

# Satellite Communications - A Review

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**Abstract:** Satellite communication is one of the most impressive spin-offs from the space programs and has made a major contribution to the pattern of international communication. A communication satellite is basically an electronic communication package placed in orbit whose prime objective is to initiate or assist another through space. This paper will explain overview of satellite communications, its working, types of satellites and services provided by these communications. This communication further includes satellite orbits and their comparison. We had also discussed satellite merits and demerits which made this communication successful along with its applications in today world (usage). New invention satellites are also discussed.

**Keywords:** Need, Elements, Orbits, Merits and demerits of satellite, satellite Footprints, Yamal 402, Intelsat 23.

## I. BACKGROUND AND INTRODUCTION

Satellite technology has progressed tremendously over the last 50 years since Arthur C. Clarke first proposed its idea in 1945 in his article in Wireless World. In 1962, the American telecommunications giant AT&T launched the world's first true communications satellite, called Telstar. Since then, countless communications satellites have been placed into earth orbit, and the technology being applied to them is forever growing in sophistication as shown in fig 1. Today, satellite systems can provide a variety of services including broadband communications, audio/video distribution networks, and maritime navigation, worldwide customer service and support as well as military command and control. Satellite systems are also expected to play an important role in the emerging 4G global infrastructure providing the wide area coverage necessary for the realization of the optimally connected anywhere, anytime vision that drives the growth of modern telecommunication industry.

A satellite is an object that orbits or revolves around another object. For example, the moon is a satellite of the sun. They are highly specialized wireless receiver or transmitters that are launched by a rocket and placed in orbit around the earth. A satellite communications system uses satellites to relay radio transmissions between earth terminals. Satellite launching involves a lot of investment and hard labour by scientists. The satellites ought to be light weight and durable. The satellites are generally equipped with an antenna and transponder to facilitate the communication process. The satellite majorly works on the solar power which is continuously received by the satellite's solar panels.

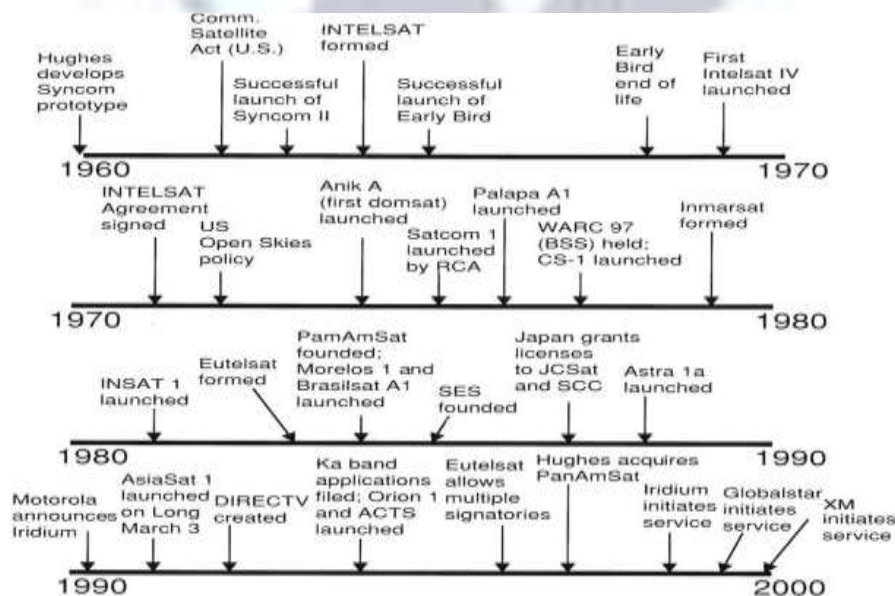


Fig. 1 Evolution of satellite communication [2]

### 1.1 Need of Satellite Communication

In early 1960's the American Telephone and Telegraph Company (AT&T) released studies indicating that a few powerful satellites of advanced design could handle more traffic than the entire American long distance communication network. The cost was also not too much with respect to long distance communication network. Satellite systems offer more flexibility than submarine cables, buried underground cables, line-of-sight microwave radio or optical fibre systems.

### 1.2 Types of Satellites

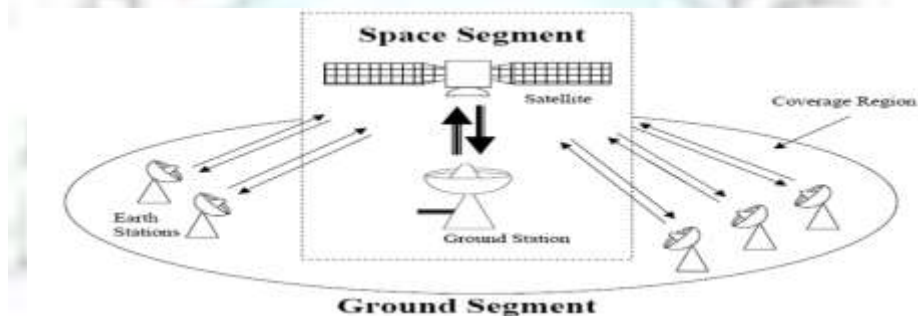
1. **Passive Satellite:** A satellite that only reflects signals from one Earth station to another, or An Earth satellite intended to transmit radio communication signals by reflection is passive satellite.
2. **Active Satellite:** A satellite carrying a station intended to transmit or retransmit radio communication signals. It performs signal processing functions such as amplification, regeneration, frequency translation, and link switching, to make the signals suitable for retransmission. Sputnik1 was the first active satellite launched.

## II. ELEMENTS OF SATELLITE COMMUNICATION

The basic elements of a communication satellite service are divided between and shown in fig 2:

1. Space Segment.
2. Ground Segment.

The space segment consists of the spacecraft and launch mechanism and ground segment comprises the earth station and network control centre of entire satellite system.

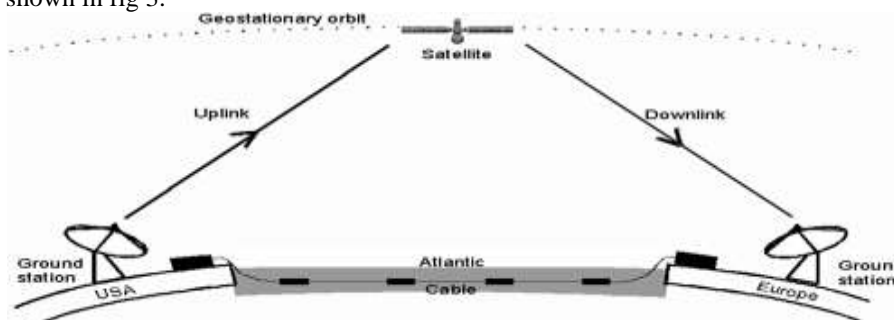


**Fig. 2 Components of satellite communication**

### 2.1 Satellite Communication Structure

A communications satellite is a microwave repeater station that permits two or more users with appropriate earth stations to deliver or exchange information in various forms. [2] Its height above the Earth means that signals can be transmitted over distances that are very much greater than the line of sight. An earth station transmits the signal up to the satellite. This is called the up-link and is transmitted on one frequency. The satellite receives the signal and retransmits it on what is termed the down link which is on another frequency. Different frequencies are used for uplink and downlink.

The heart of a satellite communications system is a satellite-based antenna in a stable orbit above the earth. In this mode of communications, two or more stations on or near the earth communicate via one or more satellites that serve as relay stations in space. The antenna systems on or near the earth are referred to as earth stations. A transmission from an earth station to the satellite is referred to as uplink, whereas transmissions from the satellite to the earth station are downlink. The component in the satellite that takes an uplink signal and converts it to a downlink signal is called a transponder [3] as shown in fig 3.



**Fig. 3 Structure of Satellite communication**

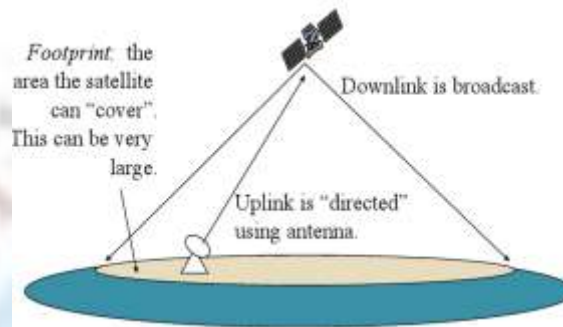
### III. TYPES OF SATELLITE SERVICE

- 1) Fixed Service Satellite: The fixed satellite system helps in the transfer of numerous data and information across the countries through fixed point on the earth's surface.
- 2) Mobile Service Satellite: It is helpful in connecting ships, aircrafts at distant and remote places.
- 3) Research Service Satellite: Research Satellite System is primarily helpful in various research processes for the scientists. The scientists can gather all the necessary and useful data through the research satellite system.

### IV. SATELLITE FOOTPRINTS

Satellite beams their signals in a straight path to the earth. The satellite focuses these microwaves signals onto the specified portions of the earth's surface to most effectively use the limited power of their transponders as shown in fig 4. These focused signals create unique beam patterns called footprints. The following are the types of footprints:

- Global beam footprint.
- Hemispheric Beam Footprint.
- Zone Beam Footprint. <sup>[6]</sup>



**Fig. 4 Satellite Footprints**

### V. SATELLITE ORBITS

An orbit is the gravitationally curved path of an object around a point in space. An open orbit has the shape of a hyperbola or a parabola. A closed orbit has the shape of an ellipse. Orbit changes can be used to extend the life of satellites. They are classified as shown in fig 5 and comparison in tab 1:

- LEOs- Low Earth Orbit.
- MEOs- Medium Earth Orbit.
- HEOs- Highly Elliptical Orbit.
- GSO- Geostationary Earth Orbit.

**Table.1: Comparison of Satellite Orbits <sup>[3]</sup>**

Orbits	LEO	MEO	GEO
Orbital Period	1.5 to 2 h	5 to 10 h	24 h
Altitude range	500 to 1500 km	8000 to 18,000 km	35,863 km
Visibility range	15 to 20 min/pass	2 to 8 hr/pass	Permanent
Elevation	Rapid variations; high and low angles	Slow variations; high angles	No variation; low angles at high latitudes
Round trip propagation delay	Several milliseconds	Tens of milliseconds	~250 ms
Instantaneous ground coverage	~6000 km	~12,000 to 15,000 km	16,000 km
Examples of systems	Orbcomm	Odyssey Inmarsat	Intelsat

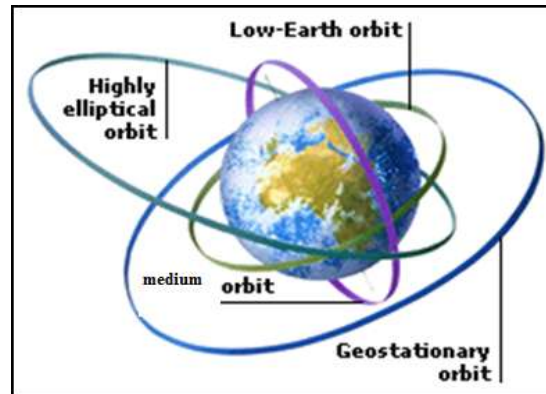


Fig.5: Satellite Orbits

### A. Low Earth Orbit

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. LEO satellites provide voice and low speed data communications. [4] These satellites can operate with handheld units about the size of a large cellular phone.

#### 1) Advantages of LEO:

- A LEO satellites proximity 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 satellites smaller area of coverage is less of a waste of bandwidth.

#### 2) Disadvantages of LEO:

- 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.

### B. Medium Earth Orbit

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.

#### 1) Advantage of MEO:

- A MEO satellites longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network.
- A progression/higher skills level from LEO satellites.

#### 2) Disadvantage of MEO:

- A MEO satellites distance gives it a longer time delay and weaker signal than a LEO satellite, though not as bad as a GEO satellite.
- Direct flight to MEO is unlikely, therefore propulsion is required.
- Mass of fuel represents loss of payload.

### C. Highly Elliptical Orbit

A highly elliptical orbit is an elliptic orbit with a low-altitude about 1,000 kilometres perigee and a high-altitude over 35,786 kilometres apogee. Perigee is the closest point and apogee is the farthest point. If the orbit is very elliptical; the satellite will spend most of its time near apogee (the furthest point in its orbit) where it moves very slowly. [1] Thus it can be above home base most of the time, taking a break once each orbit to speed around the other side.

#### 1) Advantage of HEO:

- The highly elliptical satellite orbit can be used to provide coverage over any point on the globe. The HEO is not limited to equatorial orbits like the geostationary orbit and the resulting lack of high latitude and polar coverage.

**1) Disadvantage of HEO:**

- With two satellites in any orbit, they are able to provide continuous coverage. The main disadvantage is that the satellite position from a point on the Earth does not remain the same.

**D. Geostationary Earth Orbit**

GEO are located 36,000 km above the Earth in a fixed position and provide service to a country or a region covering up to one third of the globe. They are capable of providing a full range of communications services, including voice, video and broadband data. <sup>[4]</sup>These satellites operate with ground equipment ranging from very large fixed gateway antennas down to mobile terminals the size of a cellular phone.

**1) Advantages of GEO:**

- A GEO satellites 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.

**2) Disadvantages of GEO:**

- A GEO satellites distance also causes 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, centred above the equator, have difficulty broadcasting signals to near polar regions.

**VI. YAMAL 402 and INTELSAT 23: LAUNCHED**

Intelsat 23 is one of a series of Intelsat communications satellites which are in geosynchronous orbit so that they are always located over the same part of the earth. It will be located over the equator at 307 East and is intended to replace Intelsat 707, which was launched in 1996. Intelsat 23 was launched by International Launch Services on 14 October 2012. Intelsat 23 is a communications satellite run by Intelsat which will provide communications services for the Americas, Western Europe and Africa. <sup>[1][8][9]</sup>

Yamal-402 is a Russian geostationary communications satellite. It was launched on 8 December 2012. It has a design life of 15 years, but reducing to 11 years expected after launch partial failure. On 15 December 2012, Yamal-402 was taken to its planned geostationary orbit at the altitude of 36,000 km following a series of four adjustment operations. <sup>[8][9]</sup>

**VII. ADVANTAGES OF SATELLITE COMMUNICATION**

Satellites are able to provide communications in many instances where other forms of communications technology may not provide a feasible alternative. Satellite communications provide a number of advantages which are depicted below:

- 1) Flexibility: Satellite systems are able to provide communications in a variety of ways without the need to install new fixed assets.
- 2) Mobility: Satellite communications are able to reach all areas of the globe dependent upon the type of satellite system in use, and the ground stations do not need to be in any one given location. For this reason, many ships use satellite communications.
- 3) Speedy deployment: Deployment of a satellite communications system can be very speedy. No ground infrastructure may be required as terrestrial lines, or wireless base stations are not needed. Therefore many remote areas, satellite communications systems provide an ideal solution.
- 4) Provides coverage over the globe: Dependent upon the type of satellite communications system, and the orbits used, it is possible to provide complete global coverage. As a result, satellite communications systems are sued for providing communications capabilities in many remote areas where other technologies would not be viable. <sup>[5]</sup>

**VIII. DISADVANTAGES OF SATELLITE COMMUNICATION**

When considering the use of a satellite some disadvantages also need to be taken into consideration. They are:

- 1) Cost: Satellites are not cheap to build, place in orbit and then maintain. This means that the operational costs are high, and therefore the cost of renting or buying space on the satellite will also not be cheap.
- 2) Propagation delay: As distances are very much greater than those involved with terrestrial systems, propagation delay can be an issue, especially for satellites using geostationary orbits. Here the round trip from the ground to the satellite and back can be of the order of a quarter of a second.

- 3) Specialised satellite terminals required: Even though the operator will operate all the required infrastructure, the user will still need a specialised terminal that will communicate with the satellite. This is likely to be reasonably costly, and it will only be able to be used with one provider.<sup>[5]</sup>

## **IX. USAGE OF SATELLITE COMMUNICATION**

- Communication (trucking call).
- Teleconference and Telemedicine.
- TV Broadcasting.
- Data communication.
- Telemetry.
- Weather telecast and Navigation.
- Security/Calamity monitoring.
- Military.

## **X. CONCLUSION**

Satellites have evolutionized communication. Satellite communication has served mankind in many ways for instance its is used to predict weather and broadcast storm warnings and also provides a wide range of communication services in the fields of relaying television programs, digital data for a multitude of business services. It might not surprise us if, in near future satellite links are used for voice and fax transmission to aircraft on international routes. As any invention develops with the passage of time, satellite communication has also moved a step ahead from what it was in the past with the use of several techniques such as frequency reuse, interconnecting many ground stations spread over the world, concept of multiple spot beam communications, these days lasers are effectively used for transmission through satellites. The latest development in satellites is the use of networks of small satellites in low earth orbits.

## **REFERENCES**

- [1]. Dennis Roddy, Satellite Communications, third Edition, 2001.
- [2]. Bruce R.Elbert, Introduction to Satellite Communication, 2008 Edition.
- [3]. William Stallings, Wireless Communications and Networks, Pearson Education, 2005 Edition.
- [4]. David Hart, Satellite Communications, paper May 1997.
- [5]. Satellite Communications Basics Tutorial [Online]. Available: <http://www.radio-electronics.com/>
- [6]. Kamran Ahmed, Tutorial On Satellite Communication, University of Sind, IIT Pakistan.
- [7]. Vanelli-Coralli, G. E. Corazza, G. K. Karagiannidis, Satellite Communications: Research Trends and Open Issues, Dec 2007.
- [8]. The Nasa Website [Online]. Available: <http://www.nasa.gov/>
- [9]. The Spaceflight Website [Online]. Available: <http://www.spaceflight101.com/>
- [10]. Global VSAT Forum [Online]. Available: <http://gvf.org/>
- [11]. Satellite Communication [Online]. Available: <http://web.uettaxila.edu.pk/>
- [12]. Joel Klooster, The Future of Satellite Communications, May 2002.
- [13]. Howard Hausman, Fundamentals Of Satellite Communications, May 2008.
- [14]. Igor Bisio Track: Satellite and Space Communications, IEEE GLOBECOM 2011 - Symposium on SAC.
- [15]. Yongguang Zhang, Dante De Lucia, Bo Ryu, Son K. Dao, Satellite Communications in the Global Internet: Issues, Pitfalls, and Potential, November 1996.