SATELLITE ORBITS

1.1 Introduction to satellite communication:

Satellites are specifically made for telecommunication purpose. They areused for mobile applications such as communication to ships, vehicles, planes, hand -held terminals and for TV and radio broadcasting.

They are responsible for providing these services to an assigned region (area) on the earth. The power and bandwidth of these satellites depend upon the preferred size of the footprint, complexity of the traffic control protocol schemes and the cost of ground stations.

A satellite works most efficiently when the transmissions arefocused with a desired area.

When the area is focused, then the emissions don‟t go outside that designated area and thus minimizing the interference to the other systems. This leads more efficient spectrum usage.

Satellite ‟ s antenna patterns play an important role and must be designed to best cover the designated geographical area (which is generally irregular in shape).

Satellites should be designed by keeping in mind its usability for short and long term effects throughout its life time.

The earth station should be in a position to control the satellite if itdrifts from its orbit it is subjected to any kind of drag from the external forces.

Applications Of Satellites:

- Weather Forecasting
- Radio and TV Broadcast
- Military Satellites
- Navigation Satellites
- Global Telephone
- Connecting Remote Area
- Global Mobile Communication

Kepler's laws

Introduction

Satellites (spacecraft) orbiting the earth follow the same laws thatgovern the motion of the planets around the sun.

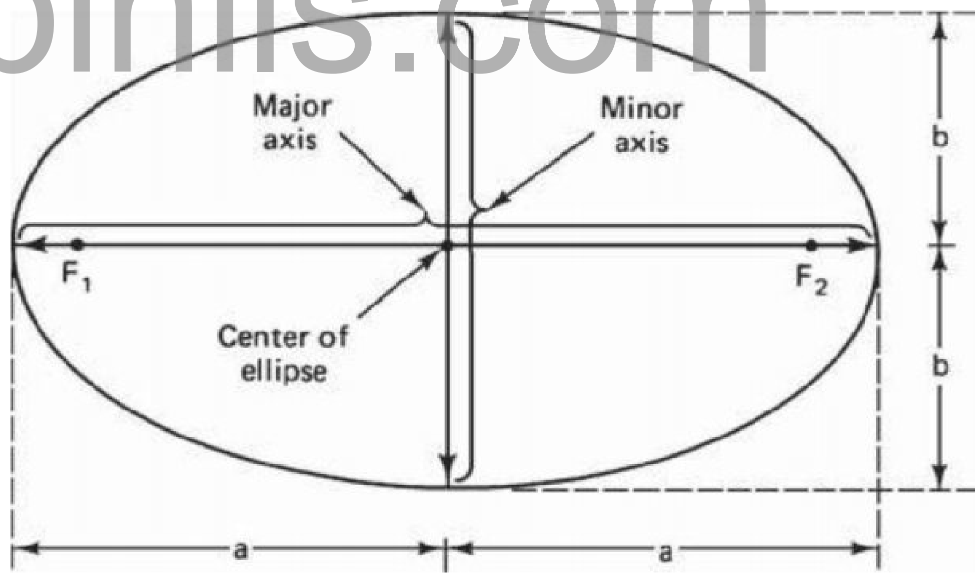
Kepler's laws apply quite generally to interact through gravitation. The moremassive of the two bodies is referred to as the *primary,* the other, the *secondary* or *satellite*.

Kepler's First Law:

Kepler's states*first*thatthe *law*pathfollowed by a satellite around the primary will be an ellipse. An ellipse hast Two focal points shown as*F*1 and *F*2in

The center of mass of the two-body system, termed the *bary center,* is alwayscenter of the foci.

The semi major axis of the ellipse is denoted by *a*, and the semi minor axis,



Kepler's Second Law :

*Kepler's second*statesthat, for*law*equal time intervals, a satellite will sweepout equal areas in its orbital plane, focused at the barycenter.

Referring to Fig, assuming the satellite travels distances *S*1 and *S*2 meters in 1 s, then the areas *A*1 and *A*2 will be equal. The average velocity in each case is *S*1 and *S*2 m/s, and because of the equal area law, it follows that the velocity at *S*2 is less than that at *S*1.

Kepler's second law the areas law*A*1and *A*2 swept out in unit time are equal.

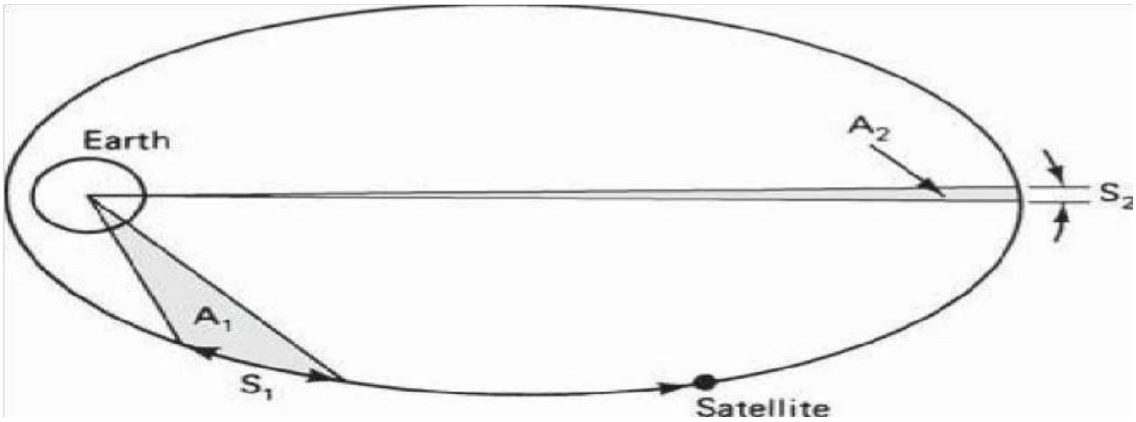


Figure Source of Dennis Roddy –Satellite Communication ,4th Edition

Kepler'sThird Law :

Kepler's states *third* that the *law* square of the periodic time of orbit is proportional to the cube of the mean distance between the two bodies. The mean distance is equal to the semi major axis *a*.For the artificial satellites orbiting the earth, Kepler's third written in the form Where n is the mean motion of the satellite in radians per second

and isthe earth's geocentric3.986005 gravitational x $10^{14} m^3/s^2$ const

Newton's law

Newton's first law:

An object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and in the same direction unless acted upon by an unbalanced force. This law is often called "the law of inertia".

Newton's second law:

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of forceneeded (to accelerate the object).

Newton's first law:

For every action there is an equal and opposite re-action. This means that for every force there is a reaction force that is equal in size, but oppositein direction. That is to say that whenever an object pushes another object it gets pushed back in the opposite direction equally hard.

orbital parameters:

Apogee: A point for a satellite farthest from the Earth. It is denoted as **ha.**

***Perigee*:** A point for a satellite closest from the Earth. It is denoted as **hp.**

Line of Apsides: Line joining perigee and apogee through centre of the Earth.It is the major axis of the orbit. One-half of this line‟s length is the semi-majoraxis equivalents to satellite‟s mean distance from the Earth.

Ascending Node: The point where the orbit crosses the equatorial planegoing from north to south.

Descending Node: The point where the orbit crosses the equatorial plane going from south to north.

Inclination: the angle between the orbital plane and the Earth‟s equatorial plane. Its measured at the ascending node from the equator to the orbit, going from East to North. Also, this angle is commonly denoted as **i.**

Line of Nodes: the line joining the ascending and descending nodes through the centre of Earth.

Prograde Orbit: an orbit in which satellite moves in the same direction as the Earth‟s rotation. Its inclination is always between 00 to 900. Many satellites follow this path as Earth‟s velocity makes it easier to lunch these satellites.

Retrograde Orbit: an orbit in which satellite moves in the same directioncounter to the Earth‟s rotation.

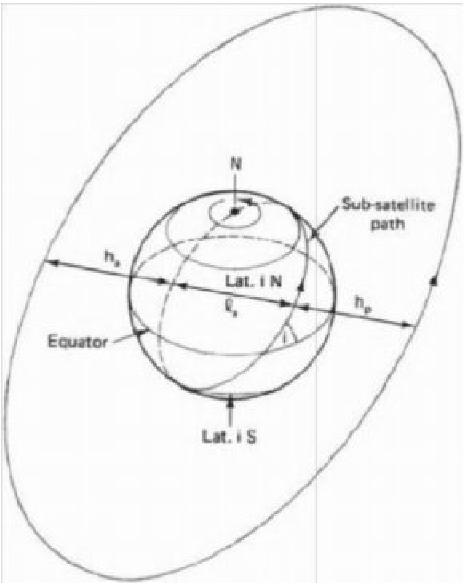
Argument of Perigee: An angle from the point of perigee measure in the orbital plane at the Earth‟s centre, in the direction of the satellite motion.

Right ascension of ascending node: The definition of an orbit in space, the position of ascending node is specified. But as the Earth spins, the longitude of ascending node changes and cannot be used for reference. Thus for practical determination of an orbit, the longitude and time of crossing the ascending node isused .For absolute measurement, a fixed reference point in space is required

It could also *right* be *ascension* defined *of the* ascending *node;*“ *right ascension isthe angular position measured eastward along the celestial equator from the vernal equinox vector to the hour circle of the object*”.

Mean anamoly: It gives the average value to the angular position of thesatellite with reference to the perigee.

True anamoly: It is the angle from point of perigee to the satellite's position,measure at the Earth‟s centre.



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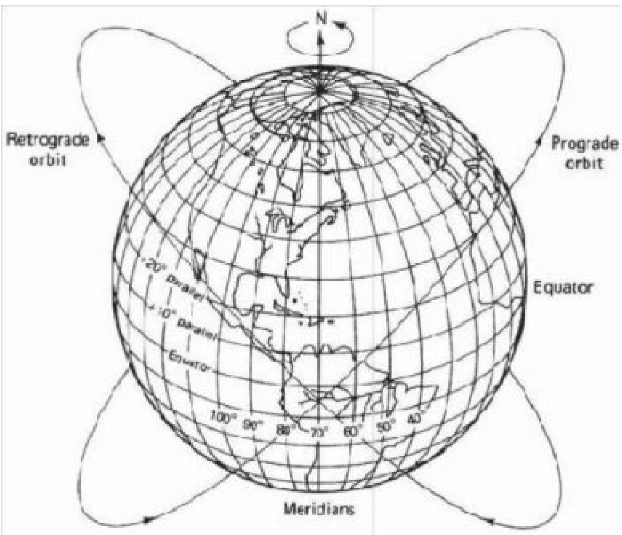


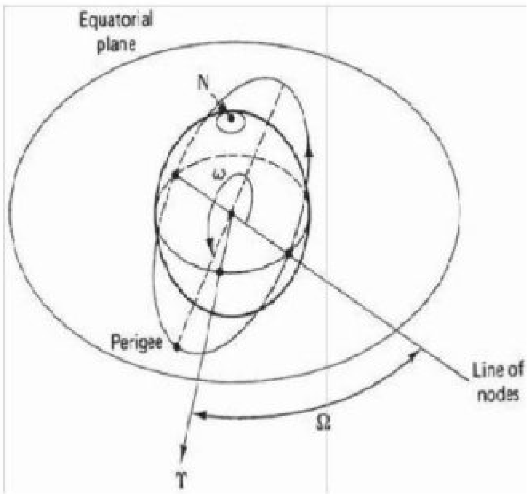


Figure Source of Dennis Roddy –Satellite Communication ,4th Edition

Atmospheric Drag:

For Low Earth orbiting satellites, the effect of atmospheric drag is more pronounces. The impact of this drag is maximumat the point of perigee. Drag (pull towards the Earth) has an effect on velocity of Satellite (velocity reduces).

This causes the satellite to not reach the apogee height successive revolutions. This leads to a change in value of semi-major axis and eccentricity. Satellites inservice are maneuvered by the earth station back to their original orbital position

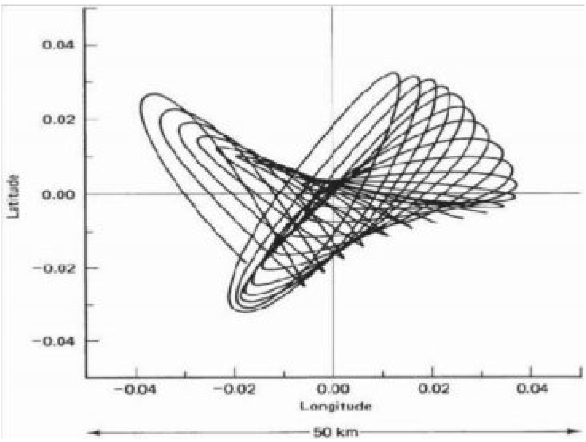
Station Keeping:

In addition to having its attitude controlled, it is important that a geostationarysatellite be kept in its correct orbital slot. The equatorial ellipticity of the earthcauses geostationary satel- lites to drift slowly along the orbit, to one

of two stable points, at 75°E and 105°W.

To counter this drift, an oppositely directed velocity com-ponent is imparted to the satellite by means of jets, which are pulsed once every 2 or 3 weeks

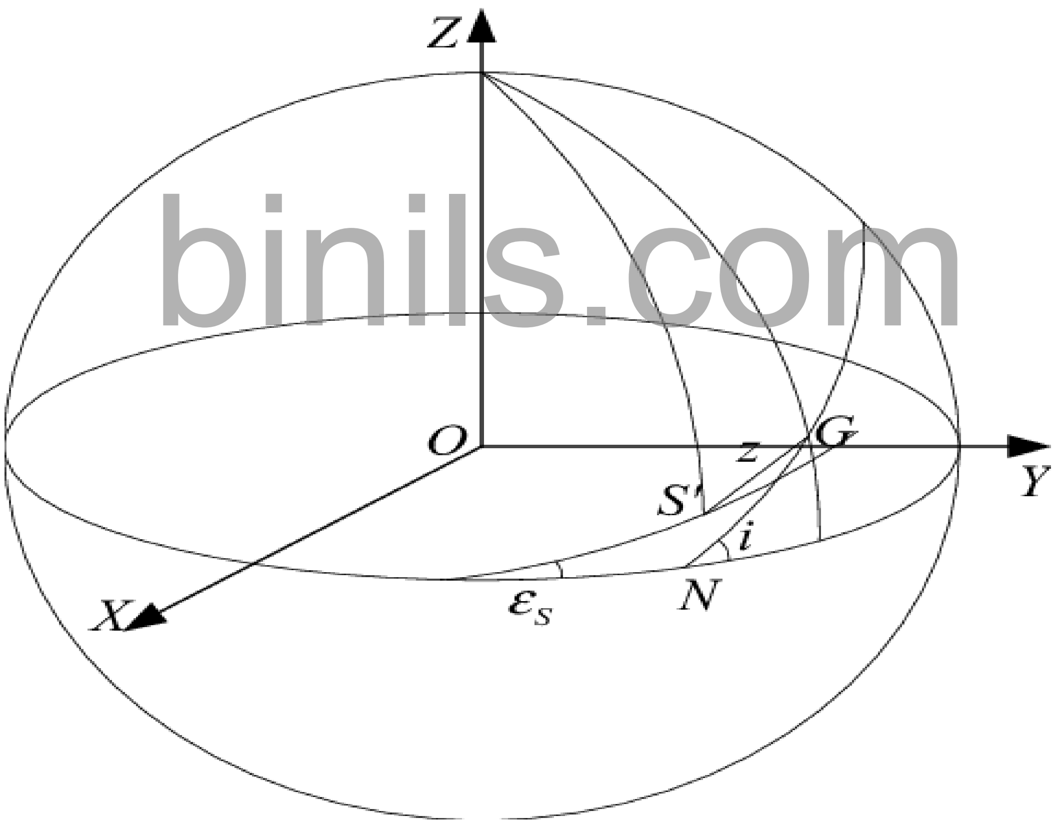
These maneuvers are termed *east-west station-keeping* Satellites in the 6/4-GHz band must be kept within 0.1°of the desig- nated longitude, and in the 14/12-GHz band, within 0.05°.
Typical satellite motion.



Sub satellite Point

- Point at which a line between the satellite and the center of theEarth intersects theEarth's surface
- Location of the point expressed in terms of latitude and longitude

- If one is in the US it is common to use o Latitude –degrees north fromequator o
Longitude –degrees west of the Greenwich meridian
- Location of the sub satellite point may be calculated from coordinates of the rotatingsystem as:



Sun Transit Outage :

Sun transit outage is an interruption in or distortion of geostationary satellite signals caused by interference from solar radiation.

Sun appears to be an extremely noisy source which completely blanks out the signal from satellite. This effect lasts for 6 days around the equinoxes. They occur for a maximum period of 10 minutes.

Generally, sun outages occur in February, March, September and October, thatis, around the time of the equinoxes.

At these times, the apparent path of the sun across the sky takes it directly behind the line of sight between an earth station and a satellite.

As the sun radiates strongly at the microwave frequencies used to communicate with satellites (C-band, Ka band and Ku band) the sun swamps the signal from the satellite.

The effects of a sun outage can include partial degradation, that is, an increase inthe error rate, or total destruction of the signal.

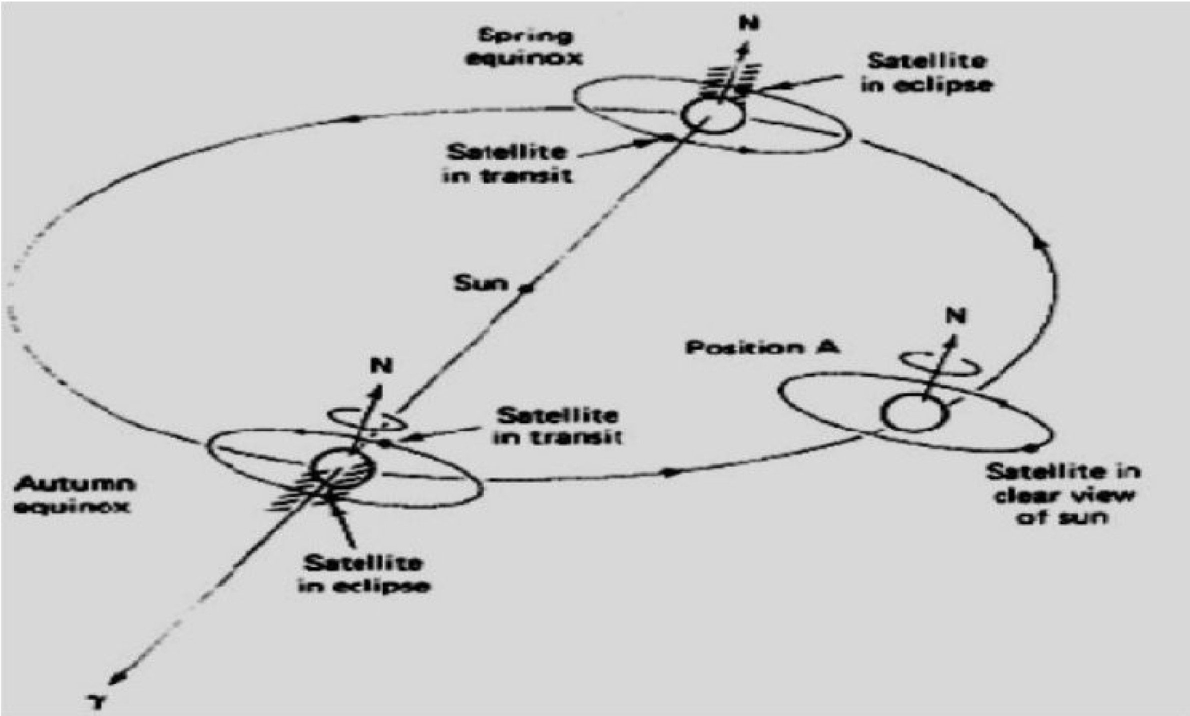


Figure: Earth Eclipse of a Satellite and un transit Outage

Launching Procedures :

Intoduction:

Low Earth Orbiting satellites are directly injected into their orbits. This cannot be done incase of GEOs as they have to be positioned 36,000kms above the Earth‟s surface.Launch vehicles are hence used to set these satellites in their orbits. These vehicles are reusable. They are also known as STS .

When the orbital altitude is greater than 1,200 km it becomes expensive to directly inject the satellite in its orbit.

About Hohmann Transfer Orbit: This manoeuvre is named for the German civil engineer who first proposed it, Walter Hohmann, who was born in 1880.

Travel that included people such as Willy Ley, Hermann, and Werner von Braun. He published his concept of how to transfer between orbits in his 1925 book, The Attainability of Celestial Bodies.

The transfer orbit is selected to minimize the energy required for the transfer. This orbit forms a tangent to the low attitude orbit at the pointof its perigee and tangentto high altitude orbit .