Satellite Communications

Satellite Communications
Systems Engineering
Louis J. Ippolito, Jr.

COM 301

Satellite Communications (1)

Syllabus

- Principles of cellular radio.
- Mobile radio propagation and channel modeling , Multiple access methods , Physical and Logical channels.
- Digital mobile Communications systems :TDMA , GSM , CDMA, WCDMA , multi – carrier and OFDM systems.
- Overview of satellite Communications; link calculations; Earth station and satellite antennas; Earth station engineering.
- Communications repeaters; spacecraft engineering; digital modulation and demodulation.
- multiple access techniques: GSM architecture, TDMA frame structure, mapping of logical channels on physical channels, CDMA spread spectrum systems of codes and power control in CDMA.

COURSE SPECIFICATIONS

Class Attendance

Regular attendance is critical for good success in the course

GRADING

Quizzes, assignments, and class attendance	40%
Mid-of-Semester Exam	20%
End-of-Semester Exam	40%
Total	100%

Lecturer

Dr. Hend Ali Elsayed

Chapter 1:Introduction to Satellite Communications
Chapter 2:Satellite Orbits
Chapter 3:Satellite Subsystems
Chapter 4:The RF Link

Chapter 1
Introduction to Satellite Communications

- A communications satellite is an orbiting artificial earth satellite that receives a communications signal from a transmitting ground station, amplifies and possibly processes it, then transmits it back to the earth for reception by one or more receiving ground stations

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**.

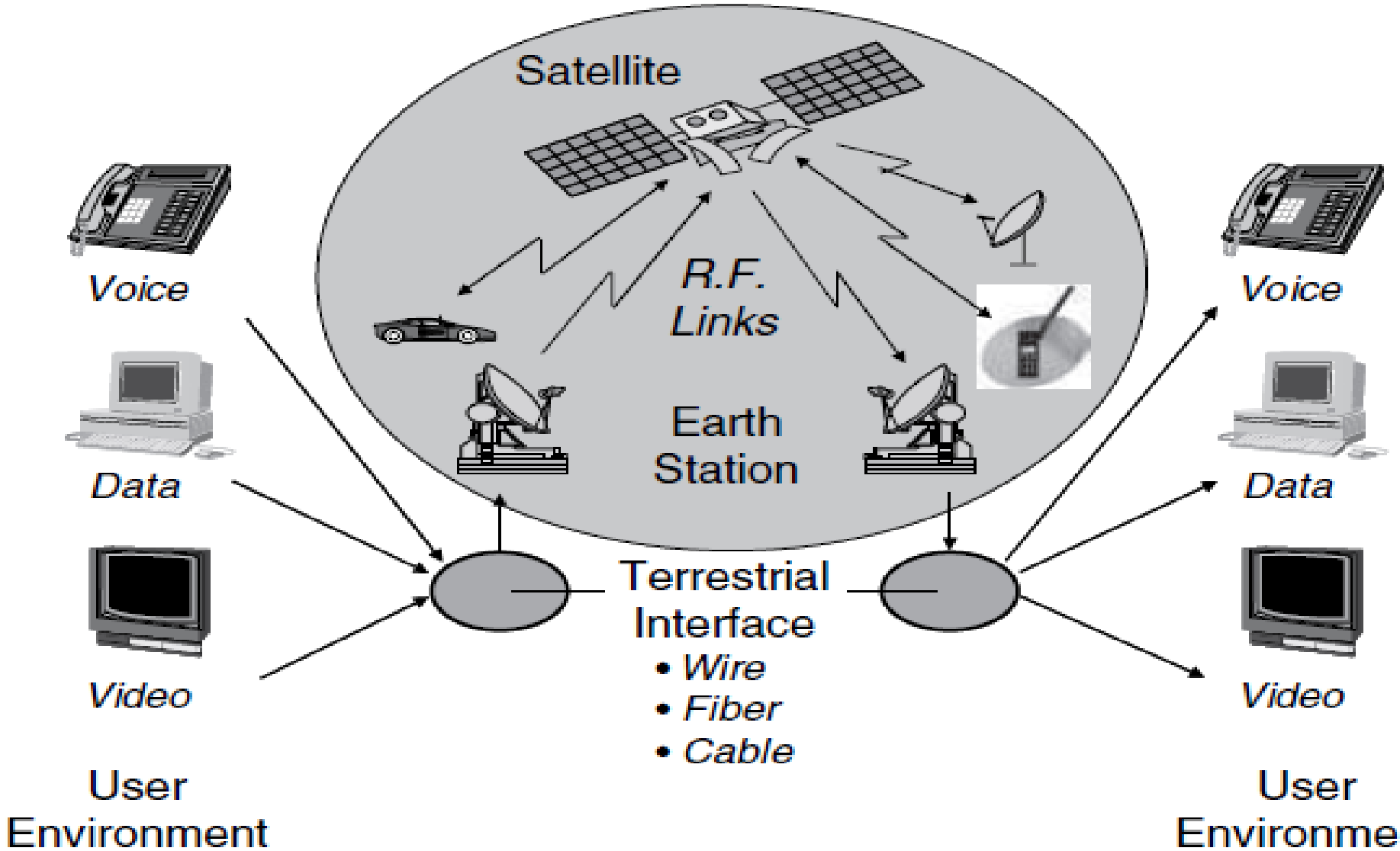
Basics: Advantages of Satellites

- The advantages of satellite communication over terrestrial(الارضية) 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.

Communications via satellite in the telecommunications infrastructure



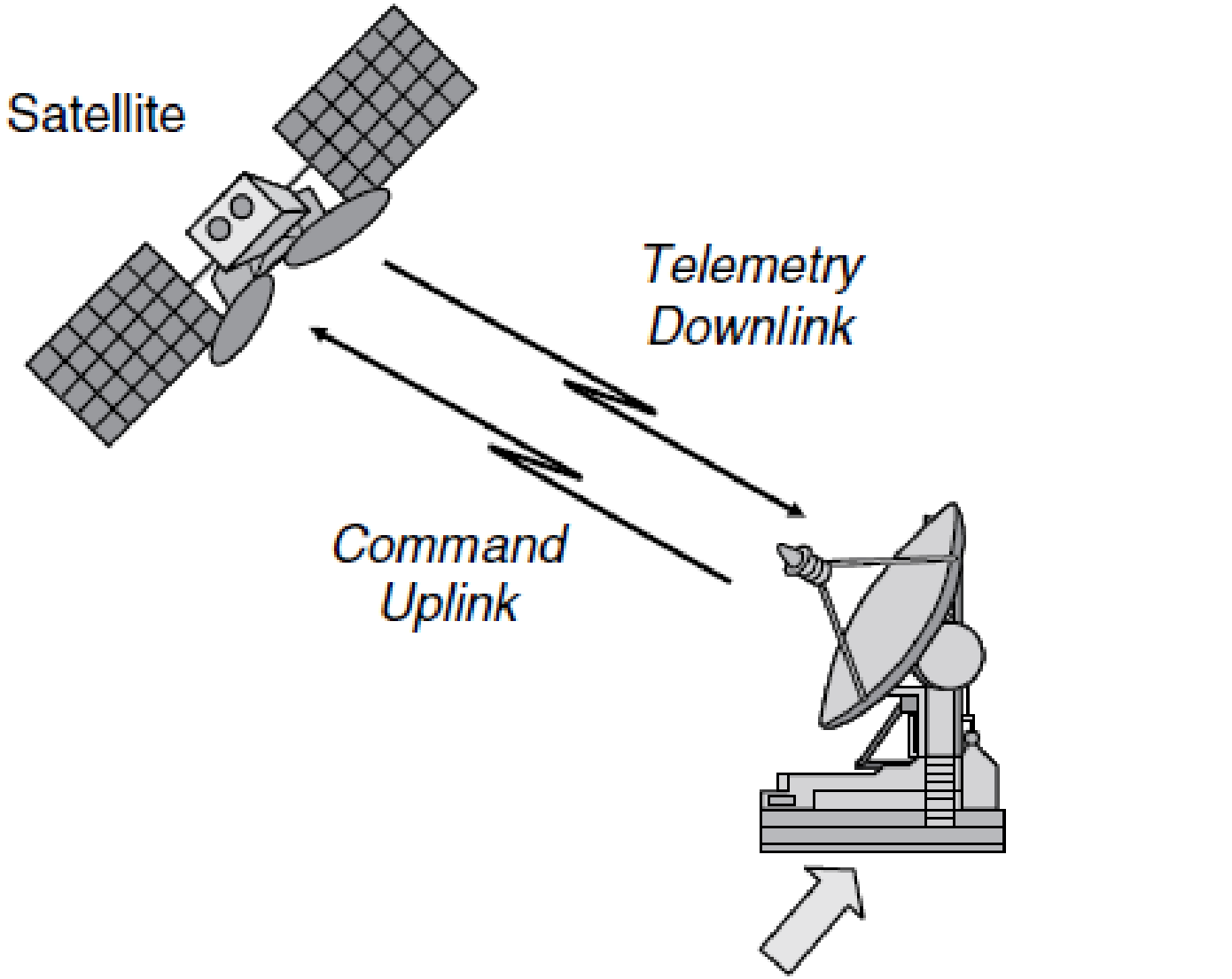
1.2 Some Basic Communications Satellite System Definitions

- This section provides some of the basic definitions and parameters used in the satellite communications industry, which will be used throughout the book in the evaluation and analysis of satellite communications systems design and performance

1.2.1 Satellite Communications Segments

1.2.1.1 Space Segment

- The space segment includes the satellite in orbit in the system, and the ground station that provides the operational control of the satellite(s) in orbit.
- The ground station is variously referred to as the ***Tracking, Telemetry, Command (TT&C)*** or the ***Tracking, Telemetry, Command and Monitoring (TTC&M)*** station


Satellite
Telemetry
Downlink
Command
Uplink
TT&C
(Tracking, Telemetry, Command) & Monitoring
(TTC&M)
Ground Station

Cont. Space Segment

- The TTC&M station provides essential spacecraft management and control functions to keep the satellite operating safely in orbit.
- The TTC&M links between the spacecraft and the ground are usually separate from the user communications links.
- TTC&M links may operate in the same frequency bands or in other bands.

1.2.1.2 Ground Segment

The ground segment of the communications satellite system consists of the earth surface area based terminals that utilize the communications capabilities of the Space Segment.
ground stations are not included in the ground segment.
The ground segment terminals consist of three basic types:

- fixed (in-place) terminals;
- transportable terminals;
- mobile terminals.

Cont. Ground Segment

- Fixed terminals are designed to access the satellite while fixed in-place on the ground.

  They may be providing different types of services, but they are defined by the fact that they are

  not moving while communicating with the satellite. Examples of fixed terminals are small terminals used in private networks, or terminals mounted on residence buildings used to receive broadcast satellite signals.

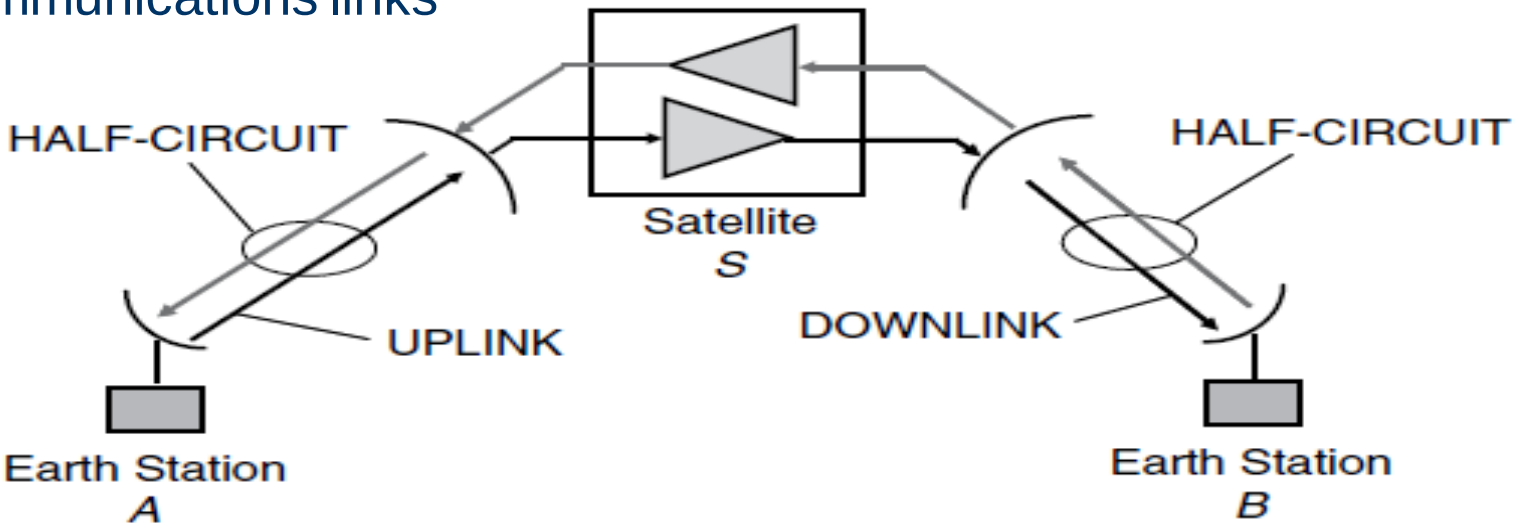
Cont. Ground Segment

- Transportable terminals are designed to be movable, but once on location remain fixed during transmissions to the satellite. Examples of the transportable terminal are satellite news gathering (SGN) trucks, which move to locations, stop in place, and then deploy an antenna to establish links to the satellite.
- Mobile terminals are designed to communicate with the satellite while in motion. They are further defined as land mobile, aeronautical الطيرانmobile, or maritimeبحري mobile

1.2.2 Satellite Link Parameters

The communications satellite link is defined by several basic parameters, some used in traditional communications system definitions, others unique to the satellite environment.

The figure summarizes the parameters used in the evaluation of satellite communications links



CHANNEL – one way link from $A \rightarrow B$ or $B \rightarrow A$
CIRCUIT – full duplex link – $A \rightleftarrows B$
HALF CIRCUIT – two way link – $A \rightleftarrows S$ or $S \rightleftarrows B$
TRANSPONDER – ▷ basic satellite repeater electronics, usually one channel

Cont Satellite Link Parameters

Two one way free-space or *air links* between Earth Stations *A* and *B

The *uplink* is the link from the earth station to the satellite

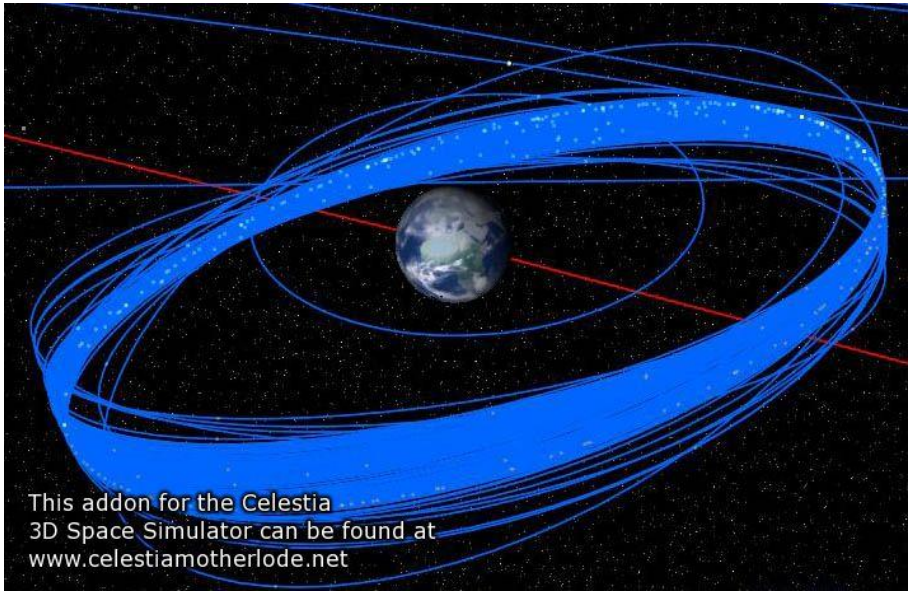
The *downlink* is the link from the satellite to the ground

The *transponder* is the electronics part in the satellite that receives the uplink signal, amplifies and possibly processes the signal, and then reformats and transmits the signal back to the ground.

the ***transponder***, designated by the triangular amplifier symbol in the figure (the point of the triangle indicates the direction of signal transmission)

1.2.3 Satellites Orbits

- Satellite Orbits
  - GEO
  - LEO
  - MEO
  - HAPs



1mile=0.87 nmi (nautical بحريmile)
1mile=1.609km

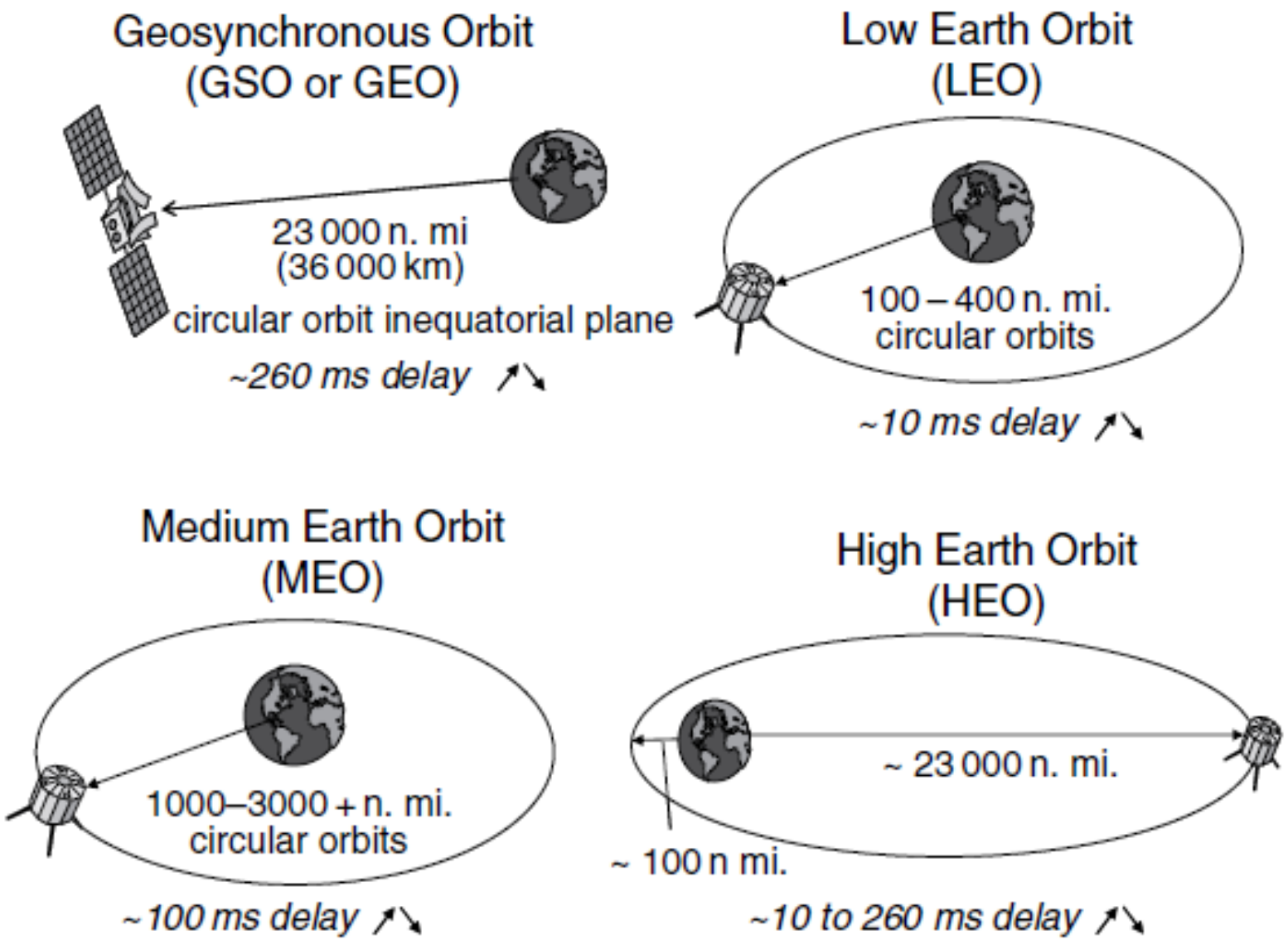


Figure 1.4 Satellite orbits

Geostationary Earth Orbit (GEO) or Geosynchronous Orbit (GSO)

- These satellites are in orbit 35,863 km above the earth's surface along the equatorخط الاستواء.
- Objects in Geostationary orbit revolve تدور حول 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 قرب 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 cause by their relative movement.
  - Atmospheric drag effects LEO satellites, causing gradual orbital deterioration يتدهور.

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.

High Earth Orbit (HEO)

- The HEO is the only non-circular orbit of the four types. It operates with an elliptical orbit, with a maximum altitude (apogee) similar to the GSO, and a minimum altitude (perigee) similar to the LEO. The HEO, used for special applications where coverage of high latitude locations is
- Required.
- Satellite orbits that are not synchronous, such as the LEO, MEO, or HEO, are often referred to as non-geosynchronous orbit (NGSO) satellites.

1.2.4 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 الارصاد الجويه 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**

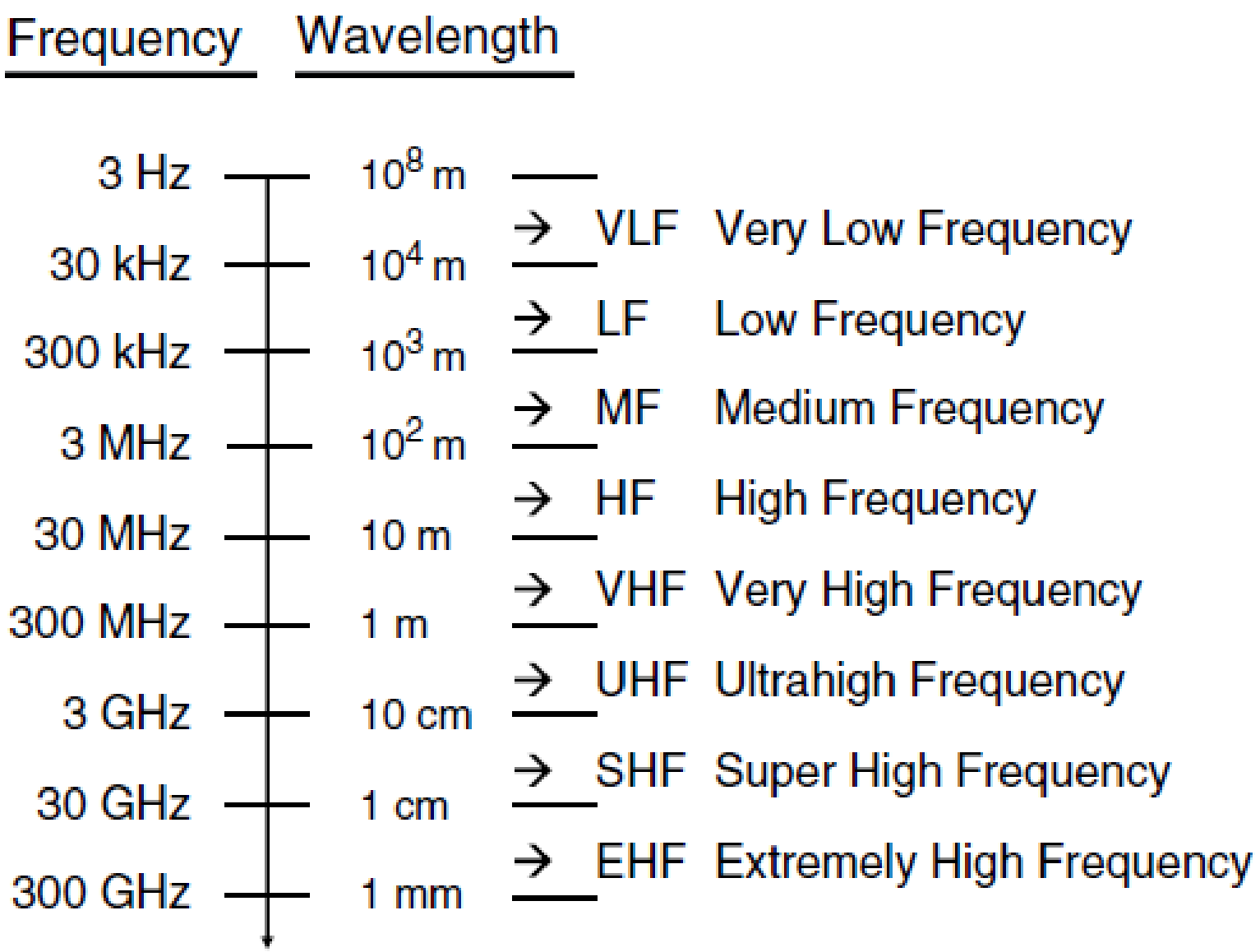


Figure 1.6 Frequency band designations by wavelength