UNIT-IV

Satellite Remote Sensing

Satellite remote sensing as the use of satellite-borne sensors to observe, measure and record the electromagnetic radiation reflected or emitted by the earth and its environment for subsequent analysis and extraction of information.

Types of Satellites

A satellite is a body that orbits around another body in space. Based on the origin of satellites it is classified in to natural satellite and man-made satellite.

1. Natural Satellites

Examples of natural satellites are the Earth and Moon. The Earth rotates around the Sun and the Moon rotates around the Earth.

The Moon is a natural satellite of the Earth

2. Man-made Satellites

A man-made satellite is a machine that is launched into space and orbits around a body in space. Examples of man-made satellites include the Hubble Space Telescope and the International Space Station. Man-made satellites come in many shapes and size and have different pieces of instruments on them to perform different functions while in space. Satellites are built by engineers and take months sometimes even years to build. The satellites have to endure many tests to make sure the satellite can withstand the launch and the harsh environment of space.

Satellites can be classified by their function since they are launched into space to do a specific job. The satellite must be designed specifically to fulfill its role. There are nine different types of satellites i.e. Communications Satellite, Remote Sensing Satellite, Navigation Satellite, LEO, MEO, HEO, GPS, GEOs, Drone Satellite, Ground Satellite, Polar Satellite, Nano satellite, Mini satellite, micro satellite etc.

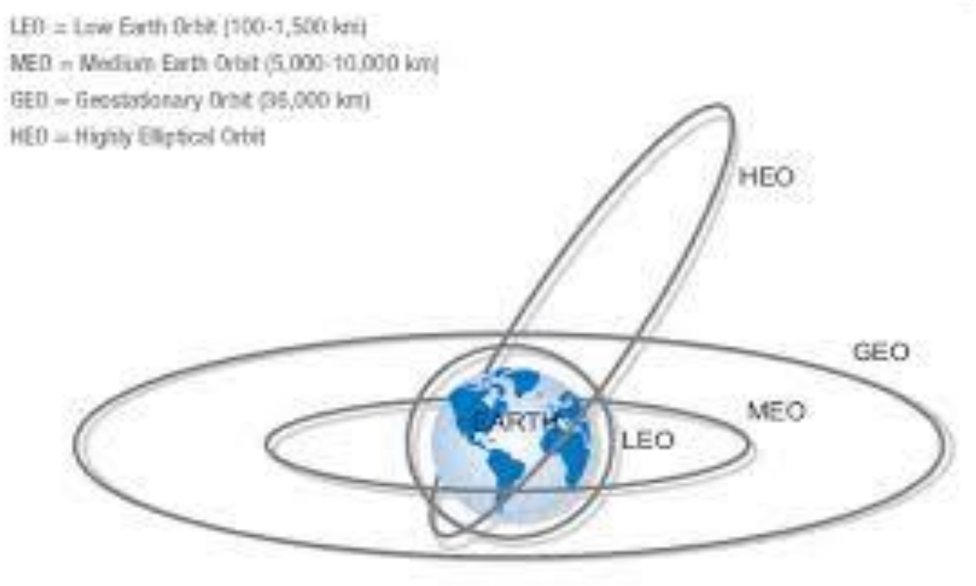
1.Communications satellite – is an artificial satellite that relays and amplifies radio telecommunications signals via a transponder; it creates a communication channel between a source transmitter and a receiver at different locations on Earth. Communications satellites are used for television, telephone, radio, internet, and military applications. There are about 2,000 communications satellites in Earth's orbit, used by both private and government organizations. Many are in geostationary orbit 22,236 miles (35,785 km) above the equator, so that the satellite appears stationary at the same point in the sky, so the satellite dish antennas of ground stations can be aimed permanently at that spot and do not have to move to track it.

The high frequency radio waves used for telecommunications links travel by line of sight and so are obstructed by the curve of the Earth. The purpose of communications satellites is to relay the signal around the curve of the Earth allowing communication between widely separated geographical points. Communications satellites use a wide range of radio and microwave frequencies. To avoid signal interference, international organizations have regulations for which frequency ranges or "bands".

2. Remote Sensing Satellite - A satellite with remote sensors to observe the earth is called a **remote sensing satellite** or earth observation satellite. Meteorological satellites are sometimes discriminated from the other remote sensing satellites. Remote sensing satellites are characterized by their altitude, orbit and sensors. Example Landsat.

3. NAVIGATION SATELLITES - Artificial satellites can provide the basis for all-weather, long-term navigation systems to determine with accuracy geodetic position, speed, and direction of a surface vehicle or aircraft, north reference, and vertical reference. GPS Satellite Constellation: The baseline satellite constellation consists of 24 satellites positioned in six earth-centered orbital planes with four operation satellites and a spare satellite slot in each orbital plane. The system can support a constellation of up to thirty satellites in orbit.

4. Geocentric orbit Satellites or Earth orbit Satellites - involves any object orbiting the Earth, such as the Moon or artificial satellites. In 1997 NASA estimated there were approximately 2,465 artificial satellite payloads orbiting the Earth and 6,216 pieces of space debris as tracked by the Goddard Space Flight Center.



a. <u>Low Earth orbit</u> Satellite (LEO)

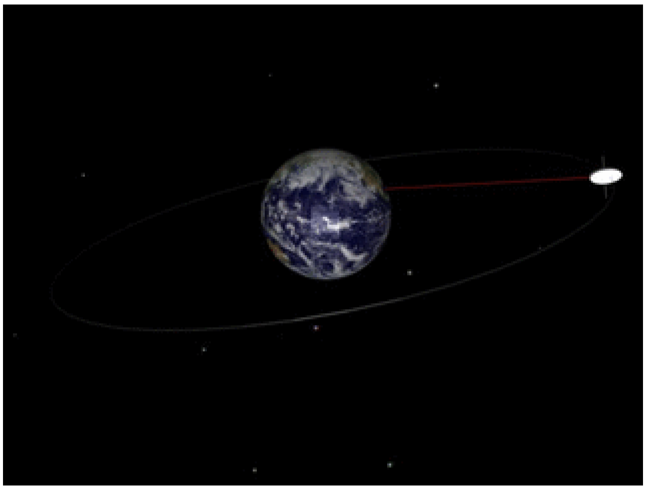
Geocentric orbits ranging in altitude from 160 kilometers (100 statute miles) to 2,000 kilometres (1,200 mi) above mean sea level At 160 km, one revolution takes approximately 90 minutes, and the circular orbital speed is 8,000 metres per second (26,000 ft/s).

b. Medium Earth Orbit Satellite (MEO)

Geocentric orbits with altitudes at apogee ranging between 2,000 kilometres (1,200 mi) and that of the geosynchronous orbit at 35,786 kilometres (22,236 mi).

c. Geosynchronous orbit Satellite (GEO)

Geocentric circular orbit with an altitude of 35,786 kilometres (22,236 mi). The period of the orbit equals one sidereal day, coinciding with the rotation period of the Earth. The speed is approximately 3,000 metres per second (9,800 ft/s).



d. High Earth Orbit Satellite (HEO)

Geocentric orbits with altitudes at apogee higher than that of the geosynchronous orbit. A special case of high Earth orbit is the <u>highly elliptical orbit</u>, where altitude at perigee is less than 2,000 kilometres (1,200 mi)

5. GPS Satellite

GPS, or the Global Positioning System, is a global navigation satellite system that provides location, velocity and time synchronization.
GPS is everywhere. You can find GPS systems in your car, your smartphone and your watch. GPS helps you get where you are going, from point A to point B. The satellite system consists of a constellation of 24 satellites in six Earth-centered orbital planes, each with four satellites, orbiting at 13,000 miles (20,000 km) above Earth and traveling at a speed of 8, 700 mph (14,000 km/h).

6. Geostationary satellites

A geostationary satellite is launched in such a way that it follows an orbit parallel to the equator and travels in the same direction as the earth's rotation with the same period of 24 hours. Thus, it appears stationary with respect to the earth surface. ... A large area of the earth can also be covered by the satellite.

Examples

- **Geostationary** Operational Environmental **Satellite** (GEOS) of USA.
- INSAT of India.
- Himawari of Japan.
- Fengyun of China.
- Meteostat of Europe.

7. Drone satellite

In aviation and in space, a drone refers to an unpiloted aircraft or spacecraft. Another term for it is an "unmanned aerial vehicle," or UAV. On Earth, drones are often used for military purposes because they don't put a pilot's life at risk in combat zones. In addition, drones don't require rest, enabling them to fly as long as there is fuel in the craft and there are no mechanical difficulties.

Technically speaking, space borne drones could include cargo spacecraft, satellites and machines that leave Earth, although they aren't usually referred to as such. Perhaps the best example of a drone in space is the U.S. military's mysterious X-37B spacecraft, which has made multiple flights into orbit for hundreds of days at a time. Its mission is highly classified, leading to speculation about what it is doing.

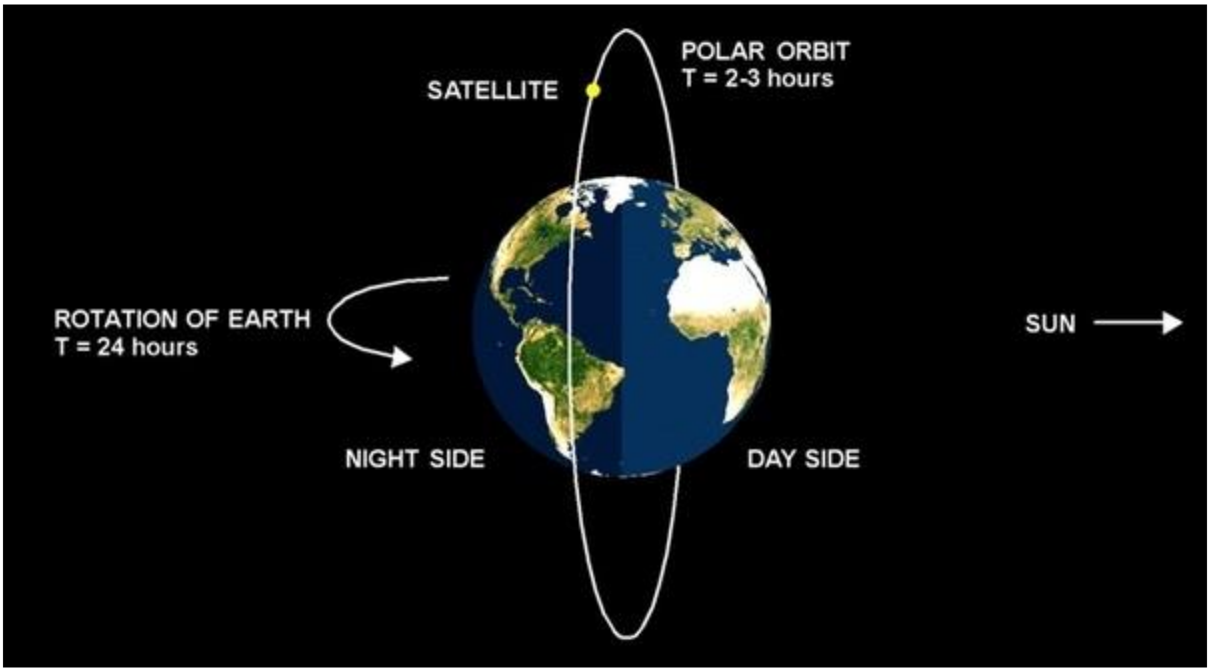
8. Ground Satellite

Ground stations consist largely of an antenna that physically communicates data from orbiting spacecraft and processes it into actionable reports for satellite and human spaceflight operators. A single ground station can support multiple spacecraft, repositioning to communicate with each one.

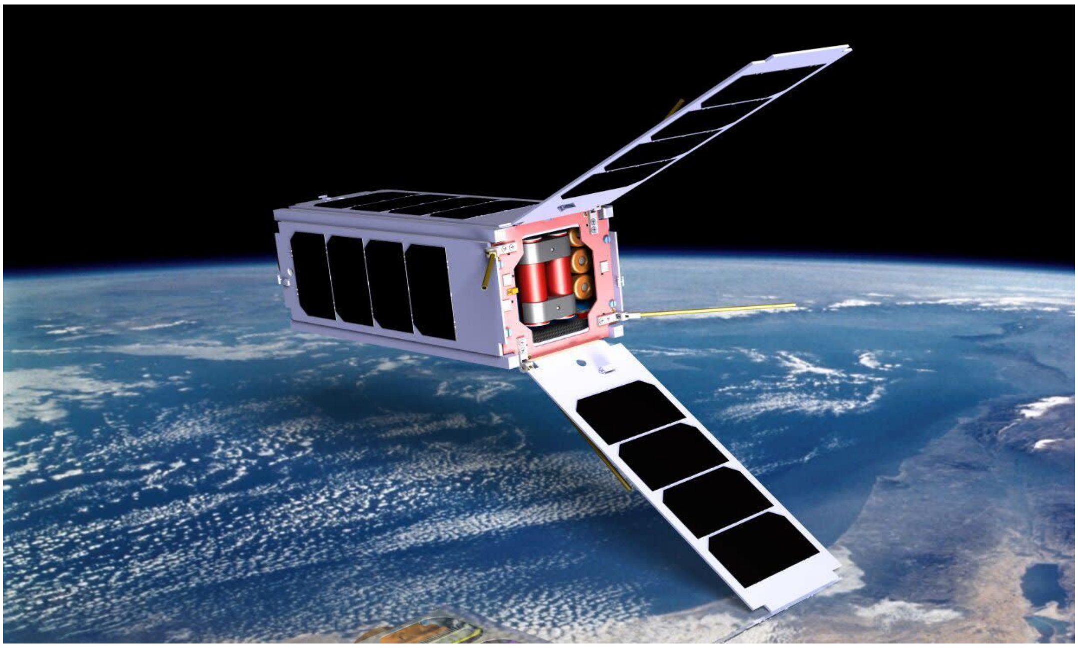
Specialized satellite earth stations are used to telecommunicate with satellites—chiefly communications satellites. A ground station that primarily receives telemetry data, or that follows a satellite not in geostationary orbit, is called a tracking station.

8. Polar Satellite

Polar satellite is a satellite whose orbit is perpendicular or at right angles to the equator or in simple words it passes passes over the north and south poles as it orbits the earth . It can be at any height from the earth, typically at 500–800 Kms . As the earth rotates under it while it orbit the earth , Earth present a different face at every pass, making it possible to map / scan the entire earth surface with Polar satellite over time. This property makes them excellent tool as earth observation / reconnaissance or spy satellite.

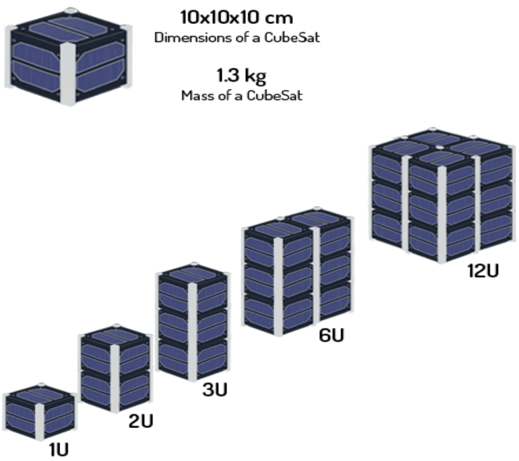


9. Nano Satellites



Nano satellites are loosely defined as any satellite weighing less than 10 kilograms. CubeSats must also comply with a series of specific criteria that control factors such as their shape, size and weight.

CubeSats can come in various sizes, but they are all based on the standard CubeSat unit, namely a cube-shaped structure measuring 10x10x10 centimetres with a mass of somewhere between 1 and 1.33 kg. This unit is known as 1U. After the first few years, this modular unit was multiplied and larger nanosatellites are now common (1.5U, 2U, 3U or 6U).



10. Small satellites or Minisatellite

The term "small satellite", or sometimes "minisatellite", often refers to an artificial satellite with a wet mass (including fuel) between 100 and 500 kg (220 and 1,100 lb), but in other usage has come to mean any satellite under 500 kg (1,100 lb).

Small satellite examples include Demeter, Essaim, Parasol, Picard, MICROSCOPE, TARANIS, ELISA, SSOT, SMART-1, Spirale-A and -B, and Starlink satellites.

11. Microsatellites

The term "microsatellite" or "microsat" is usually applied to the name of an artificial satellite with a wet mass between 10 and 100 kg (22 and 220 lb). However, this is not an official convention and sometimes those terms can refer to satellites larger than that, or smaller than that (e.g., 1–50 kg (2.2–110.2 lb)). Sometimes, designs or proposed designs from some satellites of these types have microsatellites working together or in a formation.[10] The generic term "small satellite" or "smallsat" is also sometimes used,[11] as is "satlet".

Examples: Astrid-1 and Astrid-2, as well as the set of satellites currently announced for LauncherOne (below)

In 2018, the two Mars Cube One microsats—massing just 13.5 kg (30 lb) each—became the first CubeSats to leave Earth orbit for use in interplanetary space. They flew on their way to Mars alongside the successful Mars InSight lander mission. The two microsats accomplished a flyby of Mars in November 2018, and both continued communicating with ground stations on Earth through late December. Both went silent by early January 2019.

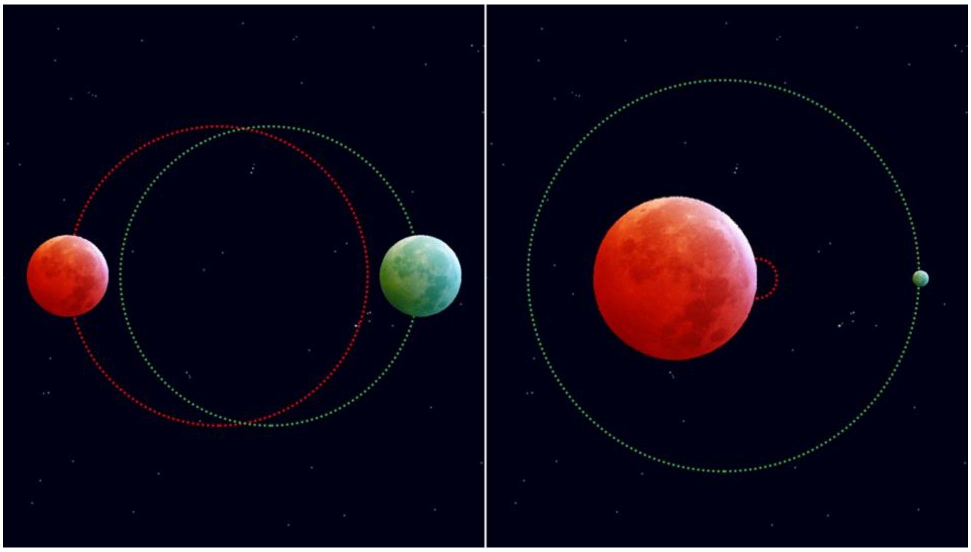
(Nano satellites <10kg

Minisatellite or small satellite 100-500kg

Microsat -10-100kg)

ORBITS

An orbit is a regular, repeating path that one object in space takes around another one. An object in an orbit is called a satellite. A satellite can be natural, like Earth or the moon. Many planets have moons that orbit them. A satellite can also be man-made, like the International Space Station.



When rockets launch our satellites, they put them into orbit in space. There, gravity keeps the satellite on its required orbit – in the same way that gravity keeps the Moon in orbit around Earth. A satellite is put into orbit by being placed hundreds or thousands of kilometres above Earth's surface (as if in a very tall tower) and then being given a 'push' by the rocket's engines to make it start on its orbit. In space, there is no air and therefore no air friction, so gravity lets the satellite orbit around Earth with almost no further assistance. Putting satellites into orbit enables us to use technologies for telecommunication, navigation, weather forecast, and astronomy observations.

Types of orbit

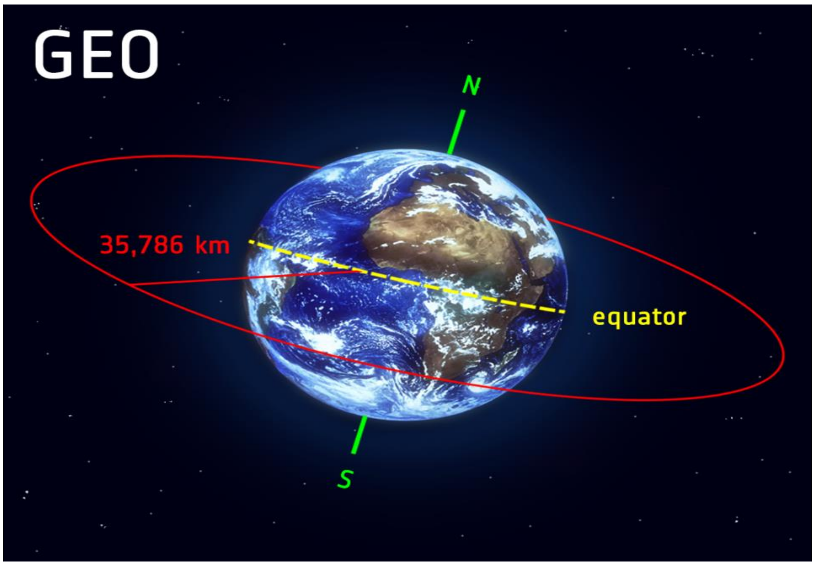
Upon launch, a satellite or spacecraft is most often placed in one of several particular orbits around Earth – or it might be sent on an interplanetary journey, meaning that it does not orbit Earth anymore, but instead orbits the Sun until its arrival at its final destination, like Mars or Jupiter.

There are many factors that decide which orbit would be best for a satellite to use, depending on what the satellite is designed to achieve.

- Geostationary orbit (GEO)
- Low Earth orbit (LEO)
- Medium Earth orbit (MEO)
- Polar orbit and Sun-synchronous orbit (SSO)
- Transfer orbits and geostationary transfer orbit (GTO)
- Lagrange points (L-points)

1. Geostationary orbit (GEO)

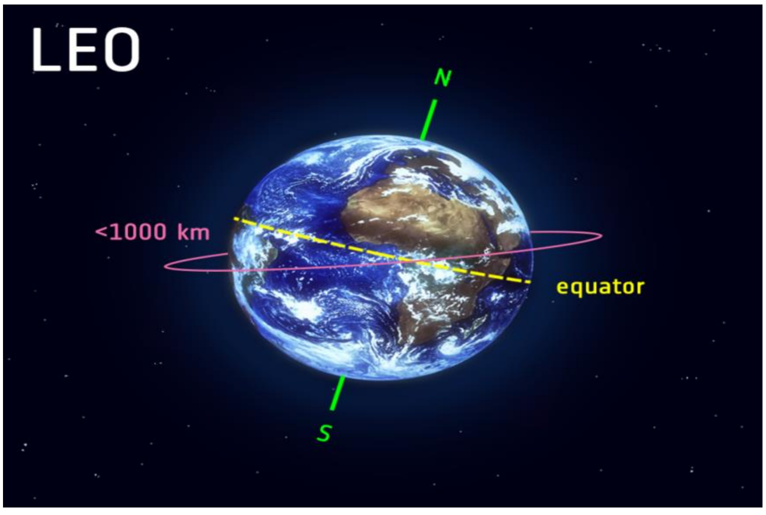
Satellites in geostationary orbit (GEO) circle earth above the equator from west to east following earth's rotation – taking 23 hours 56 minutes and 4 seconds – by travelling at exactly the same rate as Earth. This makes satellites in GEO appear to be 'stationary' over a fixed position. In order to perfectly match Earth's rotation, the speed of GEO satellites should be about 3 km per second at an altitude of 35 786 km. This is much farther from Earth's surface compared to many satellites.



2. Low Earth orbit (LEO)

A low Earth orbit (LEO) is, as the name suggests, an orbit that is relatively close to Earth's surface. It is normally at an altitude of less than 1000 km but could be as low as 160 km above Earth – which is low compared to other orbits, but still very far above Earth's surface.

By comparison, most commercial aeroplanes do not fly at altitudes much greater than approximately 14 km, so even the lowest LEO is more than ten times higher than that.



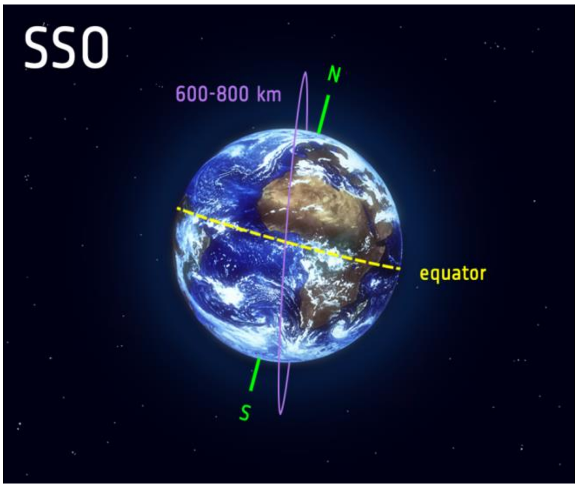
3. Medium Earth orbit (MEO)

Medium Earth orbit comprises a wide range of orbits anywhere between LEO and GEO. It is similar to LEO in that it also does not need to take specific paths around Earth, and it is used by a variety of satellites with many different applications. It is very commonly used by navigation satellites, like the European Galileo system (pictured). Galileo powers navigation communications across Europe, and is used for many types of navigation, from tracking large jumbo jets to getting directions to your smartphone. Galileo uses a constellation of multiple satellites to provide coverage across large parts of the world all at once.

4. Polar orbit and Sun-synchronous orbit (SSO)

Satellites in polar orbits usually travel past Earth from north to south rather than from west to east, passing roughly over Earth's poles.Satellites in a polar orbit do not have to pass the North and South Pole precisely; even a deviation within 20 to 30 degrees is still classed as a polar orbit. Polar orbits are a type of low Earth orbit, as they are at low altitudes between 200 to 1000 km.

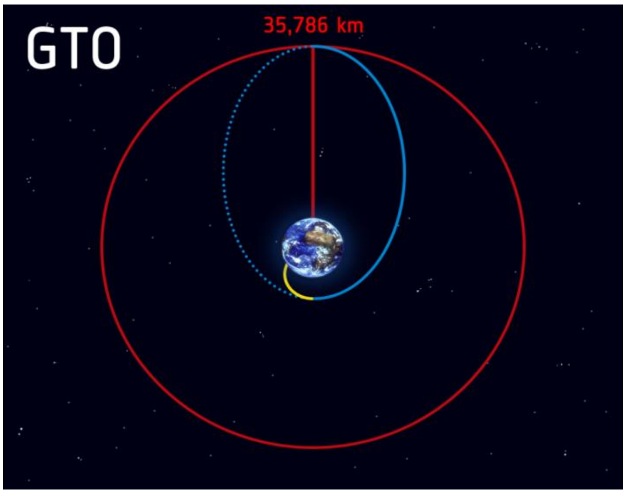
Sun-synchronous orbit (SSO) is a particular kind of polar orbit. Satellites in SSO, travelling over the polar regions, are synchronous with the Sun. This means they are synchronised to always be in the same 'fixed' position relative to the Sun. This means that the satellite always visits the same spot at the same local time – for example, passing the city of Paris every day at noon exactly.



5. Transfer orbits and geostationary transfer orbit (GTO)

Transfer orbits are a special kind of orbit used to get from one orbit to another. When satellites are launched from Earth and carried to space with launch vehicles such as Ariane 5, the satellites are not always placed directly on their final orbit. Often, the satellites are instead placed on a transfer orbit: an orbit where, by using relatively little energy from built-in motors, the satellite or spacecraft can move from one orbit to another.

This allows a satellite to reach, for example, a high-altitude orbit like GEO without actually needing the launch vehicle to go all the way to this altitude, which would require more effort – this is like taking a shortcut. Reaching GEO in this way is an example of one of the most common transfer orbits, called the geostationary transfer orbit (GTO).



6. Lagrange points

Lagrange points, or L-points, allow for orbits that are much, much farther away (over a million kilometres) and do not orbit Earth directly. These are specific points far out in space where the gravitational fields of Earth and the Sun combine in such a way that spacecraft that orbit them remain stable and can thus be 'anchored' relative to Earth. If a spacecraft was launched to other points in space very distant from Earth, they would naturally fall into an orbit around the Sun, and those spacecraft would soon end up far from Earth, making communication difficult. Instead, spacecraft launched to these special L-points stay fixed, and remain close to Earth with minimal effort without going into a different orbit.

RESOLUTION

The resolution of an image refers to the potential detail provided by the imagery. In remote sensing four types of resolution are there:

1. Spatial Resolution – refers to the size of the smallest feature that can be detected by a satellite sensor or displayed in a satellite image. It is usually presented as a single value representing the length of one side of a square. For example, a spatial resolution of 250m means that one pixel represents an area 250 by 250 meters on the ground.

2. Spectral Resolution – refers to the ability of a satellite sensor to measure specific wavelengths of the electromagnetic spectrum. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

3. Temporal Resolution – refers to the time between images. The capability for satellites to provideimage of the same geographical area more frequently has increased dramatically since the dawn of the space age.

4. Radiometric Resolution – refers to the smallest change in intensity level that can be detected by the sensing system. The intrinsic radiometric resolution of a sensing system depends on the signal to noise ratio of the detector. In a digital image, the radiometric resolution is limited by the number of discrete quantization levels used to digitize the continuous intensity value.

SENSOR

Sensor is an instrument to collect data by detecting the energy that is reflected from earth. Sensors are classified in to passive and active sensors.

Passive Sensor: Passive sensors are the sensor which measure energy that is naturally available. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the earth.

Active Sensor: Active sensors provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Example laser fluorosensor and a synthetic aperture radar (SAR).

LANDSAT

Instrument	Launched	Terminated	Duration	Notes
Landsat 1	July 23, 1972	January 6, 1978	5 years, 6 months and 14 days	Originally named Earth Resources Technology Satellite 1. Landsat 1 carried two vital instruments; a camera built by the Radio Corporation of America (RCA) known as the Return Beam Vidicon (RBV). As well as a Multi spectral Scanner (MSS) built by the Hughes Aircraft Company. (RBV+MSS)

Landsat 2	January 22, 1975	February 25, 1982	7 years, 1 month and 3 days	Nearly identical copy of Landsat 1. Payload consisting of a Return Beam Vidicon (RBV) and a Multi spectral Scanner (MSS). The specifications of these instruments were identical to Landsat 1(RBV+MSS)
Landsat 3	March 5, 1978	March 31, 1983	5 years, 26 days	Nearly identical copy of Landsat 1 and Landsat 2. Payload consisting of a Return Beam Vidicon (RBV) as well as a Multi spectral Scanner (MSS). Included with the MSS was a short-lived thermal band. MSS data was considered more scientifically applicable than the RBV which was rarely used for engineering evaluation purposes. (RBV+MSS –short lived thermal band)
Landsat 4	July 16, 1982	December 14, 1993	11 years, 4 months and 28 days	Landsat 4 carried an updated Multi Spectral Scanner (MSS) used on previous Landsat missions, as well as a Thematic Mapper. (Updated MSS +TM)
Landsat 5	March 1, 1984	June 5, 2013	29 years, 3 months and 4 days	Nearly identical copy of Landsat 4. Longest Earth-observing satellite mission in history. Designed and built at the same time as Landsat 4, this satellite carried the same payload consisting of a Multi Spectral Scanner (MSS) as well as a Thematic Mapper. (MSS+TM)
Landsat 6	October 5, 1993	October 5, 1993	0 days	Failed to reach orbit. Landsat 6 was an upgraded version of its predecessors. Carrying the same Multi spectral Scanner (MSS) but also carrying an Enhanced Thematic Mapper, which added a 15m-resolution panchromatic band. (MSS+Enhanced TM)
Landsat 7	April 15, 1999	Still active	21 years, 6 months and 22 days	Operating with scan line corrector disabled since May 2003.[11] The main component on Landsat 7 was the Enhanced Thematic Mapper Plus (ETM+). Still consisting of the 15m-resolution panchromatic band, but also includes a full aperture calibration. This allows for 5% absolute radiometric calibration (ETM+15m resolution panchromatic band)

Landsat 8				Originally named Landsat Data Continuity Mission from launch until May 30, 2013, when NASA operations were turned over to USGS.[13] Landsat 8 has two sensors with its payload, the Operational Land Imager (OLI) and the Thermal InfraRed Sensor (TIRS)
Landsat 9	April 8, 2021 (expected)			Landsat 9 will be a rebuild of its predecessor Landsat 8

Uses

Natural resources management

a. Agroindustry
b. Forestry

Climate change and disasters

a. The shrinking of Aral sea
b. Yellowstone part historic fires
c. Glacier retreat

Discovery of new species

SPOT

France, Sweden and Belgium joined together and pooled up their resources to develop the System Pour Observation dela Terre (SPOT), an earth observation satellite programme. The first satellite of the series, SPOT-1 was launched ro4m Kourou Launch Range in French Guiana on February 21, 1986 aboard an Ariance Launch vehicle (AIV). This is the first earth resource satellite ystem to include a linear array sensor employing the pushroom scanning technique. This enables side-to-side oft-nadir viewing capabilities and affords a full scene stereoscopic imaging from two different viewing points of the same area. The high resolution data obtained from SPOT sensors, namely, Thematic Mapper ™ and High Resolution Visible (HRV), have been extensively used for urban planning, urban growth assessment, transportation planning, besides the conventional applications related to natural resources. The characteristics of SPOT satellite and HRV;

SPOT satellite	
Orbit	Near polar sun-synchronous
Altitude	832 km
Inclination	98.7 Degree
Equatorial Crossing Time	10.30 Hours

Repeat Cycle	26 Days
HRV Sensor	
Channel	Waveband (Micron) Multispectral
1	0.50-0.59
2	0.61-0.68
3	0.79-0.89