SATELLITES

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Introduction

A satellite is any smaller object traveling around a larger object. By this definition, the Moon is a satellite to the Earth and the Earth is a satellite to the Sun. However, for this reference, a satellite is a human-made spacecraft placed in space to orbit another body. These spacecraft can be crewed, such as the Space Shuttle, or uncrewed, such as NASA's Hubble Space Telescope. They can be sent into space with the intention that they will not be recovered, or they can be designed to be recovered or repaired by Space Shuttle crews.

Satellites may be either active or passive. Passive satellites contain no radio transmitters or other energy signals, but rather only reflect signals beamed at them from Earth. Active satellites collect data and emit radio signals that transmit the information down to Earth.

Satellites are designed to serve one of three general purposes: space science, applications, or communications. Space science satellites carry instruments to study the Sun, measure magnetic fields or to examine the universe in the different energy wavelengths of the electromagnetic spectrum, including gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves and radio waves. Application satellites survey the Earth's resources and supply weather photographs and other information to forecasters. Communication satellites relay telephone calls and television signals, transmit scientific information from other satellites down to Earth, and relay voice communications between the astronauts orbiting on the Space Shuttle and mission controllers on Earth.

The Benefits of Satellites

More than 3,500 satellites orbit the Earth today. Data from these satellites help promote an awareness of the environment, the world, and the universe. The new technologies developed for these satellites have additional applications that benefit life on Earth.

The new technologies created for satellites are transferable and have additional applications, called “spin offs.” These technologies represent a valuable national resource that can be applied to new products and processes. For example, by applying the computerized image enhancement technology developed to read Earth resources satellite photographs, experts are now able to provide “maps” of the human body. Unlike X-rays, this application of satellite technology allows doctors to “see” into bones, making problems such as tumors stand out clearly.

Much of the information gathered by satellites shows us what is happening to our Earth. For example, Landsat satellites make accurate maps of the Earth’s surface in both visible and infrared light. Landsat maps provide checks on existing maps. Landsat images also help determine where vegetation is healthy or diseased, and serve as a tool for monitoring pollution. A French satellite, called SPOT (from the initials of Satellite Probatoire de L-Observation de la Terre), helped illustrate the damage caused by the explosion of the former Soviet Union’s nuclear reactor in Chernobyl.

Scientific satellites such as NASA’s Hubble Space Telescope have broadened our knowledge of the universe. Hubble has revealed planet-wide atmospheric storms on Saturn, the birth of stars in a nearby galaxy, the evolution of a supernova, and phenomena that suggests the existence of black holes — a likely power source for active galaxies.

Satellite Orbits

Each satellite has a set path in space above the Earth's atmosphere called an orbit. If a satellite traveled through the atmosphere, air would push against it and slow the satellite down. To be completely free of the atmosphere, satellites orbit at least 180 miles (300 kilometers) above sea level.

Sir Isaac Newton first theorized about the possibilities of human-made satellites in the 17th century. But it wasn't until almost 300 years after Newton's death that the first artificial satellite was put into orbit. The former Soviet Union launched Sputnik 1, the first artificial Earth-orbiter in 1957. The velocity, or speed, and inclination to the equator, or angle, with which a satellite is launched determine the satellite's orbit. Satellites are launched into a variety of orbits, depending on the satellite's purpose.

Polar or near polar orbits are launched at an inclination of approximately 90 degrees to the equator. These satellites travel in a circular pattern over the North and South Poles so that they can survey all or a major portion of the Earth as it turns below them. Some weather satellites use this type of orbit to track the approach or development of a storm.

Another type of orbit is a geosynchronous orbit, which is 22,300 miles (35,888 kilometers) above the equator. At this height, a satellite's velocity matches that of a point on the Earth's equator. Seen from Earth, the satellite appears to be floating over a certain spot on the equator. Weather and communications satellites use geosynchronous orbits.

Many satellites are placed into a low-Earth orbit about 200 miles (320 kilometers) above the Earth. This is the level where the Space Shuttle and the Russian Mir space station orbit. Scientific satellites, such as the Hubble Space Telescope and Compton Gamma-Ray Observatory also use a low-Earth orbit. Other satellites have an elliptical orbit around the Earth. This orbit is useful for making scientific measurements — such as ozone levels — at various altitudes.

The most distant point of a satellite's orbit from Earth is called its apogee; its closest point to Earth is its perigee. The difference between the apogee and the perigee is known as the degree of eccentricity of the orbit.

Satellite Structure

Satellites differ markedly in size and weight. The first U.S. satellite, Explorer I, was launched in 1958. Explorer I was 6.6 feet (2 meters) long and weighed 17.6 pounds (8 kilograms). In contrast, NASA's Compton Gamma Ray Observatory, launched in April 1991, is much larger. Compton measures 70 feet (21.3 meters) from the tip of one solar array to the tip of the other solar array and weighs more than 17 tons (17,273 kilograms)! While satellites may vary in size and weight, there are elements that all satellites share.

All satellites need a power source. Most are powered by solar cells, which gather energy from the Sun and convert the energy directly to electricity to power spacecraft systems. Interplanetary satellites that travel far away from the Sun, such as Voyagers 1 and 2, launched in 1977, and Ulysses, launched in 1990, use radioisotope thermoelectric generators — a nuclear power source.

Any satellite's orbit will change with time due to atmospheric drag — or the pull of gravity — on the spacecraft. Frequent adjustment of the satellite is necessary to keep its solar panels facing the Sun and to align the satellite with its target region. Ground controllers use special propulsion systems aboard the satellite, called thrusters, to "push" the satellite into its desired orbit.

All satellites have instrumentation consisting of the scientific and engineering sensors that measure the changes in the satellite and its surroundings. The instruments detect changes in the power supply, the temperature, and the pressure of the satellite. Guidance and control sensors keep the satellite on its proper course. Sensors such as horizon seekers, star trackers, and Sun seekers help determine the satellite's position. A ground station may send commands to make adjustments if the satellite is off course. Natural forces in space, such as the Earth's gravitational pull, or the drag of its upper atmosphere, may disturb the attitude of the satellite. Attitude controls keep the satellite properly oriented. Environmental controls regulate the temperature needed to keep the satellite functioning properly. They also protects the satellite from radiation and vibration that it may be exposed to in space.

Application Satellites

A large number of satellites are used in testing and developing ways to improve global weather forecasting. Weather satellites are vital in predicting where and when tropical storms, hurricanes, floods, cyclones, tidal waves and even forest fires may strike. Knowing this information in advance allows time to prepare for these events and avoid disaster. Advanced weather information helps farmers decide when to plant or harvest their crops or prevent their destruction by hail or snow. Weather satellite information may warn citrus growers of frost and sugarcane farmers of rain that may effect harvesting and growth. An accurate weather forecast also can allow engineers to schedule the best time for construction of large-scale projects such as bridges, highways, and dams.

The Television Infrared Observation Satellite (TIROS) was the first series of meteorological satellites to carry television cameras to photograph the Earth's cloud cover and demonstrate the value of using spacecraft for meteorological research and weather forecasting. The first TIROS was launched in 1960 and returned data that showed a large degree of organization within the cloud cover over the Earth.

Nimbus, a second-generation meteorological satellite, named for a cloud formation, is larger and more complex than the TIROS satellites. NASA initiated the Nimbus program to test a global meteorological satellite system. Nimbus 1 was launched in 1964 and carried two television cameras and two infrared cameras. Although Nimbus 1 had only about a one-month life-span, the satellite tracked the storm pattern of Hurricane Cleo helping prevent severe damage. Nimbus 7 operated from 1978 through 1993. This satellite carried a Total Ozone Mapping Spectrometer that played a major role in the study of both global ozone and the "ozone hole" over the Antarctic.

The Geostationary Operational Environmental Satellite (GOES) series are built for the National Oceanic and Atmospheric Administration (NOAA) under technical guidance and management by NASA. The newest GOES satellite, GOES-

I, launched in 1994, represents the first in a series of the next generation of weather satellites. GOES satellites provide the now-familiar weather pictures seen on newscasts worldwide. Each satellite in the series carries two major instruments, an imager and a sounder, which acquire high-resolution visible and infrared data, as well as temperature and moisture profiles of the atmosphere.

Several satellites in the NOAA system, including this newest GOES, monitor search and rescue frequencies as part of an international program known as COSPAS (a Russian abbreviation of Space System for search vessels in distress) /SARSAT (Search and Rescue Satellite Aided Tracking System). This satellite-aided search and rescue project, reduces the time it takes to find stranded victims and increases the chance of saving lives. Since its establishment in 1982, COSPAS/SARSAT has helped save more than 1,600 lives. The system can determine the location of distress signals within approximately 1.25 miles (2 kilometers). The distress signals are relayed by the satellites to Local User Terminals (LUTs) where the signals are processed for location information. The information is passed to a Mission Control Center in either the U.S., Canada, France, the Soviet Union, Norway or the United Kingdom to alert local rescue authorities. More than 500,000 beacons around the world and more than 30 LUTs participate in this search and rescue system.

A constellation of Global Positioning Satellites, also known as NavStar, aids the U.S. military with navigation. The system provides position, velocity, and time information to users on the ground, at sea, in the air, and out in space.

Scientific Satellites

Scientific satellites are probably the most well-known type of satellite. They capture data that gives scientists vital information about Earth and our universe.

Satellites that “look” at Earth are part of NASA’s Mission to Planet Earth series. The information gathered from these satellites clarifies the Earth’s history, present condition, and what the future may hold. NASA launched the first satellite in this series, the Upper Atmosphere Research Satellite (UARS), in 1991, to investigate the mechanisms controlling Earth’s upper atmosphere. UARS produced the first global map of chlorine monoxide confirming a direct link between its presence and ozone depletion.

Other scientific satellites “look” away from the Earth and investigate the Sun, stars, planets and other phenomena in our Universe. In 1976, Viking spacecraft took close-up pictures of the surface of Mars. The pictures showed the orange-red soil that gives Mars its color. The International Ultraviolet Explorer (IUE), operating since 1978, studied the intense ultraviolet output from an exploding star, Supernova 1987A, and revealed an unexpectedly rapid cooling off of the explosion.

Like NASA’s Hubble Space Telescope, the Compton Gamma Ray Observatory has made a number of scientifically important discoveries. Compton found that gamma ray bursts, one of the great mysteries of astronomy, may be far more energetic than previously thought and may originate far beyond the Milky Way Galaxy.

Through scientific satellites, we learn more about how the universe was created. In April 1992, NASA's Cosmic Background Explorer (COBE), detected small temperature variations in the cosmic background radiation from the Big Bang, the explosion that began the universe 15 billion years ago. The temperature fluctuations verified a theory that said that the universe's structure and behavior was determined by tiny variations when the universe was less than one-trillionth of a second old.

Communications Satellites

Today, it is taken for granted that at anytime, a phone call can be placed anywhere in the world and be connected. It is also expected that the latest breaking news from around the world will be broadcast as it happens. Until recently, this capability was not possible.

A remarkable development in communications has taken place since 1945 when science fiction author Arthur C. Clarke proposed an idea for a network of communications satellites. Satellites easily overcame difficult land-link communication obstacles such as mountains and bodies of water to establish global communication. In addition to telephone communication and global television capabilities, satellites also allow connections by other means such as facsimile, telex, and personal satellite dishes.

Communications satellites were the first commercial satellites. Private industry has incorporated this type of space technology for its own advancement. While several communications satellites are owned and operated by the government, private companies maintain most communications satellites.

Aluminum-coated balloons were the first communications satellites. The first Echo balloon, launched in 1960, was considered passive because radio signals reflected off of the balloon's surface rather than being transmitted from the satellite. Because of the limitations of this system, active transmitting satellites soon followed. This modern generation of communications satellites receives a signal from an appropriate antennae, amplifies the signal with onboard devices, and retransmits it to another part of the Earth. These spacecraft are known as relay satellites.

As companies in the communications field realized the potential profits in this technology, they began developing their own satellites. In 1962, the American Telephone and Telegraph (AT&T) Company launched Telstar 1. This satellite transmitted phone calls and photos between Europe and America. Telstar was the first satellite to transmit black-and-white as well as color television between two continents. The satellite was capable of 600 telephone channels or one television channel. Shortly after Telstar 1 ceased operating in 1963, Telstar 2 was launched and established the first direct link between Japan and Europe.

Further developments in television transmissions and telephone communication quickly followed with the higher altitude Synchronous Communications Satellite (Syncom) and the Communications Satellite Corporation's (Comsat) Early Bird satellite.

The International Telecommunications Satellite Consortium (Intelsat), an international organization of 65 nations, was established out of the growing demand for channels of communication and greatly expanded the commercial communications network. The first Intelsat satellite only permitted links between two Earth stations at a time. Today, Intelsat provides the capacity of up to 120,000 simultaneous two-way telephone circuits.

In May 1992, the astronaut crew on Space Shuttle mission STS-49 captured and redeployed an INTELSAT VI satellite stranded in an unusable orbit after it launched in 1990. During the summer following this successful mission, the redeployed satellite helped broadcast the Summer Olympic Games in Barcelona, Spain.

In order to help maintain the U.S. competitive position, NASA develops and tests satellite communications technologies that are usable in multiple frequency bands and applicable to a wide range of future communications systems. A major step towards that end was the launch of the Advanced Communications Technology Satellite (ACTS) in September 1993. ACTS technologies provide as much as three times the communications capacity for the same weight as today's communications satellites, making this technology more cost effective. ACTS technology also allows communication at much higher rates — as much as five times that offered by existing satellites. The flight and testing of ACTS will allow industry to adapt these technologies for commercial use at minimal risk.

NASA has established its own satellite constellation, called the Tracking and Data Relay Satellite System (TDRSS), which supports flights and nearly all of the agency's scientific satellites. The TDRSS uses just two ground stations in White Sands, N.M., which helps to reduce the cost of upgrading and operating a network of tracking and communications ground stations around the world. TDRSS can support up to 26 user spacecraft simultaneously. At its highest capacity, TDRSS can transfer in a single second the equivalent of a 20-volume encyclopedia containing more than 34-million words.

Satellites and the Future

NASA is exploring ways to provide frequent flight opportunities for relatively inexpensive space missions. One initiative, the Small Explorer (SMEX) program provides low-cost, quick-turnaround missions. SMEX spacecraft weigh approximately 400 pounds (180 kilograms) each and in spite of their small size will investigate some of the most important questions raised in astrophysics and space physics.

Capitalizing on the availability of mature or developed instrumentation to carry out scientific investigations allows SMEX missions to be accomplished quickly and frequently. It is a goal of the SMEX program to bring each mission to launch readiness within three years after the start of detailed design activities. The first SMEX, the Solar, Anomalous and Magnetospheric Explorer was launched in 1992. Two additional SMEX missions will be launched over the next several years, and follow-on SMEX missions will take NASA well into the next century of space exploration.

Through satellites, NASA hopes to continue learning about the fragile balance of life on our planet. To learn more about our planet as a system, NASA has established the Earth Observing System (EOS) as the centerpiece for the country's Mission to Planet Earth Program. Through a series of orbiting platforms, EOS will provide scientific data that will help scientists understand Earth's basic processes and develop and apply predictive models. The first EOS platform, AM, is scheduled to launch towards the end of this century. Several follow-on platforms also are planned.

Satellites will continue to improve life on Earth. Around the globe, satellites put persons and their computers on the information super highway. Electronic mail by satellite already has become a reality. It is possible that in the future, we may receive information such as newspapers and magazine via satellites.

Scientists have only begun to discover the mysteries of space. One can only guess what future missions may reveal. Take an opportunity on the next clear night and look at the stars. If you notice one slowly moving across the sky, it may be one of the thousands of satellites serving us all. For satellites and the future, the sky is the limit.

Source: NASA