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# Satellite Communication - A Review

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## ABSTRACT

The transfer of information from source to destination i.e transmitter to receiver is called the communication. Basically communication is possible in two ways they are wire communication and the other one is wireless communication. The satellite communication is a best example for the wire-less communication. In this paper we are first giving a brief satellite history and next why we are using satellite for communication and the orbital model. How the satellites stay in orbits and orbit types. After we are concentrating how an artificial satellite is launched. And what components required for satellite designers. And after we are giving few applications and key research challenges.
**Keywords:** Satellite, Orbit, Satellite communication

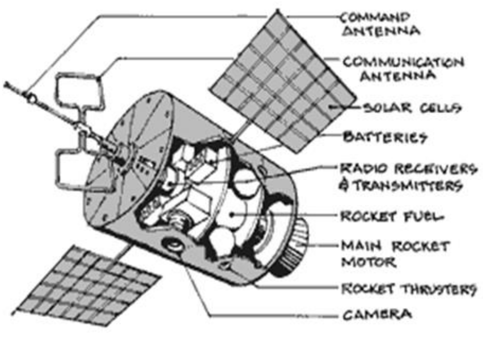
## I. INTRODUCTION

A satellite is an object that goes around, or orbits, a larger object, such as a planet. While there are natural satellites, like the moon, hundreds of man-made satellites also orbit the Earth.

What are the components of a human-made satellite?

- communication capabilities with Earth
- a power source
- a control system to accomplish its mission

Communications antennae, radio receivers and transmitters enable the satellite to communicate with one or more ground stations, called command centers.




Messages sent to the satellite from a ground station are "uplinked"; messages transmitted from the satellite to Earth are "downlinked."

Many satellites are powered by rechargeable batteries, taking advantage of the ultimate battery charger, the sun. Silvery solar panels are prominent features on many satellites. Other satellites have fuel cells that convert chemical energy to electrical energy, while a few rely on nuclear energy. Small thrusters provide attitude, altitude, and propulsion control to modify and stabilize the satellite's position in space.

Specialized systems accomplish the tasks assigned to the satellite. These often include sensors capable of imaging a range of wavelengths. Telecommunications satellites require no optics, while environmental satellites do. Environmental satellites transmit images as numbers to a computer on Earth, which translates this digital data into images.

Some of the data can be enhanced to look like photographs. Bright colors (false colors) are often added to enhance the contrast, make details stand out, or allow us to see what was recorded in the wavelengths beyond our visual range. The false colors do not necessarily correspond to the colors we expect to see. For example, a field of wheat might look pink; clear water may appear black.

**1) How are satellites launched?**

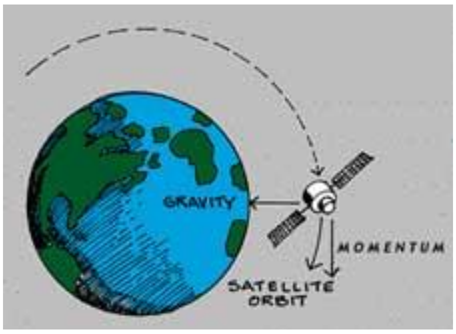
The trick to launching a satellite is getting it high enough to do its job without losing the capsule to outer space. It's a delicate balance of push and pull, accomplished by the inertia of the moving object and the Earth's gravity. If you launch a satellite at 17,000 mph, the forward momentum will balance gravity, and it will circle the Earth. On the other hand, if the satellite is launched faster than 23,500 mph, it will leave the gravitational pull of the Earth.

**2) Why does a satellite stay in orbit?**

Due to the balance of two effects:

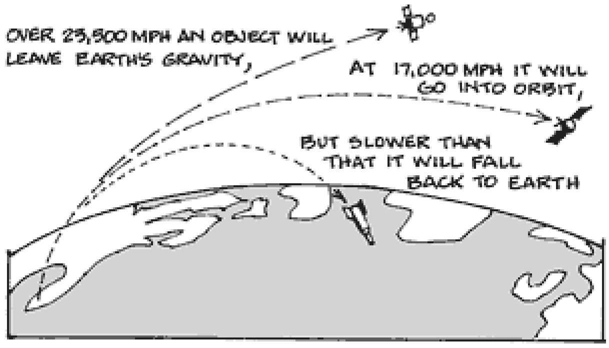
(1) velocity, or the speed at which it would travel in a straight line,

(2) the gravitational pull between the Earth and the satellite.




To illustrate this principle, attach a small weight or a ball to a string, and swing it around in a circle. If the string were to break, the ball would fly off in a straight line. But because it is tethered (like gravity tethers a satellite), it orbits your hand.

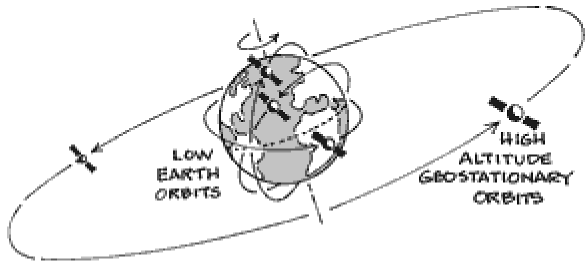
Imagine that you could climb an imaginary mountain whose summit pokes above the Earth's atmosphere (it would be about ten times higher than Mt. Everest). If you threw a baseball from the mountain top, it would fall to the ground in a curving path. Two motions act upon it: travelling in a straight line and falling toward Earth. The faster you throw the ball, the farther it will go before it hits the ground. If you could throw the ball at a speed of 17,000 mph, the ball wouldn't reach the ground. It would circle the Earth in a curved path; it would be in orbit. (It would be traveling at 5 miles per second and take about 10 minutes to cross the United States.) This is the speed needed to put satellites into orbit, which is why the Space Shuttle and other satellites require such powerful boosters.




**3) Orbits**

Human-made satellites circle the Earth in two special ways: polar orbits and geostationary orbits.

A satellite in a polar orbit travels over the North and South Poles. A polar orbit may be several hundred miles to several thousand miles above Earth. A satellite in a relatively low orbit circles the Earth approximately 14 times each day, while higher-orbiting satellites orbit less frequently. Because the Earth is turning more slowly than the satellite, the satellite gets a slightly different view on every revolution. Over the course of a few days, a satellite in a polar orbit will cover almost the entire planet.




A satellite in a high-altitude, geostationary orbit circles the Earth once every 24 hours, the same amount of time it takes for the Earth to spin on its axis. The satellite turns eastward (like our Earth) along the Equator. It stays above the same point on Earth all the time. To maintain the same rotational period as the Earth, a satellite in geostationary orbit must be 22,237 miles above the Earth. At this distance, the satellite can view half of the Earth's surface. (Its viewing area is called its "footprint.") Because the high-altitude satellite appears to remain fixed in one position (it's really orbiting at the same rate as the Earth turns), it requires no tracking to receive its downlink signal. That is why when we turn our home satellite dish to receive the TV signal from a particular geostationary satellite, we don't have to keep jumping up to adjust its position.

One of the advantages of geostationary satellites is that imagery is obtained and displayed constantly, compared to imagery transmitted more sporadically by low Earth-orbiting platforms.

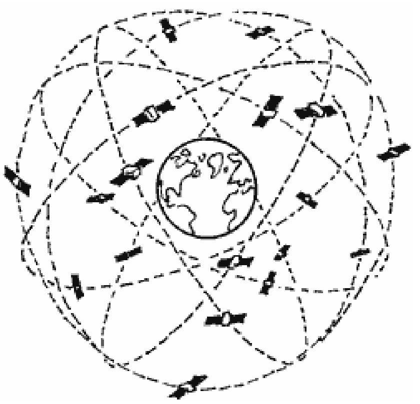
Most satellites serve one or more functions:

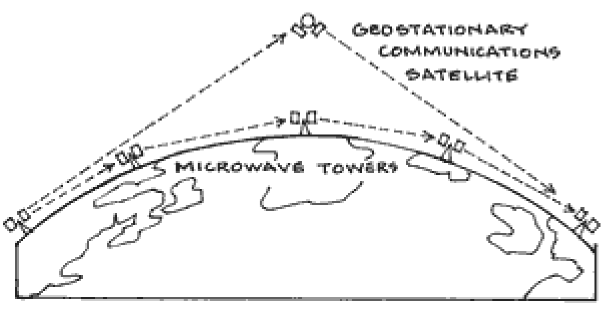
- Communications
- Navigation
- Weather Forecasting
- Environmental Monitoring
- Manned Platforms

**4) Communications Satellites**

Communications satellites have a quiet, yet profound, effect on our daily lives. They link remote areas of the Earth with telephone and television. Modern financial business is conducted at high speed via satellite. Newspapers such as USA Today and The Wall Street Journal are typeset and then transmitted to printing plants around the country via satellite.

Radio signals near the microwave frequency range are best suited to carry large volumes of communications traffic, because they are not deflected by the Earth's atmosphere as lower frequencies are. Basically, they travel in a straight line, known as "line-of-sight communication." If someone in San Francisco tried to beam a microwave signal directly to Hawaii, it would never get there; it would disappear into space or dissipate into the ocean. Over short distances, we erect microwave towers every 25 miles or so to act as "repeaters" to repeat and boost the signal. Think of a geostationary communications satellite as a repeater in the sky.






**Navigation Satellites**

Where am I? Where do I want to go? How can I get there? These are questions we've all asked at one time or another. Satellites for navigation were developed in the late 1950s as a direct result of surface ships and submarines needing to know exactly where they were at any given time. In the middle of the ocean out of sight of land, one can't determine an accurate position by looking out the window.

The idea of using satellites for navigation began with the launch of Sputnik 1 on October 4, 1957. Monitoring that satellite, scientists at Johns Hopkins University's Applied Physics Laboratory noticed that when the transmitted radio frequency was plotted on a graph, a curve characteristic of the Doppler shift appeared. By studying this apparent change of radio frequency as the satellite passed overhead, they were able to show that the Doppler shift, when properly used, described the orbit of the satellite.

Most navigation systems use time and distance to calculate location. Early on, scientists recognized the principle that, given velocity and the time required for a radio signal to be transmitted between two points, the distance between the two points can be computed. To do this calculation, a precise, synchronized departure time and measured arrival time of the radio signal must be obtained. By synchronizing the signal transmission time between two precise clocks, one in a satellite and one at a ground-based receiver, the transit time could be measured and then multiplied by the speed of light to obtain the distance between the two positions.

This three-dimensional satellite navigational system (NAVSTAR) enables a traveler to obtain his or her position anywhere on or above the planet. Data transmitted from the satellite provides the user with time, precise orbital position of the satellite, and the position of other satellites in the system. Currently, there is a full constellation of 24 orbiting satellites devoted to navigation.

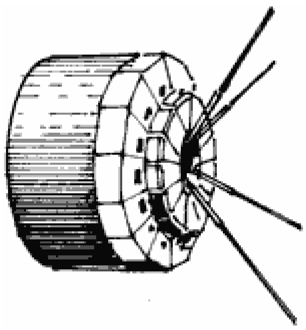
Using a commercial Global Positioning System (GPS) locator, the user can calculate distance by measuring the time it takes for the satellite's radio transmissions, traveling at the speed of light, to reach the receiver. Once distance from four satellites is known, position in three dimensions (latitude, longitude, and altitude) can be calculated by triangulation, and velocity in three dimensions can be computed from the Doppler shift in the received signal. The new GPS receivers do all of the work; a traveler simply turns on the unit, makes certain that it's locked onto at least four satellites, and the precise position of the GPS unit is displayed automatically. One innovative application of GPS technology is to determine Earth's ground movement after an earthquake. Referencing a network of these sensitive receivers can lead to a remarkably accurate assessment of plate movement.

There are two available radio signals that GPS receivers can use: the Standard Positioning Service (SPS) for civilians, and the Precise Positioning Service (PPS) for military and other authorized personnel. The most significant cause of errors in positioning is the deliberate effort by the Department of Defense to decrease the accuracy of user systems for national security reasons. Selective Availability (SA) refers to the purposeful degradation of the information broadcast by the satellites. SA affects the accuracy of the SPS, but not PPS. With SA, a GPS system will be accurate 95% of the time to within 328 feet (100 meters) horizontally and 512 feet (156 meters) vertically.

For those who require positions with higher accuracy, Differential Global Positioning Systems (DGPS) add a new element to GPS. DGPS places a GPS stationary receiver at a known location on or near the Earth's surface. This reference station receives satellite signals and adjusts for transmission delays and Selective Availability, using its own known latitude, longitude, and altitude. The stationary receiver sends out a correction message for any suitably-equipped local receiver. A DGPS-compatible receiver adjusts its position calculations using the correction message. DGPS reference stations are constructed, operated, and maintained by the United States Coast Guard.

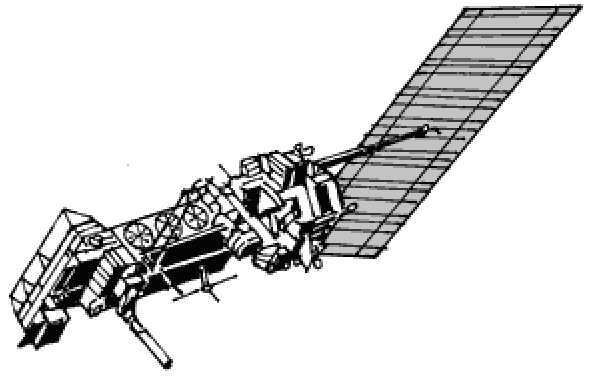
**5) Weather Satellites**

Weather satellites have been our eyes in the sky for more than 30 years, since the April, 1960 launch of Tiros I. Today, satellite images showing the advance of weather fronts are regular elements of the evening news. This meteorological information is also available to anyone with a personal computer. A network of American, European, Japanese, and Russian satellites orbits the Earth in various configurations to provide "real-time" monitoring of our environment. Many of these satellites transmit signals directly to ground stations in schools, including the Frank H. Harrison Middle School in Yarmouth, Maine, and Wiscasset Primary School in Wiscasset, Maine. Highly-trained technicians, like Georgie Thompson's second-grade students, operate the controls of such a station. They are able to predict when the satellites will be overhead, when they can expect to receive an image, and they can loop together several images of cloud conditions and movements from different passes of the satellites to make reliable weather predictions. Any school can establish such a ground station at a surprisingly low cost.



**6) Polar Orbiting Satellites**

TIROS polar orbiting satellites (NOAA-class), launched and operated by the United States, are the principal sources of environmental data for the 80% of the globe that is not covered by conventional monitoring equipment. These satellites measure temperature and humidity in the Earth's atmosphere, record surface ground and surface sea water temperatures, and monitor cloud cover and water/ice boundaries. They have the capability to receive, measure, process, and retransmit data from balloons, buoys, and remote automatic stations distributed around the globe. These satellites also carry Search and Rescue (SAR) transponders, which help locate downed airplanes or ships in distress. Polar orbiting satellites send back pictures to Earth via



Automatic Picture Transmission (APT) or High Resolution Picture Transmission (HRPT) formats.

NOAA (National Oceanic and Atmospheric Administration) class satellites and Russian Meteor class satellites orbit very close to the poles on each revolution of the Earth. At an altitude of 860 km. (600 miles), the sensors scan the Earth's entire surface over a 24-hour period. The sensors are sensitive to visible light and infrared (IR) radiation. As each NOAA polar-orbiting satellite orbits the Earth, it sends back a constant stream of data.

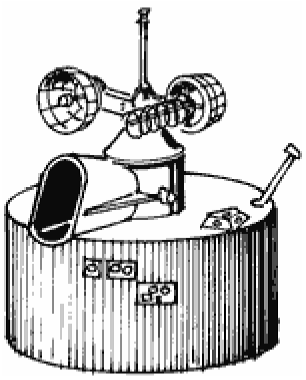
Instruments on board the satellite scan the Earth's surface from side to side (perpendicular to the ground track), with each scan covering an area about 2 km. high and 3,000 km. wide. Typically, the lower resolution APT imagery is transmitted at 2 lines/second, or 120 lines/minute. In a pass lasting 12 minutes, this translates into an image approximately 5,800 km. long and 3,000 km. wide. As an example, the entire east coast of the United States would be visible in one image, from southern Florida north up to Hudson Bay, and from the Atlantic Ocean to west of the Great Lakes.

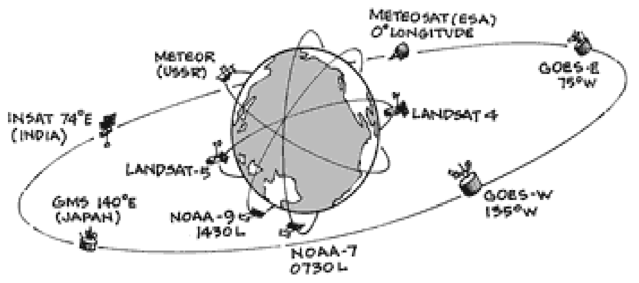
During the day, this data stream consists of one visible and one infrared image. At night, both channels are infrared. Imagery in both the visible and infrared formats is transmitted simultaneously. Students are familiar with the visible image because it is similar to one from a conventional camera. Understanding what the infrared imagery represents is sometimes harder to grasp. Various land and water bodies absorb heat differentially, so they reflect different levels of heat energy. The Gulf Stream offers an excellent example: on an infrared image, the warmer temperatures of the Gulf Stream are clearly delineated as the darker portions of the image, while the cooler temperatures of the surrounding Atlantic are lighter in color. With readily-available computer software, students can use a mouse to place a cursor anywhere on the image and accurately measure the surface water temperature to within 2 degrees Fahrenheit.

Currently, four NOAA-class satellites, which transmit both APT and HRPT imagery, are available for classroom use. NOAA 14 passes over Maine in the middle of the day. NOAA 12 is considered the primary early morning and early evening satellite. In addition to the United States' NOAA satellites, Russian Meteor class satellites transmit weather satellite imagery in the APT format as well. As a result, these satellites are also a valuable resource for your classroom.

### 7) Geostationary (GOES) Satellites

In late 1966, ATS-1 was launched into a geostationary orbit over the equator south of Hawaii. For the first time, meteorologists could monitor the weather continuously during daylight. It provided images of nearly one-third of the Earth's surface every 23 minutes with 4 km. resolution. In May of 1974, the first of a new series of GOES satellites was launched. Both visible and infrared images were acquired simultaneously by the Visible and Infrared Spin Scan Radiometer (VISSR) on board the spacecraft. The visible channel offers ground resolution of 0.8 km. for sections of the full Earth view and 6.2 km. resolution in the infrared spectra. The greatest advantage to having both visible and infrared capability is that weather systems can be monitored both day and night (at 30-minute intervals). Thus, destructive hurricanes can be tracked around the clock. Most satellite images seen on our local evening news and the Weather Channel are produced by GOES satellites. Usually, the infrared images are "loop animated" to show the progression and movement of storms.






While the United States maintains and operates its GOES satellites, the European community is served by its European Space Agency (ESA) Meteosat satellite, and Japan with its GMS satellite. This network provides complete global coverage of all but the extreme north and south Polar Regions.

GOES satellites make day and night observations of weather in the coverage area and transmit real-time VISSR data, monitor cataclysmic weather events such as hurricanes, relay meteorological observation data from surface collection points, and perform facsimile transmission of processed graphic and imaged weather data. This rebroadcast function is known as WEFAX, which stands for Weather Facsimile.

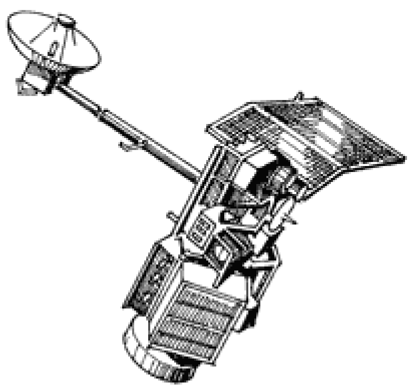
The primary function of our GOES satellites to the education community is to provide imagery of varying resolution and time frames. VISSR is the most stunning example, although it requires a much more sophisticated ground station to receive and process the signal. From Hawaii to Maine, land features can be examined to 0.8 km. resolution. The snow-capped Rocky Mountains stand out nicely, as do larger lakes and reservoirs.

WEFAX, on the other hand, is easily received with relatively simple equipment. Much of the imagery transmitted via WEFAX is considered low resolution, usually 4 km. Along with satellite imagery, weather charts and other information are also transmitted regularly.

**8) Mission to Planet Earth**

Four Landsat satellites (launched in 1972, 1975, 1978, and 1982) were specifically designed to learn about how different parts of the planet interact. Three are still sending back data. The newest generation of environmental satellites is part of a National Aeronautics and Space Administration (NASA) initiative that aims its space instruments at the Earth instead of the stars.

This program, Mission to Planet Earth, may well take precedence over space exploration for the next few years. Its Earth Observing System (EOS) will include 17 new satellites to be launched over the next 15 years. "The idea grew out of a critical mass of scientists coming together to understand how the Earth as a system is changing," explains Robert Price, director of the Mission to Planet Earth office for NASA. "If humankind is changing the face of the Earth, it's time we started answering some of the scientific questions relating to that." EOS focuses on the remote sensing of climate change indicators such as the ozone layer in the upper atmosphere, cloud cover, and sea-ice at the poles.



In addition, it follows the climatological effects of localized phenomena like volcanic eruptions and El Niño, a periodic change in wind patterns and current movements that results in decreased fisheries along the southern Pacific coast. The information provided by EOS satellites will determine the course of environmental management in the future.

**9) Topex/Poseidon**

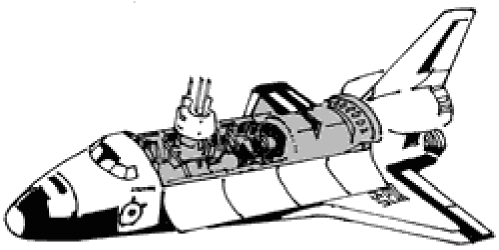
The Topex/Poseidon project is a joint venture between NASA and the French Space Agency designed to study the dynamics of the ocean as part of Mission to Planet Earth. The satellites orbit 830 miles above the Earth and measure the height of sea level to within 5 inches. Using these measurements, scientists examine ocean circulation patterns and interactions between the ocean and the atmosphere in an effort to predict climate changes on a global level. Topex/Poseidon imagery helped scientists predict the 1994-1995 El Nino and its effects in the Northern Hemisphere.

**10) SeaWIFS**

The SeaWIFS satellite will provide important data on ocean productivity. SeaWIFS stands for the Sea-viewing Wide Field of View Sensor, designed to measure the amount of phytoplankton in the ocean and the seasonal changes in distribution. This satellite will also examine the fate of sediments washed from the land into the ocean and the mixing of nutrients at the edge of eddies and boundary currents. Measuring phytoplankton blooms from space has an obvious advantage over trying to cover the vast tracts of the ocean from a boat. The SeaWIFS satellite replaces an earlier sensor called the Coastal Zone Color Scanner (CZCS) that failed in the late 1980s.

**11) Space Shuttle**

The Space Transportation System (STS) followed the Apollo Project to the Moon and Skylab which orbited the Earth from 1973 to 1979. With the flight of the shuttle Columbia on April 12, 1981, America entered a new era in manned space flight. The reusable shuttle enables regularly-scheduled transportation for people and cargo between Earth and low Earth orbit, providing dramatic imagery of bold satellite rescue and repair missions. Less dramatic, but more personal, offshoots of this aerospace research include computer software in cars and airplanes and a host of medical technologies including CAT scans, portable x-ray machines, and laser surgery.



The current schedule of space shuttle missions provides an excellent opportunity for students and teachers to monitor flight activity on a real-time basis. Shuttle launch manifests offer approximate dates and durations of upcoming missions. A great deal of space-related information, including current shuttle manifests, is available at NASA's SpaceLink WWW page.

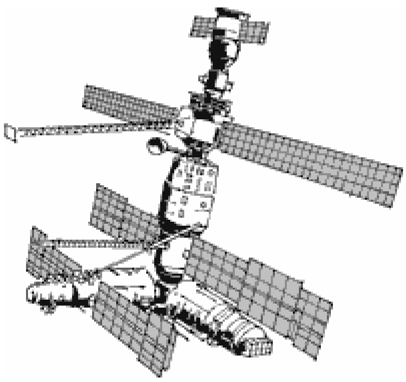
Schools with Amateur Radio ("ham") equipment or short-wave listening equipment can also monitor the audio portion of most shuttle missions. Station WA3NAN, located at the Goddard Space Flight Center in Greenbelt, Maryland, re-transmits live air-to-ground shuttle communications on amateur frequencies. The best times to monitor transmissions are during the launch and landing sequence and satellite deployment or repair missions.

**12) SIR-C/X-SAR**

In recent missions the Space Shuttle has carried a new type of radar called Spacebourne Imaging Radar - C/X - band Synthetic Aperature Radar (SIR-C/X-SAR). After launching, the cargo doors on the shuttle open to deploy this radar, which is designed to look at vegetation, soil moisture levels, ocean dynamics, volcanic activity, and erosion. The projects that have evolved using this data include studies of deforestation in the Amazon, desertification of the Sahara, and soil moisture retention in the Midwest.

**13) Mir Space Station**

In February of 1986, the then-Soviet Union launched a space platform called Mir (Russian for "peace") Space Station as a replacement for the aging SALYUT 7 space station. The Russians hold the world record for long-duration flight. In 1987, two cosmonauts spent more than 300 days in space and new records are set every year.



It is especially exciting to view the Mir Space station or to monitor its progress by radio because it is one of the few satellites manned almost continuously. Students may feel a connection with the people in the capsule when they can observe it speeding overhead. Mir was launched in a fairly high inclination orbit (51.6 degrees), so the orbit is directly over the most populated portions of the Earth. Using a simple pinwheel device, students can determine when and where to look for this and other space objects. One of the largest and brightest objects currently orbiting the Earth, this platform provides for spectacular viewing several times during a 5-6 week period. Mir traverses the sky with an apparent magnitude of 0 or +1. In comparison, the brightest stars or planets are usually of a magnitude of -1, and the faintest stars visible with the naked eye are in the range of +6, +7.

In preparation for the proposed International Space Station, seven dockings between the Space Shuttle and the Mir Space Station are planned between now and 1997. In June of 1995, the Shuttle Atlantis successfully docked with Mir and began the journey to the ultimate completion of the International Space Station by the year 2002.

**14) Tracking "Space Junk"**

Tracking Earth-orbiting satellites visually makes for a great outdoor homework assignment. Literally thousands of objects orbiting our planet are listed in the latest Satellite Situation Report compiled by NORAD (North American Air Defense), and distributed by NASA. Any satellite larger than a softball is tracked by NORAD, and the data is disseminated by NASA. Many of these are debris from payloads and rocket bodies, called "space junk." On any clear evening, you have an excellent chance to see a satellite about 1 to 1 1/2 hours after sunset. Most will be observed in north-south or south-north orbit. In the space of an hour or more, a dozen satellites can be spotted. Brightness of the objects will vary depending on orbital altitude, size, and spin rate. Although part of the Earth is in the sun's shadow at night, the satellite is still in sunlight, and the reflected sunlight illuminates it for Earth-bound observers.

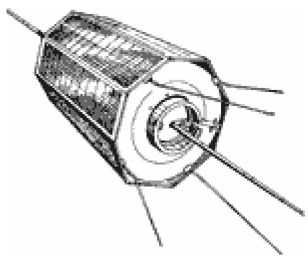
How does one know when and where to look for specific satellites, such as the Soviet Mir Space Station, and, on occasion, even the US Space Shuttle? Amateurs have been tracking satellites for more than two decades. Before the microcomputer became a household item, ham radio operators plotted orbits on maps to determine when the satellites could be seen overhead. This method is still in use and is a good primer for those interested in tracking orbiting satellites.

In 1969, interested hams formed the Amateur Radio Satellite Corporation (AMSAT) to continue to enhance amateur satellite communication. Through the years, AMSAT has been a leader in research and development for amateur satellite technology. With the advent of microcomputers, tracking programs were written to automatically track specific satellites of interest, thus leaving the operator with more time to communicate.

How does the computer operator know which satellite is which? The user must input information for each satellite. These numerical data sets are called Keplerian Elements, named after Johannes Kepler. These elements, unique to each satellite, are orbital parameters which define individual orbits. They are available from a variety of sources on the Internet. Many of the newer tracking programs, including InstaTrack (PC) and OrbiTrak (Mac), provide users with quick means of updating elements. Complete files can be downloaded in a matter of minutes, and the computer software updates elements for as many as 200 satellites in seconds. Compare this with the arduous task of updating each satellite via computer keyboard, which takes several minutes per satellite. Either way, information is available for all satellites of interest to educators, including weather satellites, amateur satellites, and objects of high visibility such as the Mir space station. It is important to secure the latest Keplerian element sets available when tracking the Russian Mir Space Station or the Space Shuttle.

**15) OSCAR Satellites**

The satellite UOSAT-11 is one of dozens of amateur satellites orbiting the earth. Sputnik, the world's first artificial Earth-orbiting satellite, transmitted a beacon on 20.005 MHz. which was monitored by thousands of hams and Short Wave Listeners (SWL). Since 1957, many OSCAR (Orbiting Satellites Carrying Amateur Radio) satellites have been constructed by ordinary people interested in satellite communications. Oscar 1, launched in December of 1961, weighed 10 pounds and transmitted a 15 milliwatt beacon for about 3 weeks. Oscar 13, launched in the summer of 1988, provides reliable, near-global communications. Interestingly enough, the OSCAR series of satellites are actually ballast for larger primary NASA payloads. It is simpler and cheaper to ballast a rocket with dead weight than to reduce the thrust. As a result, it is possible to add secondary payloads of homemade satellites to multimillion-dollar NASA missions at minimal costs.



There are currently nineteen OSCAR satellites orbiting our planet with various communications capabilities and functions. Most are used by ordinary amateur radio operators for educational, scientific, and purely recreational purposes. Anyone interested in knowing more about the OSCAR series of satellites is encouraged to contact the Amateur Radio Satellite Corporation (AMSAT).

How satellites work

A satellite is basically a self-contained communications system with the ability to receive signals from Earth and to retransmit those signals back with the use of a transponder an integrated receiver and transmitter of radio signals. A satellite has to withstand the shock of a launch into orbit at 28,100 km (17,500 miles) an hour and a hostile space environment where it can be subject to radiation and extreme temperatures for its projected operational life, which can last up to 20 years. In addition, satellites have to be light, as the cost of launching a satellite is quite expensive and based on weight. To meet these challenges, satellites must be small and made of lightweight and durable materials. They must operate at a very high reliability of more than 99.9 percent in the vacuum of space with no prospect of maintenance or repair.

The main components of a satellite consist of the communications system, which includes the antennas and transponders that receive and retransmit signals, the power system, which includes the solar panels that provide power, and the propulsion system, which includes the rockets that propel the satellite. A satellite needs its own propulsion system to get itself to the right orbital location and to make occasional corrections to that position. A satellite in geostationary orbit can deviate up to a degree every year from north to south or east to west of its location because of the gravitational pull of the Moon and Sun. A satellite has thrusters that are fired occasionally to make adjustments in its position. The maintenance of a satellite's orbital position is called "station keeping," and the corrections made by using the satellite's thrusters are called "attitude control." A satellite's life span is determined by the amount of fuel it has to power these thrusters. Once the fuel runs out, the satellite eventually drifts into space and out of operation, becoming space debris.

A satellite in orbit has to operate continuously over its entire life span. It needs internal power to be able to operate its electronic systems and communications payload. The main source of power is sunlight, which is harnessed by the satellite's solar panels. A satellite also has batteries on board to provide power when the Sun is blocked by Earth. The batteries are recharged by the excess current generated by the solar panels when there is sunlight.

Satellites operate in extreme temperatures from −150 °C (−238 °F) to 150 °C (300 °F) and may be subject to radiation in space. Satellite components that can be exposed to radiation are shielded with aluminium and other radiation-resistant material. A satellite's thermal system protects its sensitive electronic and mechanical components and maintains it in its optimum functioning temperature to ensure its continuous operation. A satellite's thermal system also protects sensitive satellite components from the extreme changes in temperature by activation of cooling mechanisms when it gets too hot or heating systems when it gets too cold.

The tracking telemetry and control (TT&C) system of a satellite is a two-way communication link between the satellite and TT&C on the ground. This allows a ground station to track a satellite's position and control the satellite's propulsion, thermal, and other systems. It can also monitor the temperature, electrical voltages, and other important parameters of a satellite.

Communication satellites range from microsatellites weighing less than 1 kg (2.2 pounds) to large satellites weighing over 6,500 kg (14,000 pounds). Advances in miniaturization and digitalization have substantially increased the capacity of satellites over the years. Early Bird had just one transponder capable of sending just one TV channel. The Boeing 702 series of satellites, in contrast, can have more than 100 transponders, and with the use of digital compression technology each transponder can have up to 16 channels, providing more than 1,600 TV channels through one satellite.

Satellites operate in three different orbits: low Earth orbit (LEO), medium Earth orbit (MEO), and geostationary or geosynchronous orbit (GEO). LEO satellites are positioned at an altitude between 160 km and 1,600 km (100 and 1,000 miles) above Earth. MEO satellites operate from 10,000 to 20,000 km (6,300 to 12,500 miles) from Earth. (Satellites do not operate between LEO and MEO because of the inhospitable environment for electronic components in that area, which is caused by the Van Allen radiation belt.) GEO satellites are positioned 35,786 km (22,236 miles) above Earth, where they complete one orbit in 24 hours and thus remain fixed over one spot. As mentioned above, it only takes three GEO satellites to provide global coverage, while it takes 20 or more satellites to cover the entire Earth from LEO and 10 or more in MEO. In addition, communicating with satellites in LEO and MEO requires tracking antennas on the ground to ensure seamless connection between satellites.

A signal that is bounced off a GEO satellite takes approximately 0.22 second to travel at the speed of light from Earth to the satellite and back. This delay poses some problems for applications such as voice services and mobile telephony. Therefore, most mobile and voice services usually use LEO or MEO satellites to avoid the signal delays resulting from the inherent latency in GEO satellites. GEO satellites are usually used for broadcasting and data applications because of the larger area on the ground that they can cover.

Launching a satellite into space requires a very powerful multistage rocket to propel it into the right orbit. Satellite launch providers use proprietary rockets to launch satellites from sites such as the Kennedy Space Center at Cape Canaveral, Florida, the Baikonur Cosmodrome in Kazakhstan, Kourou in French Guiana, Vandenberg Air Force Base in California, Xichang in China, and Tanegashima Island in Japan. The U.S. space shuttle also has the ability to launch satellites.

Satellite communications use the very high-frequency range of 1–50 gigahertz (GHz; 1 gigahertz = 1,000,000,000 hertz) to transmit and receive signals. The frequency ranges or bands are identified by letters: (in order from low to high frequency) L-, S-, C-, X-, Ku-, Ka-, and V-bands. Signals in the lower range (L-, S-, and C-bands) of the satellite frequency spectrum are transmitted with low power, and thus larger antennas are needed to receive these signals. Signals in the higher end (X-, Ku-, Ka-, and V-bands) of this spectrum have more power; therefore, dishes as small as 45 cm (18 inches) in diameter can receive them. This makes the Ku-band and Ka-band spectrum ideal for direct-to-home (DTH) broadcasting, broadband data communications, and mobile telephony and data applications.

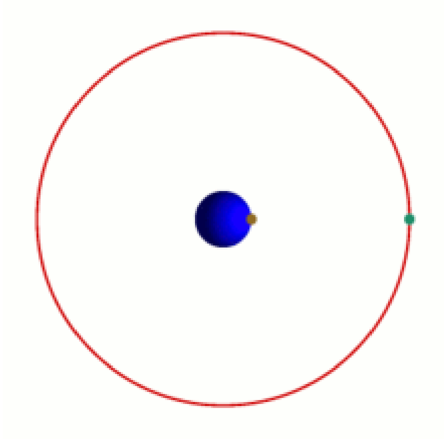
The International Telecommunication Union (ITU), a specialized agency of the United Nations, regulates satellite communications. The ITU, which is based in Geneva, Switzerland, receives and approves applications for use of orbital slots for satellites. Every two to four years the ITU convenes the World Radiocommunication Conference, which is responsible for assigning frequencies to various applications in various regions of the world. Each country's telecommunications regulatory agency enforces these regulations and awards licenses to users of various frequencies. In the United States the regulatory body that governs frequency allocation and licensing is the Federal Communications Commission.

A communications satellite or comsat is an artificial satellite sent to space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits, Molniya orbits, elliptical orbits and low (polar and non-polar Earth orbits).

For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology complementary to that of communication cables. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting.

Geostationary orbits

Main article: Geostationary orbit



**Geostationary orbit**

To an observer on the earth, a satellite in a geostationary orbit appears motionless, in a fixed position in the sky.

This is because it revolves around the earth at the earth's own angular velocity (360 degrees every 24 hours, in an equatorial orbit).

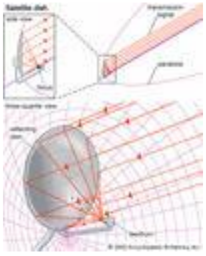
A geostationary orbit is useful for communications because ground antennas can be aimed at the satellite without their having to track the satellite's motion. This is relatively inexpensive. In applications that require a large number of ground antennas, such as DirectTV distribution, the savings in ground equipment can more than outweigh the cost and complexity of placing a satellite into orbit.

The main drawback of a geostationary orbit is that, with no direct line of sight, a satellite cannot service extreme northern and southern areas of the world. Another drawback is the height of the orbit, usually which requires more powerful transmitters, larger-than-normal (usually dish) antennas, and higher-sensitivity receivers on the earth. The large distance also introduces a significant delay, of ~0.25 seconds, into communications.

The concept of the geostationary communications satellite was first proposed by Arthur C. Clarke, building on work by Konstantin Tsiolkovsky and on the 1929 work by Herman Potočnik (writing as Herman Noordung) Das Problem der Befahrung des Weltraums der Raketen-motor. In October 1945 Clarke published an article titled "Extra-terrestrial Relays" in the British magazine Wireless World.[2] The article described the fundamentals behind the deployment of artificial satellites in geostationary orbits for the purpose of relaying radio signals. Thus, Arthur C. Clarke is often quoted as being the inventor of the communications satellite.[citation needed]

## Satellite applications

Advances in satellite technology have given rise to a healthy satellite services sector that provides various services to broadcasters, Internet service providers (ISPs), governments, the military, and other sectors. There are three types of communication services that satellites provide: telecommunications, broadcasting, and data communications. Telecommunication services include telephone calls and services provided to telephone companies, as well as wireless, mobile, and cellular network providers.



Broadcasting services include radio and television delivered directly to the consumer and mobile broadcasting services. DTH, or satellite television, services (such as the DirecTV and DISH Network services in the United States) are received directly by households. Cable and network programming is delivered to local stations and affiliates largely via satellite. Satellites also play an important role in delivering programming to cell phones and other mobile devices, such as personal digital assistants and laptops.

Data communications involve the transfer of data from one point to another. Corporations and organizations that require financial and other information to be exchanged between their various locations use satellites to facilitate the transfer of data through the use of very small-aperture terminal (VSAT) networks. With the growth of the Internet, a significant amount of Internet traffic goes through satellites, making ISPs one of the largest customers for satellite services.

Satellite communications technology is often used during natural disasters and emergencies when land-based communication services are down. Mobile satellite equipment can be deployed to disaster areas to provide emergency communication services.

One major technical disadvantage of satellites, particularly those in geostationary orbit, is an inherent delay in transmission. While there are ways to compensate for this delay, it makes some applications that require real-time transmission and feedback, such as voice communications, not ideal for satellites.

Satellites face competition from other media such as fibre optics, cable, and other land-based delivery systems such as microwaves and even power lines. The main advantage of satellites is that they can distribute signals from one point to many locations. As such, satellite technology is ideal for "point-to-multipoint" communications such as broadcasting. Satellite communication does not require massive investments on the ground—making it ideal for underserved and isolated areas with dispersed populations.

Satellites and other delivery mechanisms such as fibre optics, cable, and other terrestrial networks are not mutually exclusive. A combination of various delivery mechanisms may be needed, which has given rise to various hybrid solutions where satellites can be one of the links in the chain in combination with other media. Ground service providers called "teleports" have the capability to receive and transmit signals from satellites and also provide connectivity with other terrestrial networks.

### The future of satellite communication

In a relatively short span of time, satellite technology has developed from the experimental (Sputnik in 1957) to the sophisticated and powerful.

Future communication satellites will have more onboard processing capabilities, more power, and larger-aperture antennas that will enable satellites to handle more bandwidth. Further improvements in satellites' propulsion and power systems will increase their service life to 20–30 years from the current 10–15 years. In addition, other technical innovations such as low-cost reusable launch vehicles are in development. With increasing video, voice, and data traffic requiring larger amounts of bandwidth, there is no dearth of emerging applications that will drive demand for the satellite services in the years to come. The demand for more bandwidth, coupled with the continuing innovation and development of satellite technology, will ensure the long-term viability of the commercial satellite industry well into the 21st century.

## II. CONCLUSION

Satellite is a wide area of study, it's orbit and speed can do the operation in different way, perform various operation so, wireless communication is possible, still some area are yet to be invented like in advance disaster can be identified ,how much area will be affected may be identified in advance.

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