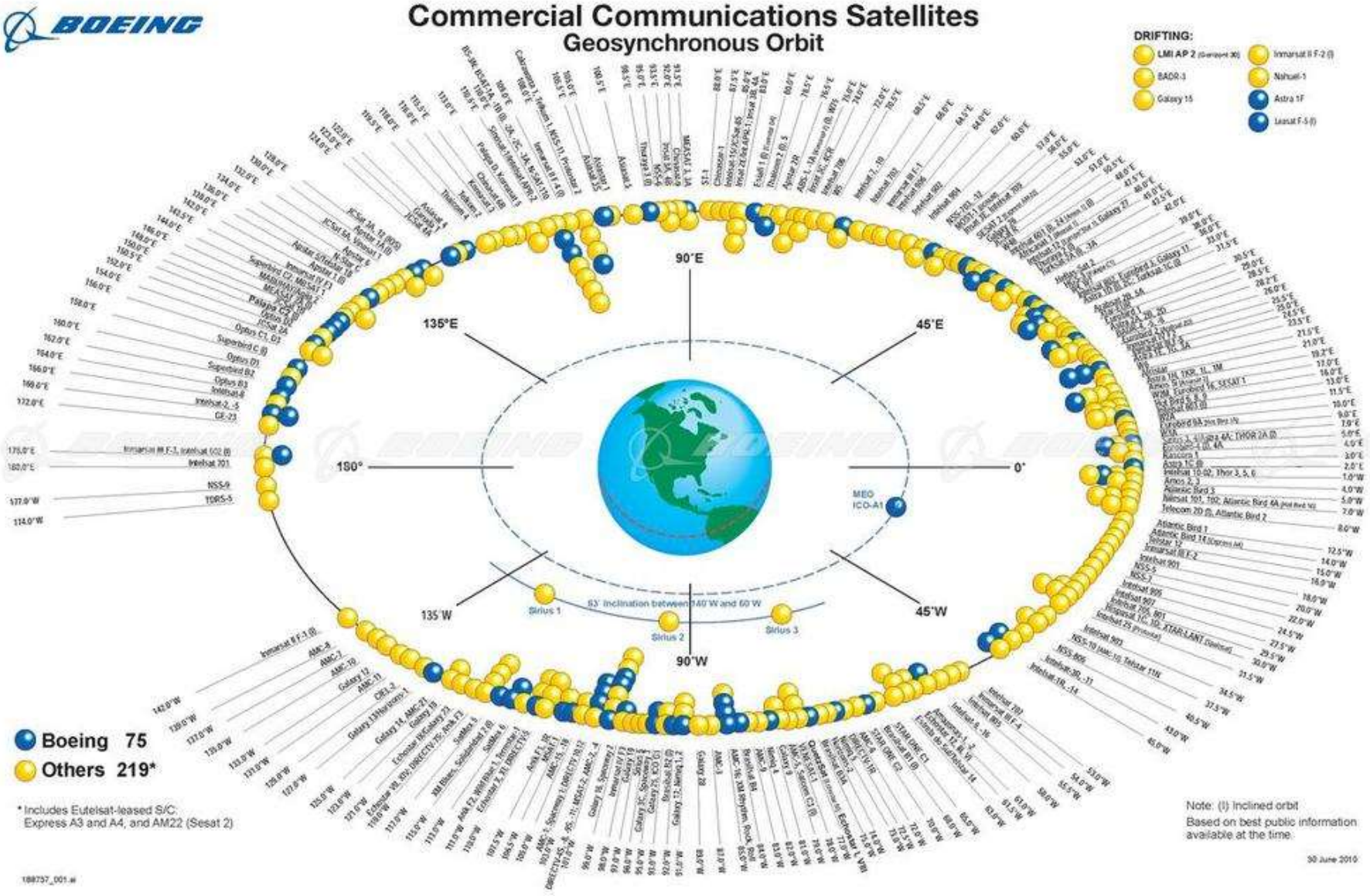
- Longer time delay and weaker signal than a LEO

Geostationary Earth Orbit (GEO)

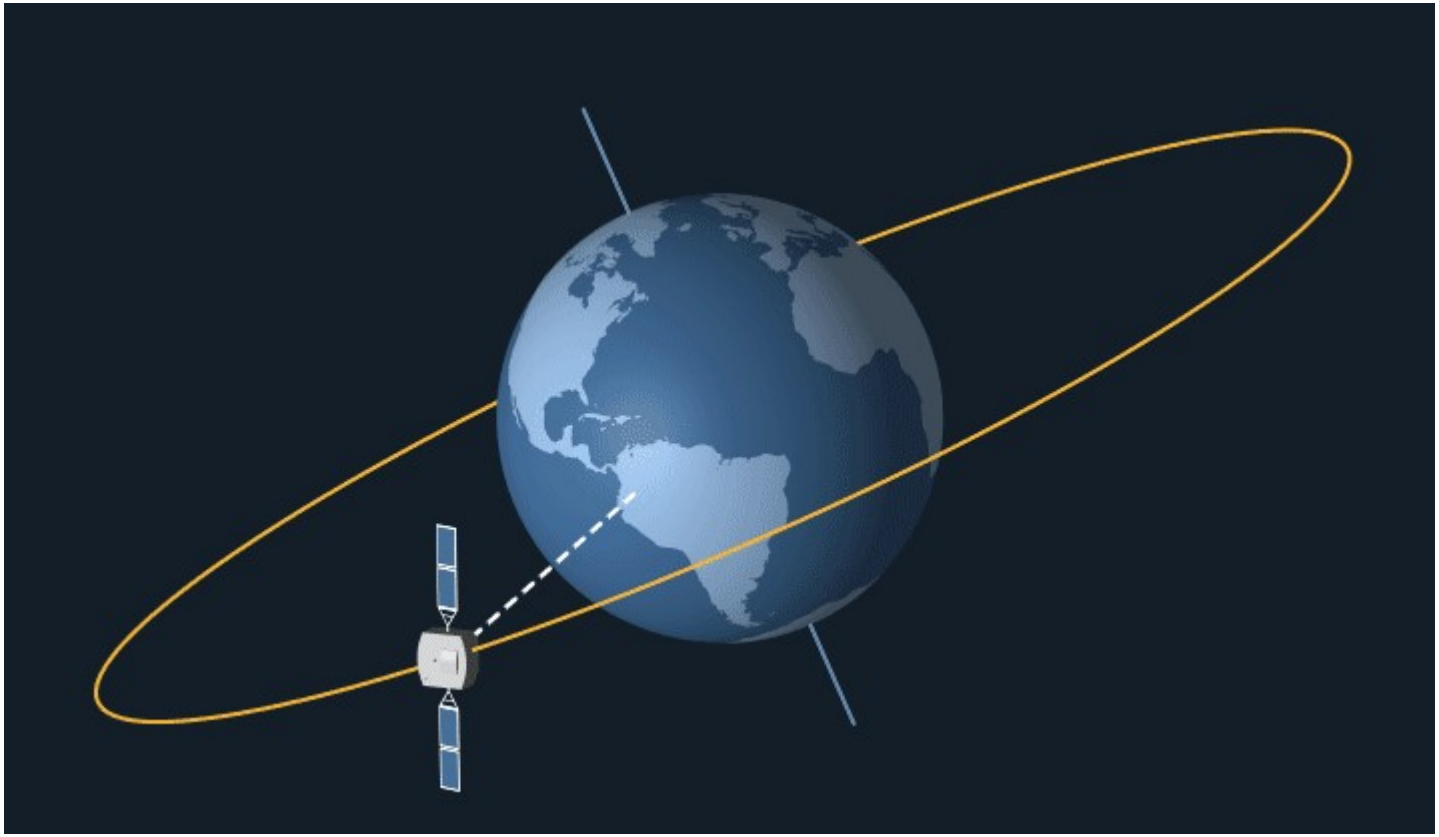
- **Geostationary Satellite**: is orbiting at the same speed as the Earth rotates, but it orbits around the equator and the earth station antenna can be pointed permanently at the position in the sky where it stays.
- From the Earth's surface, an object in a geostationary orbit looks like it is not moving at all.
- GEO is a circular orbit about 35,786 km above the Earth's equator.
- **Communications satellites** and **weather satellites** are often given geostationary orbits, so that the satellite antennas that communicate with them do not have to move to track them.
- Obtaining Satellite Details

http://www.lyngsat.com

Commercial Communications Satellites
Geosynchronous Orbit



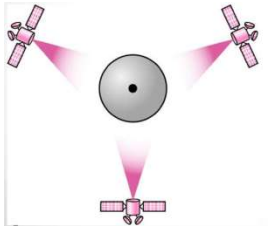
GEO Animation



Advantages and Disadvantages of GEO Satellites

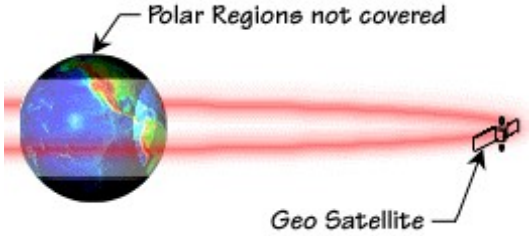
Advantages:

- A large coverage area, almost a fourth of the earth's surface.
- A 24 hour view of a particular area.
- Used for TV broadcast and VSAT.
- Only 3 satellites in Geostationary orbit can cover the entire globe.



Disadvantages:

- Weak signal and a time delay in the signal
- Have difficulty in broadcasting signals near polar regions



7. Satellites Applications

1. Communication satellites

• Communications satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world.

1- TV and Radio broadcast

2- Internet VSAT Systems

3- Mobile Satellite Communications

2. Astronomy satellites

- A big **telescope** in space and used for space observation.

3. Atmospheric studies satellites

• Used to study the Earth's atmosphere

4. Navigation satellites

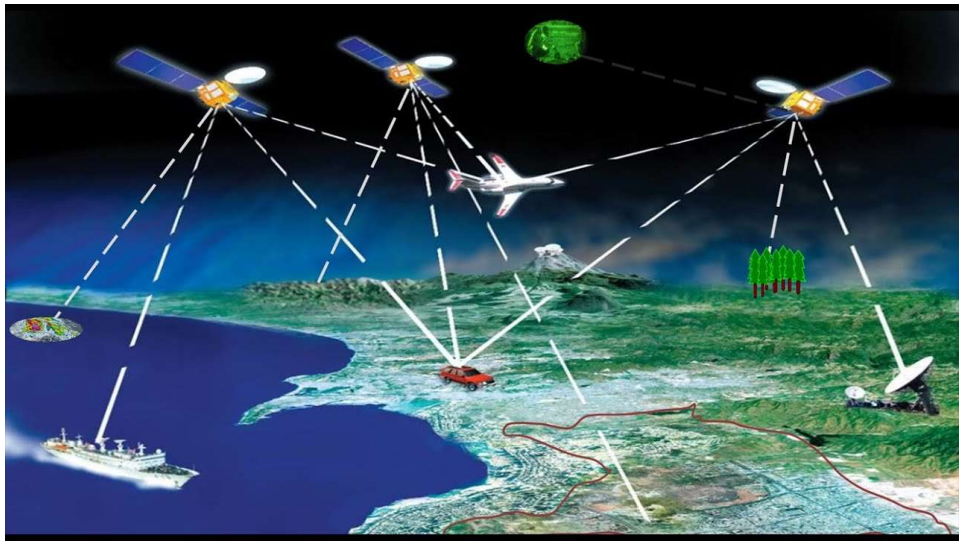
- Used to determine location of any object like GPS

5. Weather satellites

- Used to find out the weather anywhere in the world any time of the day.

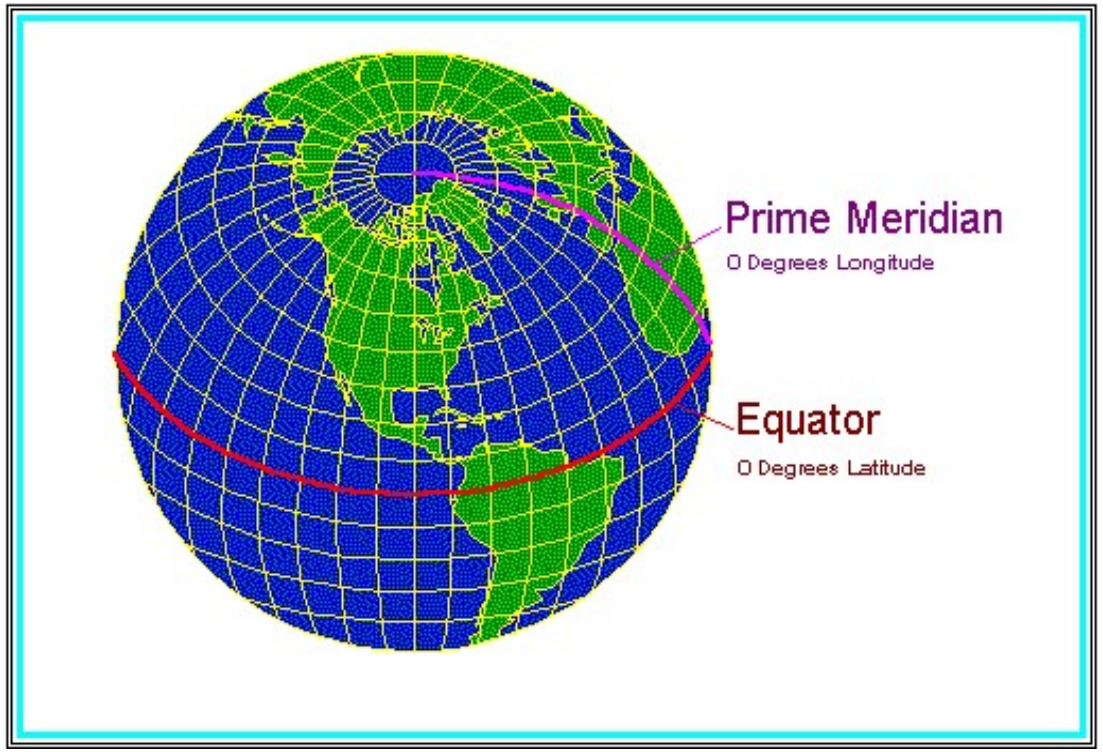
8. What is GPS?

- GPS is stands for Global Positioning System.
- The purpose of GPS is to show you your exact position on the Earth anytime, in any weather, anywhere.



Latitude and Longitude

- Latitude and Longitude are spherical coordinates on the surface of the earth.
- Latitude is measured North or South of the Equator.
- Longitude is measured East or West of Greenwich.
- GPS uses Latitudes and Longitudes to reference locations on the ground.



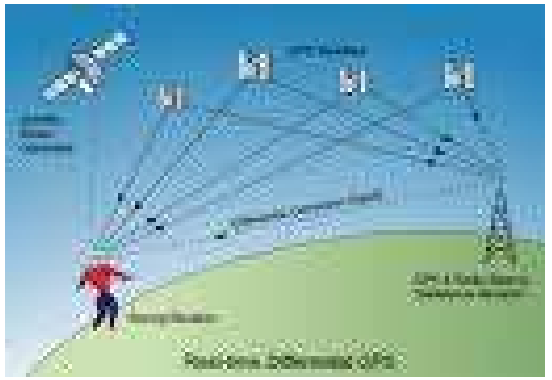
Who Can Use GPS

Military

Marine

Automobile

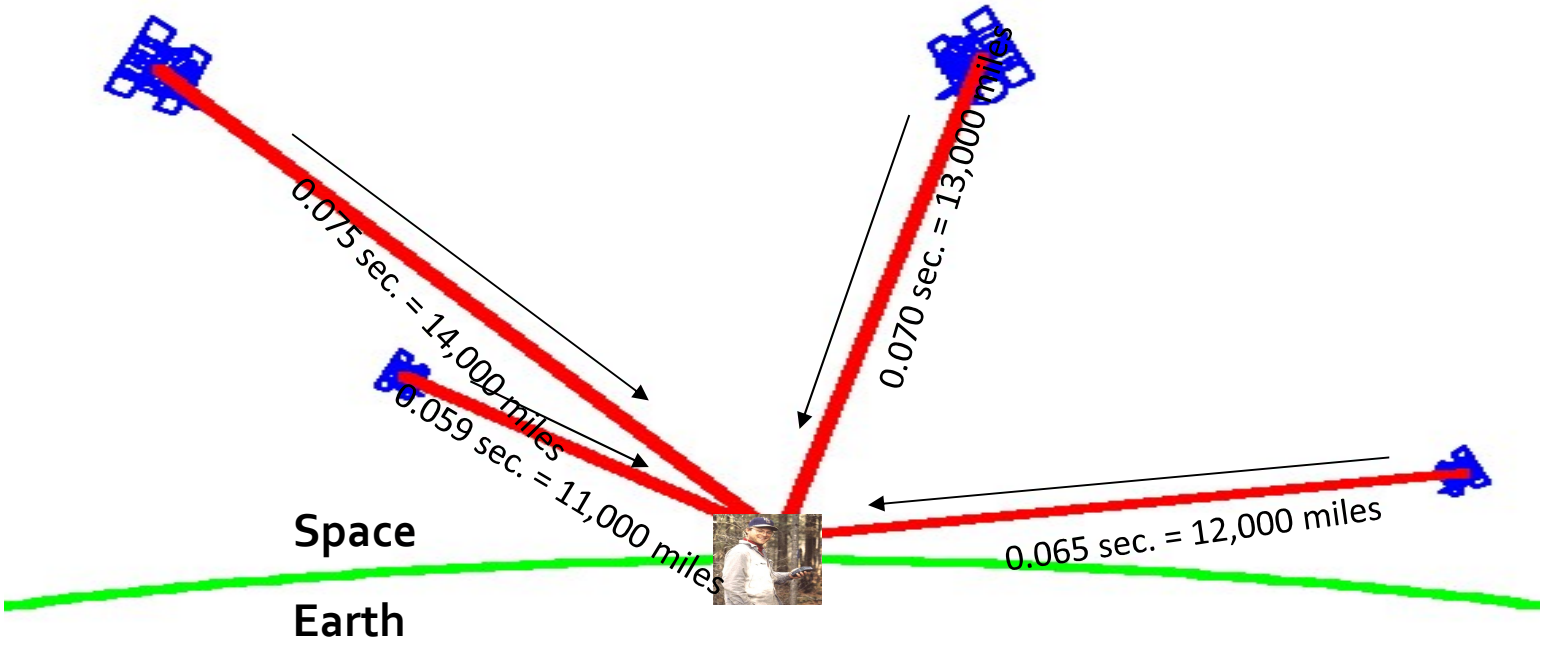
Individual



Aircraft Navigation

How does GPS work?

- Each GPS satellites transmit signals to the GPS receivers .
- These signals indicates satellite's location and the current time.
- Each GPS satellite has special clocks to provide very accurate time reference (atomic clocks).
- The receiver picks up the signals from the satellites and it uses the signal travel time to calculate distances to the satellites and then uses trigonometry to determine position of the receiver



9. What is a VSAT ?

VSAT (Very Small Aperture Terminal) Satellite-based Wide Area Network (WAN), with centrally managed hub.

VSAT technology represents a cost effective solution for users seeking an independent communications network connecting a large number of geographically dispersed sites and it provides powerful, dependable private and public network communications solutions

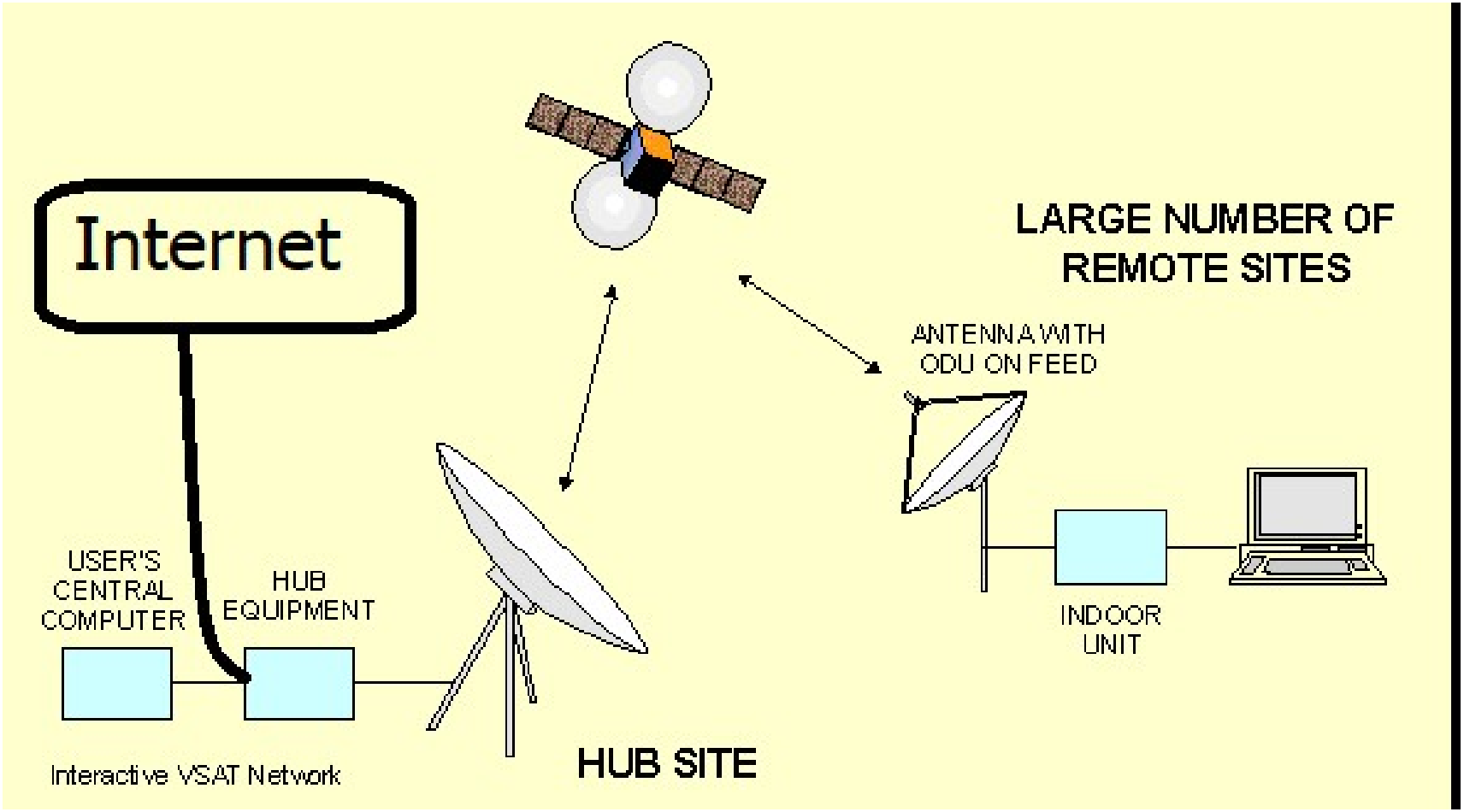
- Remote site: less than 1.2m dish antenna
- Multi-service platform: Data, telephony and multimedia communications

VSAT Services

VSAT networks offer value-added satellite-based services capable of supporting the:

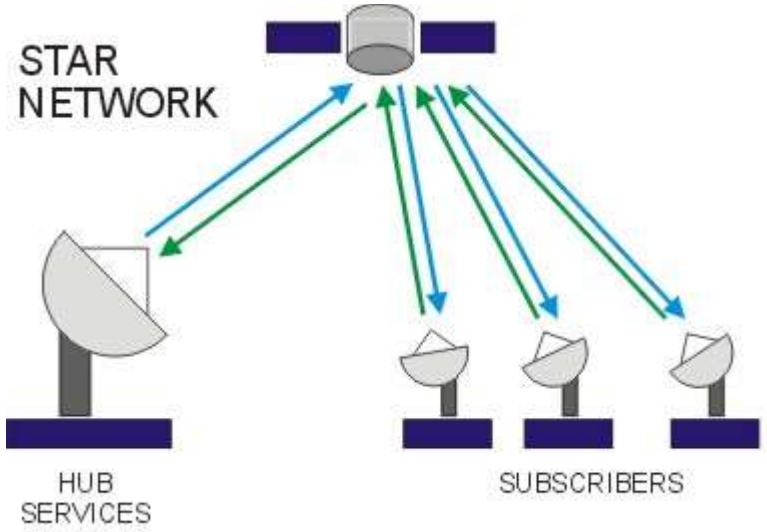
1. Internet: As a main Internet connection in rural areas and backup connection in cities.
2. Intranet LAN: Many of the largest corporations in America utilize VSAT as their primary communications technology to extend their wide area networks.
3. Voice/Fax communications,
4. Video Conferencing: for Business meetings and distance learning
5. Security Cameras: Taking into consideration time delay for control signals.

Typical VSAT Network Diagram



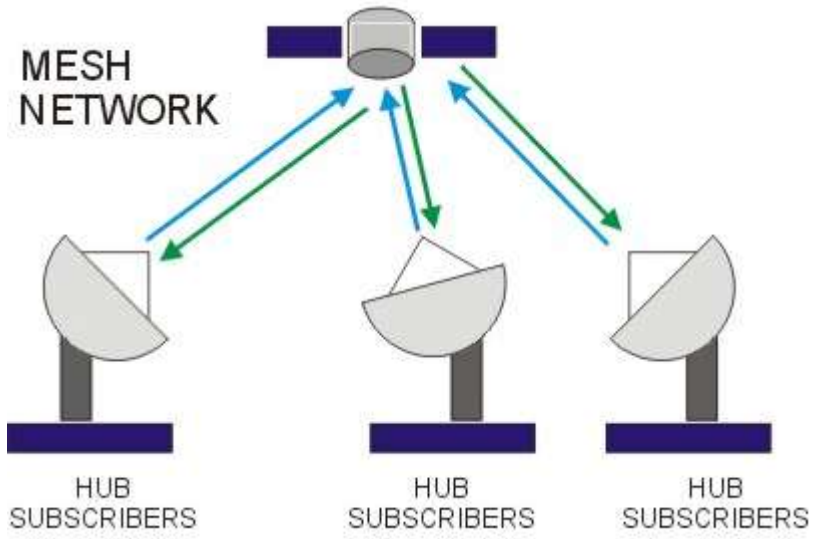
VSAT Network Architectures –
Two-Way Star Topology

- In this topology all VSATs Communicate via a Single Hub
- VSAT Antenna Size dependent upon Power and Gain of Hub Antenna
- Contention Based Access – Usually TDMA or FTDMA
- Typical Ping Times to Internet Approximately 650-700ms



VSAT Network Architectures –
Two-Way Mesh Topology

- VSATs communicate directly with each other
- Some systems require initial signaling via the Hub
- Larger Antennas, Higher Power required at the VSAT
- Smaller Antenna, Lower Power required at the Hub
- Used extensively in Telephony Networks
- Delay minimized on VSAT to VSAT Calls



Typical Satellite Modem Specs (not required in the exam)

Network Topology	Star	
	Downstream DVB-S2	***Upstream*** Adaptive TDMA
Modulation	QPSK, 8PSK, 16APSK, 32APSK	BPSK, QPSK, 8PSK
FEC	LDPC, 1/4 - 8/9	2D 16-State, 1/2 - 6/7
Max. Symbol Rate	1 - 45 Msps	128 ksps - 7.5 Msps
Max. Info Rate	149.7 Mbps	19.2 Mbps
Max. IP Data Rate	59.2 Mbps	16 Mbps
Spread Spectrum (Max Rate Mcps)		Up to 7.5 Mcps Spreading Factors: 2, 4, 8
	Max rates are achieved under optimal conditions.	

Typical view of the Globe from GEO Satellite