Satellite Auto-Acquisition Antenna System (SAAS) - A Review

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Abstract - Effective, timely, speedy and long distance communication is crucial to the growth of modern day Industries, Defense, finance sector, Research and Educational institutions and the Nation as a whole. 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. Satellite communication is being used for a couple of decades now and has led to the development of various technologies, modulation schemes and hardware within the satellite communication field. To maintain a satellite communication system have to lock with satellite. Locating a satellite from a random site on the globe, peaking the signal level and regular maintenance of the antenna terminal is still cumbersome for field technicians, site engineers, and enterprises that heavily rely on satellite communication link, because of the complexity involved in the setup, size of the antenna and lack of knowledge with the common man who is not trained to work with satellite terminals. This paper will explain overview of satellite communications, its working principle, how to keep auto track to the satellite so that communication cannot break 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).

Keywords: **Need, Elements, Orbits, Merits and demerits of satellite, satellite Footprints, satellite receiver.**

I. INTRODUCTION

Satellite Communications (SATCOM) plays a vital role in the global telecommunications system. We live in a world where an ever-increasing stream of digital data is flowing between continents. Terrestrial network infrastructures are subject to physical limitations and simply cannot meet the needs of certain activities. To fill this gap and provide improved performance, there are multiple satellite constellations orbiting the Earth. These networks are responsible for, among other things, allowing people in remote locations to access the Internet, helping vessels and aircrafts operate safely, and providing the military and emergency services with critical communication links during armed conflicts or natural disasters.

From the moment that the famous science fiction writer, Arthur C. Clarke, first proposed in 1945 that three geostationary satellites could provide global telecommunications coverage, mankind has been enthralled by the idea of using space technology to provide long-haul communication links. Since that time, use of satellite systems has grown rapidly in various areas: Remote Sensing, Imagery, Telecommunications (Broadcast, Internet, Fixed or mobile communication services, etc.), Navigation, weather, earth observation, scientific, etc. Throughout the years, satellite technology expanded. Today it can add truly global coverage to even the most remote areas and mobility/access to networks of almost infinite size. Constellation of satellites can solve problems for mobile terminals, such as fading, blockages, effective elevation angles, etc.

In other cases, they can complement terrestrial technology, such as fibers. Moreover, satellites, because they are high above the surface of the Earth, can receive and transmit signals from huge areas: the higher they are, the greater these areas become. Last, but not least, it is often far quicker and less expensive to bring broadcasting and communications to areas lacking them using satellites than it would be to provide the same services solely by terrestrial means. Consequently, using satellite communications is something that can benefit dispersed military units that operate in hostile environments.

1.1 Basic principle of satellite working:

A satellite is an object that orbits or revolves around another object. For example, the moon is a satellite of the sun. It is 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.

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. 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. Put it simple, a satellite is an object that moves around a larger object. Earth is a satellite because it moves around the sun. The moon is a satellite because it moves around Earth. However, the Earth and the moon are called "natural" satellites.

But usually when someone says "satellite," they are talking about a "man-made" satellite. Man-made satellites are machines made by people. These machines are launched into space and orbit Earth or another body in space. There are thousands of man-made satellites. Some take pictures of our planet. Some take pictures of other planets, the sun and other objects. These pictures help scientists learn about Earth, the solar system and the universe. Other satellites send TV signals and phone calls around the world.

Figure 1.1: Man-Made Satellites

1.2 Why Are Satellites Important?

Satellites fly high above the sky, so they can see large areas of Earth at one time. Such area is typically known as Footprint. Satellites also have a clear view of space. That's because they fly above Earth's clouds and air.

Before satellites, TV signals didn't go very far. TV signals only travel in straight lines. So they would go off into space instead of following Earth's curve. Sometimes they would be blocked by mountains or tall buildings.

Phone calls to faraway places were also a problem. It costs a lot and it is hard to set up telephone wires over long distances or underwater. With satellites, TV signals and phone calls can be sent up to a satellite. The satellite can then send them back down to different spots on Earth.

1.3 What's Inside a Satellite?

The **Propulsion Subsystem** includes the electric or chemical motor that brings the spacecraft to its permanent position, as well as small thrusters (motors) that help keep the satellite in its assigned place in orbit. Satellites drift out of position because of solar wind or gravitational or magnetic forces. When that happens, the thrusters are fired to move the satellite back into the right position in its orbit.

The **Power Subsystem** generates electricity from the solar panels on the outside of the spacecraft. The solar panels also store electricity in storage batteries, which provide power when the sun isn't shining on the panels. The power is used to operate the communication subsystem.

The **Communications Subsystem** handles all transmit and receive functions. It receives signal from the earth, amplifies or strengthens them, and retransmits (sends) them to another satellite or to a ground station.

The **Structure Subsystem** distributes stress of launch and acts as a strong, stable framework for attaching the other parts of the satellite.

The **Thermal Control Subsystem** keeps the active parts of the satellite cool enough to work properly. It does this by directing the heat that is generated by satellite operations out into space, where it won't interfere with the satellite.

The **Altitude Control Subsystem** maintains the communications "footprint" [*] in the correct location. Satellites can't be allowed to jiggle or wander, because if a satellite is not exactly where it belongs, pointed at exactly the right place on the earth, the television program or the telephone call it transmits to you will be interrupted. When the satellite gets out of position, the altitude control system tells the propulsion system to fire a thruster that will move the satellite back where it belongs.

Based on the application for which a satellite has been designed it may have some other components such as cameras, sensors, transponders etc.

The science and development behind satellites and their use as communication platform is one of the greatest achievements of the mankind with satellites themselves being one of the most sophisticated piece of hardware ever developed. The advent and rigorous development of satellites has opened doors for many new technologies and has provided services across deserts, oceans and poles which is nearly impractical with wired networks.

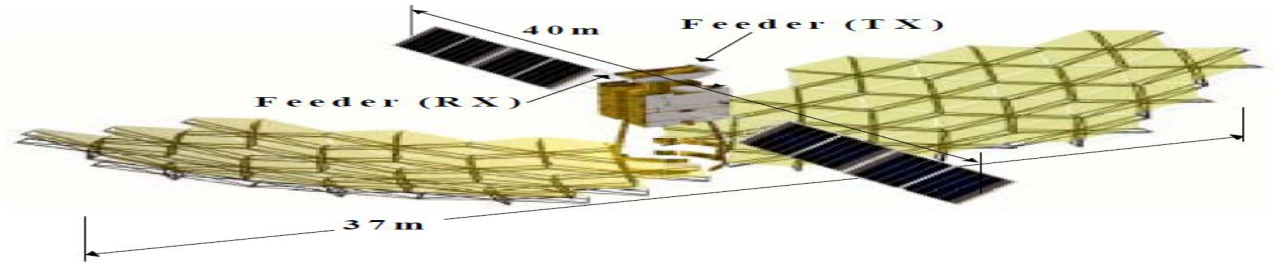

Figure 1.2: Satellite

1.4 Types of SATCOM Infrastructure

SATCOM infrastructure can be divided into two major segments, space and ground. Space includes those elements needed to deploy, maintain, track, and control a satellite. Ground includes the infrastructure required to access a satellite repeater from Earth station terminals. Earth station terminals encompass the equipment located both on the ground and on airplanes and ships meaning that this segment includes air and sea. This specific portion of the ground segment was the focus of our research. This phase focused on analyzing and reverse engineering the freely and publicly available firmware updates for popular SATCOM technologies manufactured and/or marketed by Harris, Hughes, Cobham.

II. HOW TO KEEP AUTO TRACK TO THE SATELLITE

2.1 In satellite communication whole world want to communicate in move

In the view of this we have to make a continuously track with satellite. Today need a system that shall enable a dish antenna setup to be directly controlled by a computer (laptop or desktop PC) with minimal human intervention thus burring the traditional method of manual antenna installation into history. The computer shall take care of all the movements of the antenna terminal to enable it to locate the satellite under consideration and hence allow for establishing one-way/two-way communication link between the satellite and the ground terminal in speedy and efficient manner.

Such a computer controlled antenna setup shall also play vital role in service sensitive communication links where downtimes are strictly undesirable.

2.2 What is proposed?

In this review, a SATELLITE AUTO-ACQUISITION ANTENNA SYSTEM[1] is proposed, that is in process of design

- take the minimum necessary inputs from the terminal operator
- locate the desired satellite based on the calculated azimuth and elevation relative to the terminal location on the globe (site Latitude and Longitude)
- lock the desired service on the satellite
- & finally establish one-way/two-way satellite communication link

2.3 Essence

The essence of SAAAS lays in the fact that it –

- does not require highly skilled personnel
- reduces the number of discrete components used on-site
- reduces dependency on the past experience of the operator
- saves man-hours
- can be extended to any size of antenna terminal
- reduces downtime losses of crucial enterprises (stock-exchange, railways, etc)
- helps in quick change-over of satellites without loss of critical time
- allows terminals to be mounted on mobile platforms and vehicles
- allows complex calculation and precise movements to be taken over by PC and stepper motors
- reduces imprecision introduced by human errors

[1] *Satellite auto-acquisition antenna system is referred to as SAAAS, henceforth*

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.

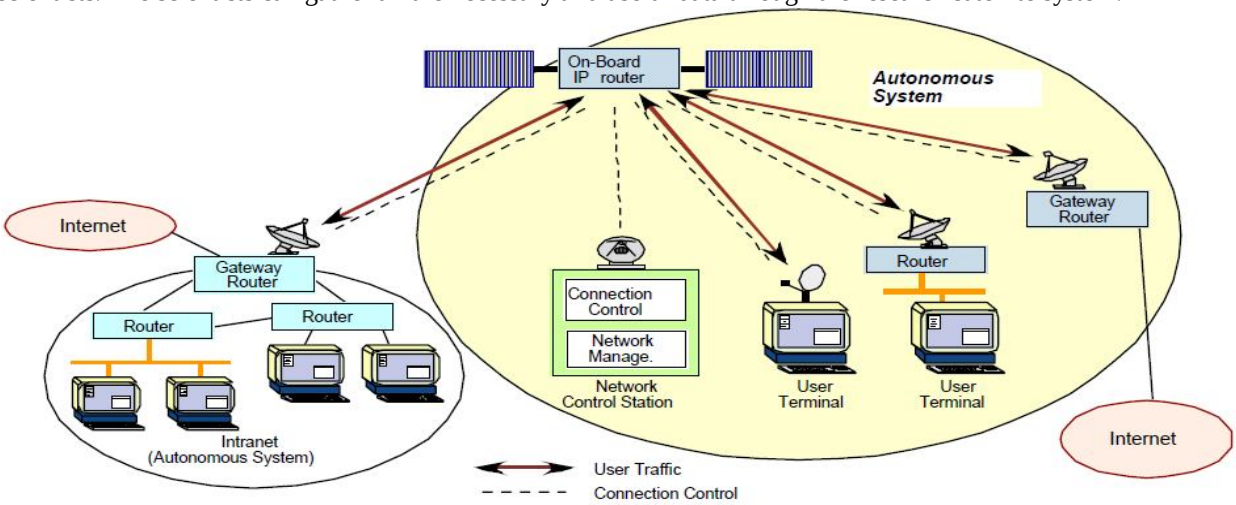

Figure 3.1: Satellite communication services

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 . 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.

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.

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. 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. 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. ADVANTAGES OF SATELLITE COMMUNICATION USING SAAS

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.

VII. DISADVANTAGES OF SATELLITE COMMUNICATION USING SAAS

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) Specialized 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.

4)System complexity:first technical man have to familarized about how to operate.

VIII. USAGE OF SATELLITE COMMUNICATION

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

IX. 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.

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