# Kepler’s Second Law

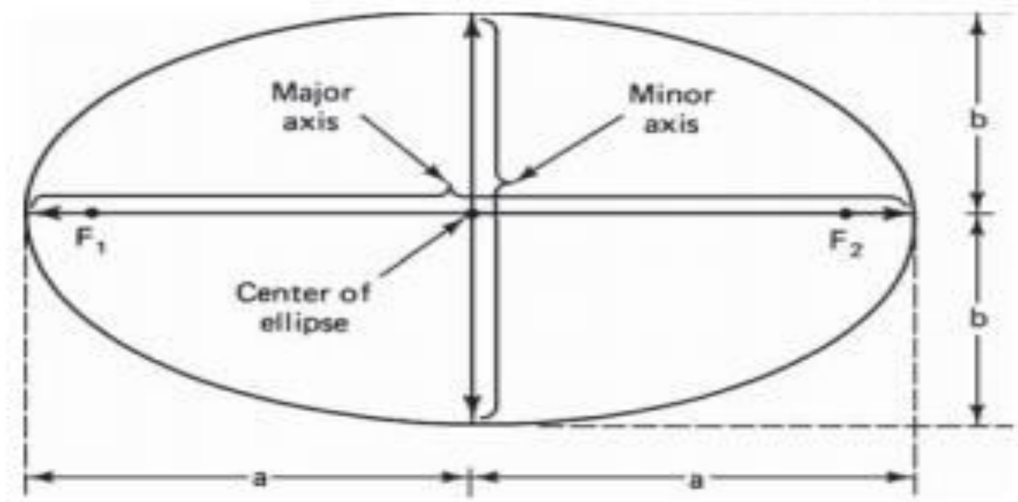
Kepler’s laws apply quite generally to any two bodies in space which interact through gravitation. The more massive of the two bodies is referred to as the primary, the other, the secondary or satellite.

# Kepler's First Law

- Kepler's first law states that the path followed by a satellite around the primary will be an ellipse. An ellipse has two focal points shown as F1 and F2 in Fig. 2.1. The center of mass of the two-body system, termed the barycenter, is always centered on one of the foci. In our specific case, because of the enormous difference between the masses of the earth and the satellite, the center of mass coincides with the center of the earth, which is therefore always at one of the foci

- The semimajor axis of the ellipse is denoted by a, and the semiminor axis, by b. The eccentricity e is given by

$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

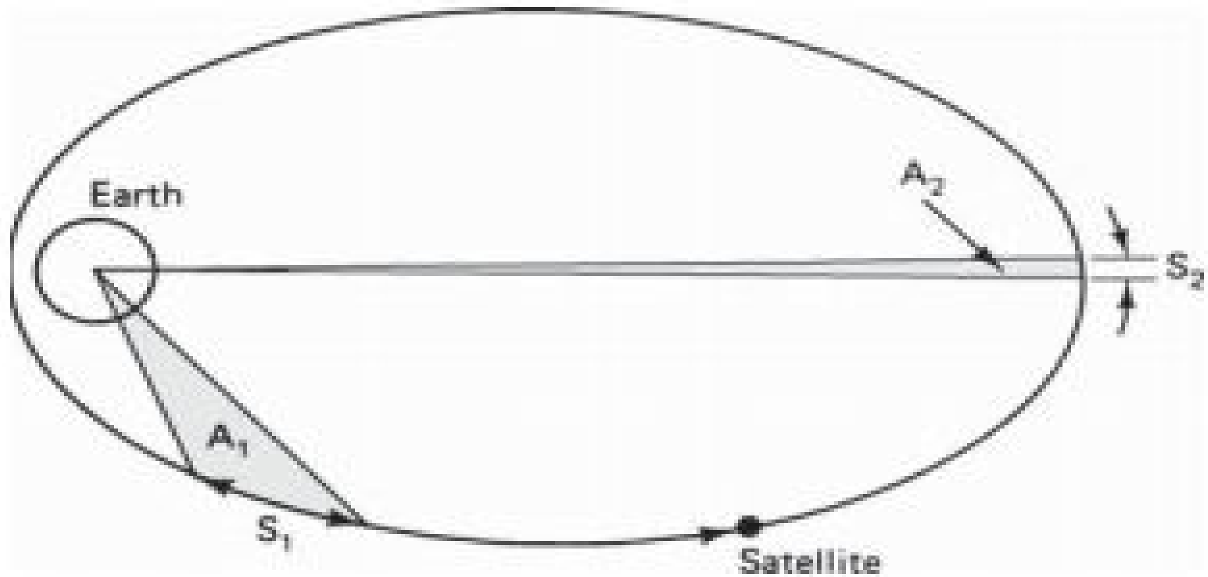



The foci F1 and F2, the semimajor axis a, and the semiminor axis b of an ellipse.

- The eccentricity and the semimajor axis are two of the orbital parameters specified for satellites (spacecraft) orbiting the earth. For an elliptical orbit, 0 e 1. When e  0, the orbit becomes circular. The geometrical significance of eccentricity, along with some of the other geometrical properties of the ellipse, is developed in App. B.

# Kepler’s Second Law

- Kepler’s second law states that, for equal time intervals, a satellite will sweep out equal areas in its orbital plane, focused at the barycenter. Referring to Fig. 2.2, assuming the satellite travels distances S1 and S2 meters in 1 s, then the areas A1 and A2 will be equal. The average velocity in each case is S1 and S2 m/s, and because of the equal area law, it follows that the velocity at S2 is less than that at S1. An important




Kepler’s second law. The areas A1 and A2 swept out in unit time are equal.

- consequence of this is that the satellite takes longer to travel a given distance when it is farther away from earth. Use is made of this property to increase the length of time a satellite can be seen from particular geographic regions of the earth

# Kepler's Third Law

- *Kepler's third law* states that the square of the periodic time of orbitis proportional to the cube of the mean distance between the twobodies. The mean distance is equal to the semimajor axis $a$. For theartificial satellites orbiting the earth, Kepler's third law can be writtenin the form

$$a^3 = \frac{\mu}{n^2}$$

where $n$ is the mean motion of the satellite in radians per second and  is the earth's geocentric gravitational constant.

# Apogee and Perigee Heights

- Although not specified as orbital elements, the apogee height and perigee height are often required. As shown in App. B, the length of the radius vectors at apogee and perigee can be obtained from the geometry of the ellipse

$$r_a = a(1 + e)$$

$$r_p = a(1 - e)$$

# ELEMENTS OF SATELLITE COMMUNICATIONS

- Two major elements of Satellite Communications Systems are
- Space Segment
- Ground Segment

The Space Segment includes

- Satellite
- Means for launching satellite
- Satellite control centre for station keeping of the satellite

The functions of the ground segment are to transmit the signal to the satellite and receive the signal from the satellite. The ground segment consists of

- Earth Stations
- Rear Ward Communication links
- User terminals and interfaces
- Network control centre

- Schematic block diagram showing the elements of Satellite Communications System is shown in fig. next slid

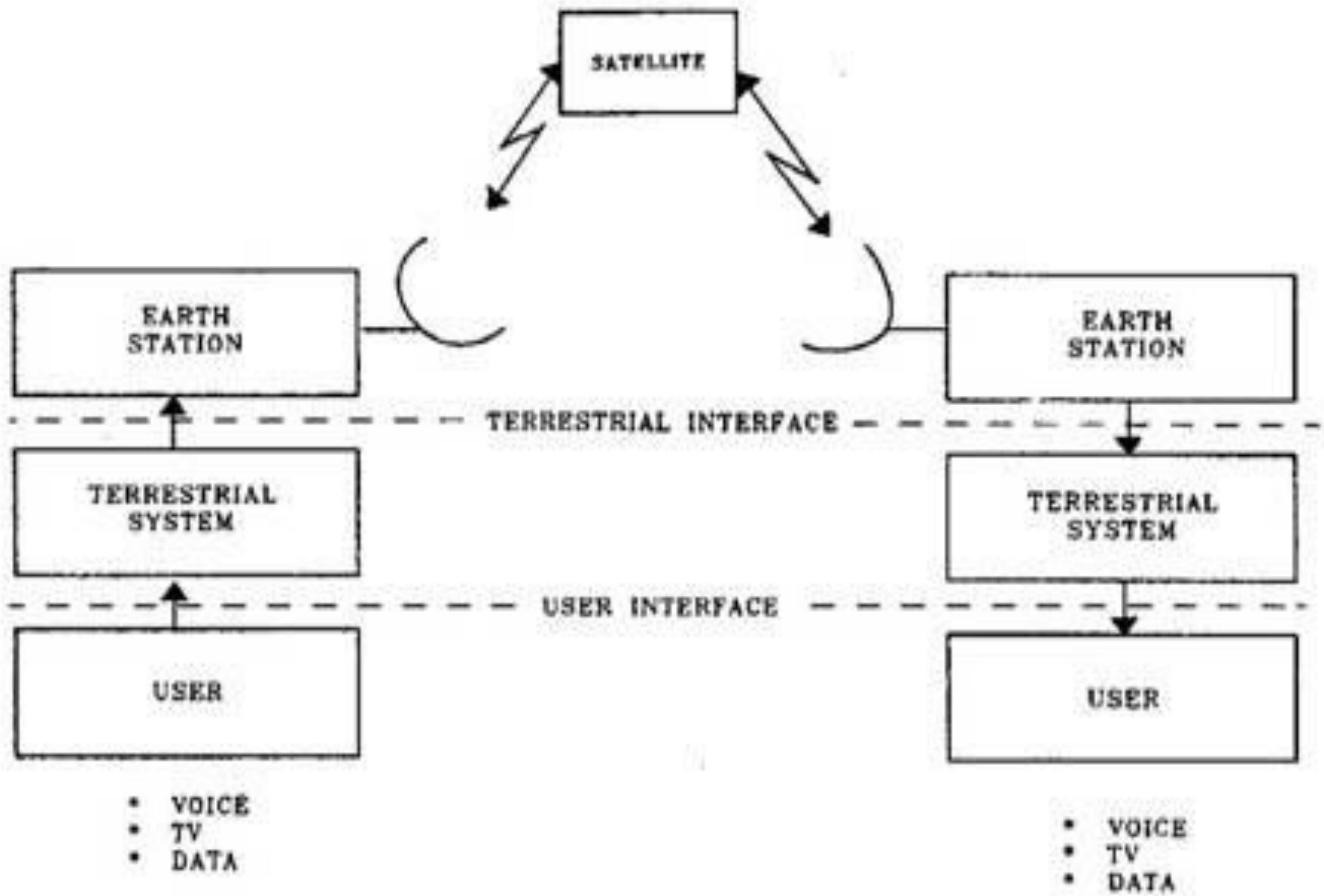



FIG. 2. ELEMENTS OF A SATELLITE COMMUNICATION SYSTEM

# SPACE SEGMENT

Communication satellites are very complex and extremely expensive to procure & launch.

The communication satellites are now designed for 12 to 15 years of life during which the communication capability of the satellite earns revenue, to recover the initial and operating costs. Since the satellite has to operate over a long period out in the space the subsystems of the satellite are required to be very reliable. Major subsystems of a satellite are:

- Satellite Bus Subsystems
- Satellite Payloads

# Satellite Bus subsystems:

- Mechanical structure
- Attitude and orbit control system
- Propulsion System
- Electrical Power System
- Tracking Telemetry and Command System
- Thermal Control System

# Satellite Payloads

- Communication transponders
- Communication Antennas

Since the communications capacity earns revenue, the satellite must carry as many communications channels as possible. However, the large communications channel capacity requires large electrical power from large solar arrays and battery, resulting in large mass and volume. Putting a heavy satellite in geosynchronous orbit being very expensive, it is logical to keep the size and mass of the satellite small. Lightweight material optimally designed to carry the load and withstand vibration & large temperature cycles are selected for the structure of the satellite.

- Attitude and orbit control system maintains the orbital location of the satellite and controls the attitude of the satellite by using different sensors and firing small thrusters located in different sides of the satellite.
- Liquid fuel and oxidizer are carried in the satellite as part of the propulsion system for firing the thrusters in order to maintain the satellite attitude and orbit. The amount of fuel and oxidizer carried by the satellite also determines the effective life of te satellite.
- The electrical power in the satellite is derived mainly from the solar cells. The power is used by the communications payloads and also by all other electrical subsystems in the satellite for house keeping. Rechargeable battery is used for supplying electrical power during ellipse of the satellite.