Comparative Study Of Leo, Meo & Geo Satellites

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ABSTRACT

A satellite is an artificial object which is intentionally placed into orbit for the large number of purposes. Common types include civilian and military Earth observation satellites, communication satellites, weather satellites, navigation satellites, and research satellites. There are many different satellite orbits that can be used like the LEO, MEO, GEO etc. The orbit that is chosen for a satellite depends upon its application. The actual satellite orbit that is chosen will depend on factors including its function, and the area it is to serve. The purpose of this paper is to statistically compare the Earth orbiting satellites namely geosynchronous orbits (GEO), low Earth orbits (LEO) and medium Earth orbits (MEO).

Keywords:- *Low Earth Orbit, Medium Earth Orbit, Geosynchronous Orbit*

1. INTRODUCTION

A satellite communication system uses satellites to relay radio transmissions between earth terminals. The two types of communications satellites are active and passive. A passive satellite reflects only the received radio signals back to the earth. An active satellite acts as a repeater; it amplifies signals received and then retransmits them back to the earth. This increases the signal strength at the receiving terminal to a higher level than would be available from a passive satellite. The two important parameters in satellite communication are the inclination and elevation angles. The inclination angle δ is defined between the equatorial plane and the plane described by the satellite orbit. An inclination angle of 0 degrees means that the satellite is exactly above the equator. In case if the satellite does not have a circular orbit, the closest point to the earth is called the perigee. These satellites are specifically made for telecommunication purpose and are also used for mobile applications such as communication to ships, planes, vehicles, hand-held terminals and for TV and radio broadcasting. They are also responsible for providing these services to an assigned region (area) on the earth. The bandwidth and power of these satellites depend upon the preferred size of the footprint, complexity in the traffic control protocol schemes and the cost of ground stations. Satellite communications play a vital role in the global telecommunications system. Approximately 2,000 artificial satellites orbiting Earth relay analog and digital signals carrying voice, data and video to and from one or many locations worldwide. Satellite communication comprises of two main components: the ground segment, consisting of fixed or mobile transmission, reception, ancillary equipment, and the space segment, which is primarily the satellite itself. These satellites are categorized on the basis of altitudes into three parts- LEO with altitudes (height) 500-1500 Km and orbital period of 10-40 minutes, MEO with altitudes (height) 5000-12000 Km and orbital period of 2-8 hrs and GEO with altitudes (height) 35,800 Km and orbital period of 24 hrs. Life of LEO is short in comparison to MEO and GEO. Propagation loss is least in LEO, high in MEO and highest in GEO.

2. MEASUREMENT OF SATELLITE SPEED AROUND THE EARTH

In space, gravity supplies the centripetal force that causes satellites (like the moon) to orbit larger bodies (like the Earth). A particular satellite can have only one speed when in orbit around a particular body at a given distance because the force of gravity doesn't change. For a satellite of a particular mass, m_1, to orbit, you need a corresponding centripetal force:

$$F_C = \frac{m_1 v^2}{r}$$

This centripetal force has to come from the force of gravity, so

$$\frac{G m_1 m_2}{r^2} = \frac{m_1 v^2}{r}$$

Rearranging this equation:

$$v = \sqrt{\frac{G m_2}{r}}$$

This equation represents the speed that a satellite at a given radius must travel in order to orbit if the orbit is due to gravity. The speed can't vary as long as the satellite has a constant orbital radius that is, as long as it's going around in circles. This equation holds for any orbiting object where the attraction is the force of gravity, whether it is a human-made satellite orbiting the Earth or the Earth orbiting the sun. If you want to find the speed of satellites that orbit the Earth, for example, take the mass of Earth in the equation:

$$v = \sqrt{\frac{G m_E}{r}}$$

Here are a few details to be noted for the orbiting speed equation:

- You have to use the distance from the center of the Earth, not the distance above Earth's surface, as the radius. Therefore, the distance you use in the equation is 6.38×10^6 meters.
- The equation assumes that the satellite is high enough off the ground that it orbits out of the atmosphere.
- The equation is independent of mass**.**

Human-made satellites typically orbit at heights of 400 miles from the surface of the Earth (about 640 kilometers, or 6.4×10^5 meters). The speed of such a satellite is:

$$v = \sqrt{\frac{G m_E}{r}} = \sqrt{\frac{\left(6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}\right)\left(5.98 \times 10^{24}\,\mathrm{kg}\right)}{\left(6.38 \times 10^6\,\mathrm{m}\right) + \left(6.40 \times 10^5\,\mathrm{m}\right)}} \approx 7.54 \times 10^3\,\mathrm{m/s}$$

This converts to about 16,800 miles per hour.

3. TYPES OF SATELLITES (BASED ON ORBITS)

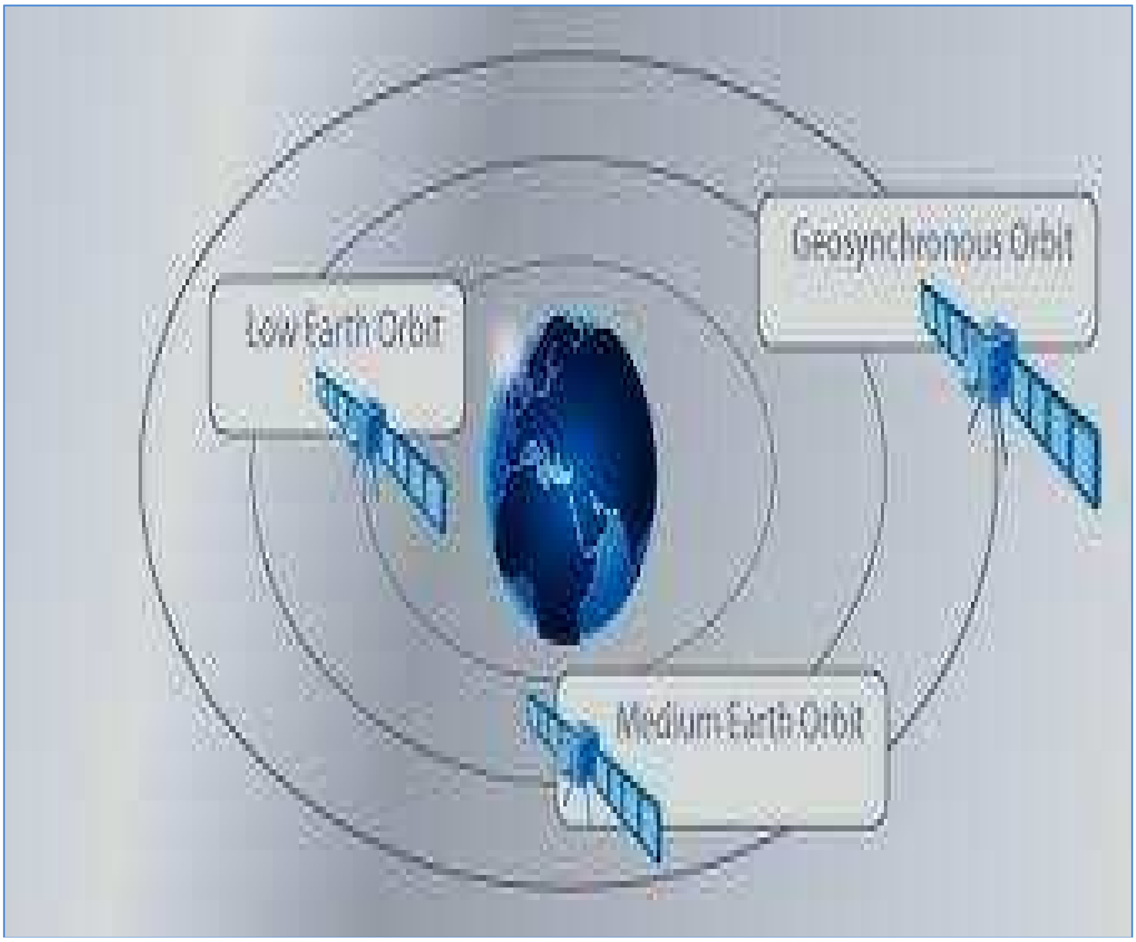

Figure 1: Various positions of satellites based on the type of orbit

3.1 Geostationary or Geosynchronous Earth Orbit (GEO)

GEO satellites are synchronous with respect to earth. Looking from a fixed point on Earth, these satellites appear to be stationary and are placed in the space in such a way that only three satellites are sufficient to provide connection throughout the surface of the Earth (that is almost 1/3rd of the Earth is covered by their footprint). The orbit of these satellites is circular.

There are three conditions which lead to geostationary satellites.

1) The satellite should be placed 37,786 kms (36,000 kms approx.) above the surface of the earth.

2) These satellites must travel as the rotational speed of earth, and in the direction of motion of earth, that is eastward.

3) The inclination of satellite with respect to earth must be 00.

3.2 Low Earth Orbit (LEO) satellites

LEO satellites are placed 500-1500 kms above the surface of the earth. As LEOs circulate on a lower orbit, they exhibit a much shorter period that is 95 to 120 minutes. LEO systems always try to ensure a high elevation for every spot on earth to provide a high quality communication link. Each LEO satellite will be visible from the earth only for ten minutes. Using advanced schemes for compression, transmission rates of about 2,400 bit/s is enough for voice communication. LEOs also provide this bandwidth for mobile terminals with Omni-directional antennas using low transmit power in the range of 1W(Watt). The delay for packets delivered via a LEO is relatively low (10 ms approx) and is comparable to long-distance wired connections (about 5–10 ms). While smaller footprints of LEOs allow for better frequency reuse, similar to the concepts used in cellular networks. LEOs can provide a much higher elevation in Polar Regions and so better global coverage.

3.3 Medium Earth Orbit (MEO) satellites

MEOs can be positioned somewhere between LEOs and GEOs, in terms of their orbit as well as due to their advantages and disadvantages. Using the orbits around 10,000 km, requires a dozen of satellites which are more than a GEO system, but less than a LEO system. These satellites move much slowly relative to the earth's rotation allowing a simpler system design (six hours orbital period). Depending on the inclination, a MEO can cover larger populations, so requires fewer handovers.

4. DIFFERENCE BETWEEN LEO, MEO & GEO

Parameter	LEO	MEO	GEO

Satellite Height	500-1500 km	5000-12000 km	35,800 km
Orbital Period	10-40 min.	2-8 hours	24 hours
Number of Satellites	40-80	8-20	3
Satellite Life	Short	Long	Long
Number of Handoffs	High	Low	Least(none)
Gateway Cost	Very expensive	Expensive	Cheap
Propagation Loss	Least	High	Highest

5. CONCLUSION

LEOs are mostly used for data communication such as paging e-mail and videoconferencing. LEOs are not fixed in space in relation to the rotation of the earth, so they move at very high speeds and therefore data being transmitted via LEOs must be handed off from one satellite to the next as the satellites move in and out of range of the earth-bound transmitting stations that are sending the signals into space and because of the low orbit, the transmitting stations do not have to be as powerful as those that transmit to satellites orbiting at greater distances from the earth's surface. LEO telecommunication systems prove to be a promising technology because they provide the ability for underdeveloped territories to acquire satellite telephone service in areas where it is either too costly or not geographically possible to lay land lines. In this region, the most common use for satellites is for navigation, communication and space or geodic environment science. Geosynchronous satellites have the advantage of remaining permanently in the same area of sky, as viewed from a particular location on the Earth, and so are permanently within view of a given ground station. Geostationary satellites have a special property of remaining permanently fixed in exactly the same position in the sky, so ground-based antennas do not need to track them but can remain fixed in one direction These satellites have revolutionized global communications, television broadcasting ,weather forecasting and also have a number of defense and intelligence applications.

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