❖ INTRODUCION

Normally, if one comes across the term Remote Sensing, one wonders 'what does it mean'. 'Remote' means far away and 'Sensing' means believing or observing or acquiring some information. Remote sensing means acquiring information of things.

In the world of geospatial science, remote sensing, also known as earth observation, means observing the earth with sensors from high above its surface. Remote sensing is used in numerous fields, including geography, land surveying and most Earth Science disciplines (for example, hydrology, ecology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning, and humanitarian applications.

❖ What is Remote Sensing?

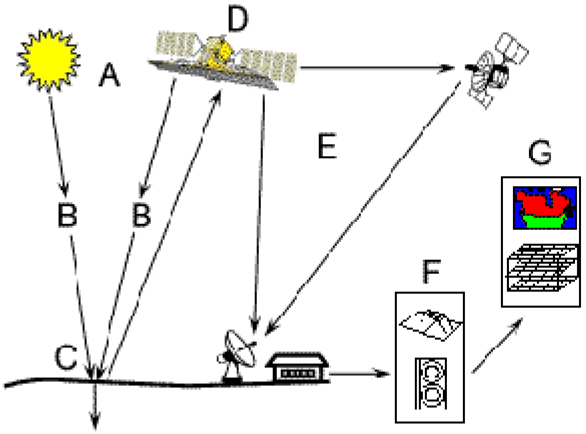
Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance from the targeted area. Remote sensing is the use of satellites, planes and other aerial technologies using advanced sensor technologies able to detect energy reflected from the Earth's surface. This makes it possible to collect data in inaccessible or dangerous areas where it would be too hazardous to bring in a team and equipment to collect data.

So what is Remote Sensing? For the purpose of this study we can use the following definition:

"Remote Sensing is the art and science of acquiring information about the earth surface without having any physical contact with it. This is done by sensing and recording of reflected and emitted energy."

❖ Remote Sensing Process

In the process of Remote Sensing involves an interaction between the incoming radiation and interest of target. This is done by using imaging and non-imaging system; however the following steps are involved in the process



1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere; it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

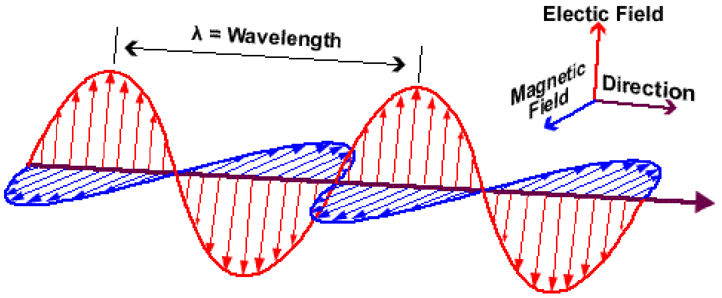
7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

❖ **Source of Energy**

The first and most important component of Remote Sensing is the Energy source to illuminate the Target. The energy is in the form of Electromagnetic Radiation. It is either natural originating from the Sun or earth by emission, or by artificial means.

• Electromagnetic radiation

Electromagnetic energy refers to all the energy that moves with the velocity of light in a harmonic wave pattern.EMR consists of an Electrical field and Magnetic field. The electrical field varies magnitude in a direction perpendicular to the direction in which the radiation is travelling and magnetic field oriented to the right angles to the electrical field.



Two characteristics of electromagnetic radiation are particularly important for understanding remote sensing. These are the wavelength and frequency.

- **Wave Lengths:**

A Wave length means the length of one wave cycle or the distance from any position in a cycle to the same position in the next cycle. It is usually represented by Greek letter lambda (λ). Wave length is usually measured in micrometer (mm, 10-6m) and the nanometer (nm,10-9m).

- **Frequency:**

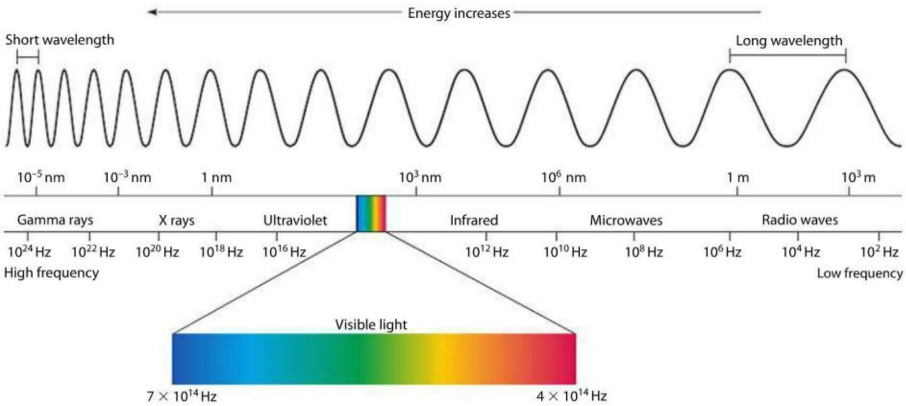
Frequency refers to the number of wave crests passing in a given point in Specific unit of time. It is normally measured in hertz (Hz). Wave length and frequency is related to following formula

$\nu = c / \lambda$

ν = Frequency   c = Speed of Light   λ = Wavelength

Electromagnetic Spectrum

The Electromagnetic Spectrum ranges from kilometers to nanometers. These are divided by ranges called Spectral bands. There are several regions in the Electromagnetic spectrum which is useful for



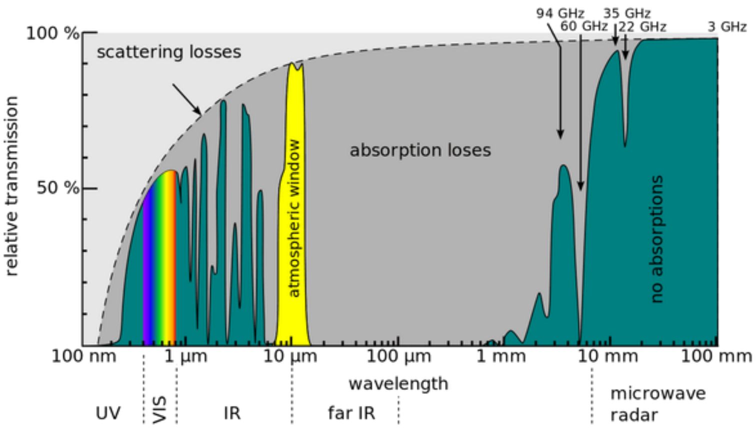
Remote Sensing. The following image shows the various regions in EMR.

Region name	Wavelength range
Ultraviolet(UV)	0.30-0.38 μm

Visible	0.4-0.75 µm Violet: 0.4 – 0.446 µm Blue: 0.446 – 0.500 µm Green: 0.500 – 0.578 µm Yellow: 0.578 – 0.592 µm Orange: 0.592 – 0.620 µm Red: 0.620 – 0.7 µm Blue, Green and Red are the primary colors in the visible spectrum.
Near Infra-red (NIR)	0.75-1.5 µm
Middle Infrared (MIR)	1.5-5 µm SWIR (1.5-3 µm) MIR (3.0-5.0 µm)
Thermal Infrared (TIR)	5.0-15.0 µm
Microwave	1mm-1m

❖ **Interactions with Atmosphere**

When the incoming solar radiation passes through the atmosphere it may come in contact with atmospheric particles and gases, leads to the mechanisms of scattering and absorption. The gases absorb the Electromagnetic radiation at specific wavelengths called absorption bands. However the high interviewing transmittance regions are often known as Atmospheric Windows.



- **Scattering**

When the incoming radiation and light passes through the atmosphere it will affected by the atmospheric particles and this will result the redirection of the light from its original path is known as scattering. Different from reflection, where radiation is deflected in one direction, some particles and molecules found in the atmosphere have the ability to scatter solar radiation in all directions. The particles/molecules which scatter light are called scatterers and can also include particulates made by human industry.

1. **Selective scattering-**

   Rayleigh scattering occurs when certain particles are more effective at scattering a particular wavelength of light. Air molecules, like oxygen and nitrogen for example, are small in size and thus more effective at scattering shorter wavelengths of light (blue and violet). The selective scattering by air molecules is responsible for producing our blue skies on a clear sunny day.

   Mie Scattering is responsible for the white appearance of clouds. Cloud droplets with a diameter of 20 micrometers or so are large enough to scatter all visible wavelengths more or less equally. This means that almost all of the light which enters clouds will be scattered. Because all wavelengths are scattered, clouds appear to be white.

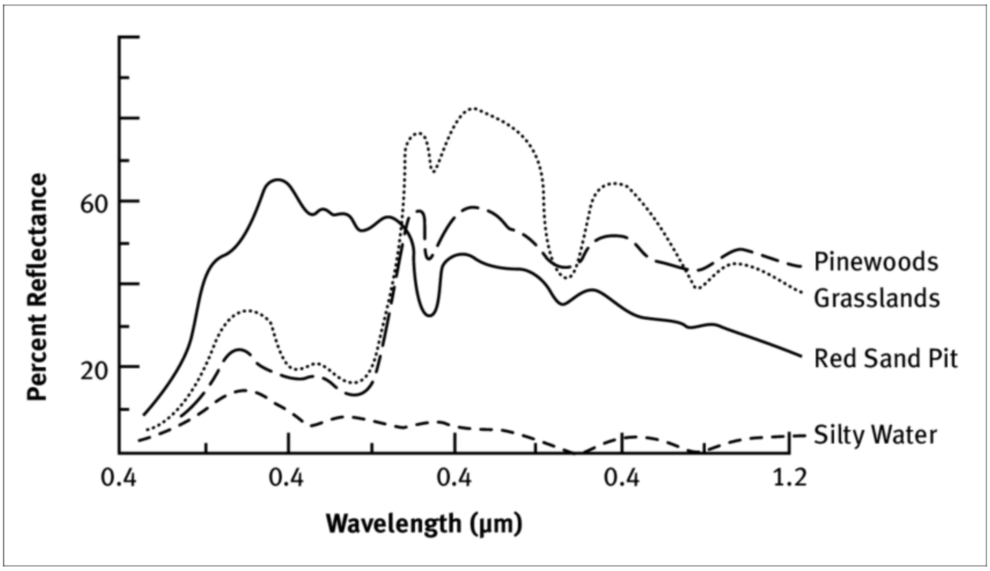
2. **Non-selective scattering-** Non-selective scattering occurs when the diameter of the particles in the atmosphere are much *larger* than the wavelength of radiation. Non-selective scatter is primarily caused by water droplets in the atmosphere. Non-selective scattering scatters all radiation evenly through out the visible and infrared portions of the spectrum - hence the term non-selective. In the visible wavelengths light is scattered evenly, hence fog and clouds appear white. Since clouds scatter all wavelengths of light, this means that clouds block most energy from reaching the Earth's surface. This can make interpreting and analyzing remote sensed imagery difficult in areas prone to cloud and fog cover. Clouds also cast shadows that change the illumination and relative reflectance of surface features. This can be a major limitation in remote sensing imagery

- **Absorption**

Absorption is another main mechanism that happens when the EMR interacts with atmospheric particles and gases. When the EMR passes through the atmosphere the molecules in the atmosphere absorbs energy at various wavelengths. Ozone, CO_2 and water vapour are the main causes of energy absorption.

- **Interaction with the target**

Radiation passed through the atmosphere interacts with the Earth's surface. There are three forms of interaction: absorption, transmission and reflection. In remote sensing, we are most interested in measuring the radiation reflected from targets. We refer to two types of reflection, which represent the two extreme ends of the way in which energy is reflected from a target: specular and diffuse reflection. The interaction with the surface depends on the wavelength of the energy and the material and condition of the surface feature. Different materials reflect and absorb differently the electromagnetic spectrum. The reflectance spectrum of a material is a plot of the fraction of radiation reflected as a function of the incident wavelength and serves as a unique signature for the material.



❖ <u>Passive and Active Remote Sensing</u>

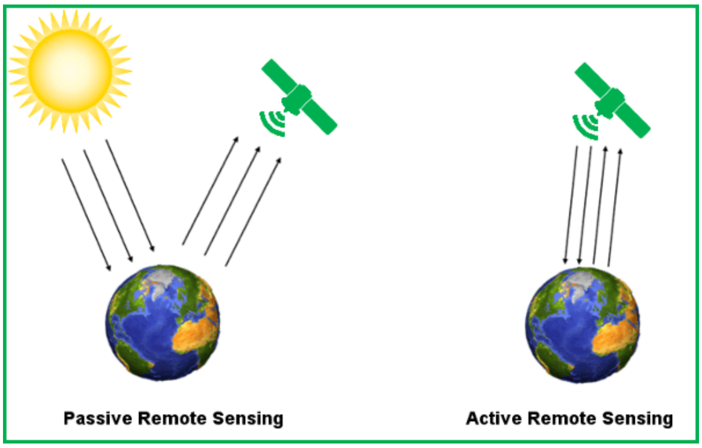
There are two types of Remote Sensing Systems namely Active and Passive sensing.

Passive sensor receives naturally emitted EM energy within its field of view (FIV) and performs measurement using it.

- Examples: remote sensing satellite, SPOT-1, LANDSAT-1 etc.
- Passive sensors rely on other sources such as sun for its operation.
- Passive sensors obtain measurements only in day time.

Active sensor emits their own EM (Electromagnetic) energy which is transmitted towards the earth and receives energy reflected from the earth. The received EM energy is used for measurement purpose.

- Examples: communication satellite, earth observation satellite (e.g. RADARSAT-1), LISS-1 etc.
- Active sensors use their own source of energy for operation.
- Active sensors can obtain measurements anytime (Day & Night).



❖ Types of Platforms

The vehicle or carrier for a remote sensor to collect and record energy reflected or emitted from a target or surface is called a platform. The sensor must reside on a stable platform removed from the target or surface being observed.

Ground Based Sensors

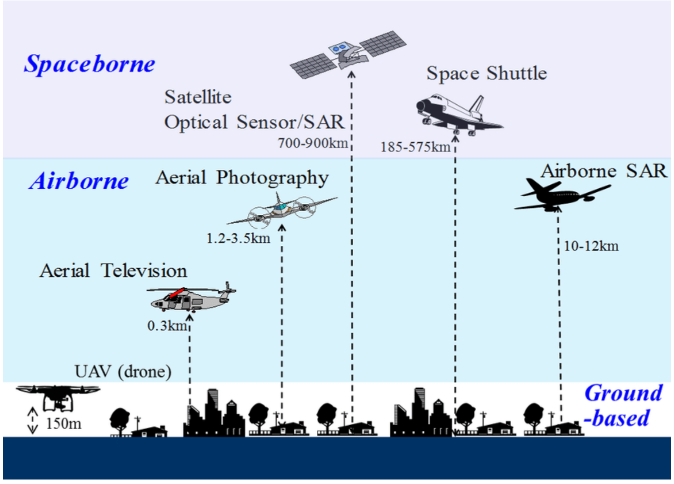
Ground-based sensors are often used to record detailed information about the surface. Ground based sensors may be placed on a ladder, scaffolding, tall building, cherry-picker, crane, etc.

Airborne Platforms

Aerial platforms are primarily stable wing aircraft, although helicopters are occasionally used. Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.

Space borne Platforms

In the space remote sensing are conducted from either using Space shuttle or Satellites. These kinds of Satellites are often known as Remote Sensing satellites. Satellite based sensors are the most efficient



and wide spread in the world.

❖ Advantages of remote sensing technology:

- Large area coverage: Remote sensing allows coverage of very large areas which enables regional surveys on a variety of themes and identification of extremely large features.
- Remote sensing allows for easy collection of data over a variety of scales and resolutions.
- Remotely sensed data can easily be processed and analyzed fast using a computer and the data utilized for various purposes.
- Data collected through remote sensing is analyzed at the laboratory which minimizes the work that needs to be done on the field.
- Remote sensing allows for map revision at a small to medium scale which makes it a bit cheaper and faster.

- Color composite can be obtained or produced from three separate band images which ensure the details of the area are far much more defined than when only a single band image or aerial photograph is being reproduced.
- It is easier to locate floods or forest fire that has spread over a large region which makes it easier to plan a rescue mission easily and fast.
- Remote sensing is a relatively cheap and constructive method reconstructing a base map in the absence of detailed land survey methods.

Disadvantages of remote sensing:

- Remote sensing is a fairly expensive method of analysis especially when measuring or analyzing smaller areas.
- Remote sensing requires a special kind of training to analyze the images. It is therefore expensive in the long run to use remote sensing technology since extra training must be accorded to the users of the technology.
- It is expensive to analyze repetitive photographs if there is need to analyze different aspects of the photography features.
- The instruments used in remote sensing may sometimes be un-calibrated which may lead to un-calibrated remote sensing data.
- Sometimes large scale engineering maps cannot be prepared from satellite data which makes remote sensing data collection incomplete.

❖ What is Satellite Imagery?

The term "satellite imagery" may refer to a number of types of digitally transmitted images taken by artificial satellites orbiting the Earth. Satellite imagery has been used for mapping, environmental monitoring, archaeological surveys and weather prediction.

❖ Satellite

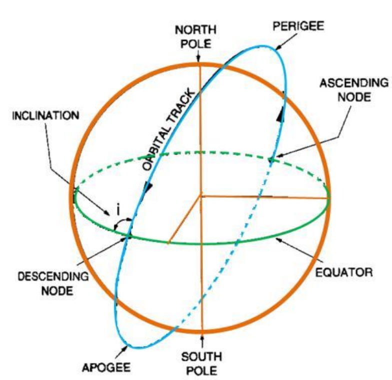
A satellite is an object in space that orbits or circles around a bigger object. There are two kinds of satellites: natural (such as the moon orbiting the Earth) or artificial (such as the International Space Station orbiting the Earth).

❖ Orbit

The path followed by a satellite in the space is called the orbit of the satellite. Orbits may be circular (or near circular) or elliptical in shape.

❖ Characteristics of satellite orbits

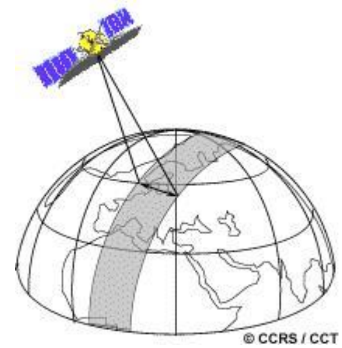
- **Orbital period:** Time taken by a satellite to compete one revolution in its orbit around the earth is called orbital period. It varies from around 100 minutes for a near-polar earth observing satellite to 24 hours for a geo-stationary satellite.
- **Altitude:** Altitude of a satellite is its heights with respect to the surface immediately below it. Depending on the designed purpose of the satellite, the orbit may be located at low (160-2000 km), moderate, and high (~36000km) altitude.
- **Apogee and perigee:** Apogee is the point in the orbit where the satellite is at maximum distance from the Earth. Perigee is the point in the orbit where the satellite is nearest to the Earth.



- **Inclination:** Inclination of the orbital plane is measured clockwise from the equator. Orbital inclination for a remote sensing satellite is typically 99 degrees. Inclination of any satellite on the equatorial plane is nearly 180 degrees.
- **Nadir, ground track and zenith:** Nadir is the point of interception on the surface of the Earth of the radial line between the center of the Earth and the satellite. This is the point of shortest distance from the satellite to the earth's surface.

Any point just opposite to the nadir, above the satellite is called zenith.

The circle on the earth's surface described by the nadir point as the satellite revolves is called the ground track. In other words, it is the projection of the satellites orbit on the ground surface.

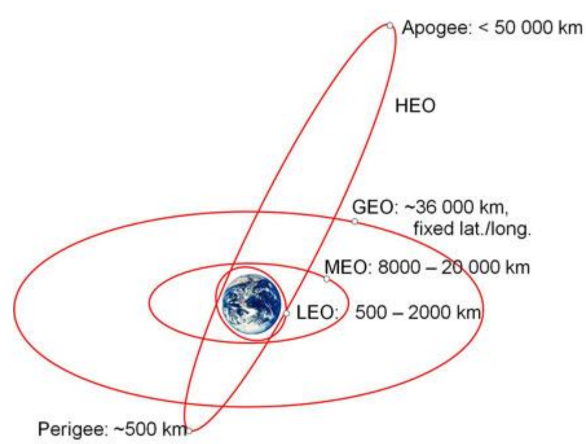


- **Swath:** Swath of a satellite is the width of the area on the surface of the Earth, which is imaged by the sensor during a single pass.

❖ Classifications of Orbit

- **Altitude classifications**

1. **Low Earth orbit (LEO):** A low Earth orbit is normally at an altitude of less than 1000 km and could be as low as 160 km above the Earth. In general, these orbits are used for remote sensing, military purposes and for human spaceflight. The International Space Station is in low Earth orbit.
2. **Medium Earth orbit (MEO):** MEO is the region of space around the Earth above low Earth orbit and below geostationary orbit. The most common use for satellites in this region is for navigation, such as the GPS constellations. MEO extends from 2000km and ends right below 35,786km.
3. **Geostationary orbit (GEO):** A geostationary orbit, often referred to as a geosynchronous equatorial orbit (GEO), is a circular geosynchronous orbit 35,786 km above Earth's equator and following the direction of Earth's rotation. Communications satellites and weather satellites are often placed in geostationary orbits. A geostationary orbit is a particular type of geosynchronous orbit, which has an orbital period equal to Earth's rotational period, or one sidereal day (23 hours, 56 minutes, 4 seconds) with an inclination of zero.
4. **High Earth orbit (HEO):** Any orbit beyond the geostationary orbit is known as high earth orbit. High earth orbit is loosely attributed to any orbit beyond 35,786km. Satellites in the HEO are useful to study our planet's magnetosphere and for other astronomical observations.

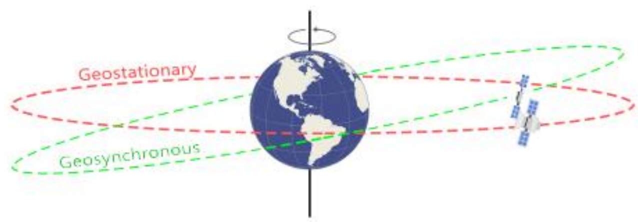


➢ <u>Synchronicity classifications</u>

1. **Synchronous orbit:** A synchronous orbit is an orbit in which an orbiting body (usually a satellite) has a period equal to the average rotational period of the body being orbited (usually a planet), and in the same direction of rotation as that body.

- **Geosynchronous orbit (GSO):** Geostationary or geosynchronous orbit is the one in which the time required for the satellite to cover one revolution is the same as that for the Earth to rotate once about its polar axis. In order to achieve this orbit period, geo-synchronous orbits are generally at very high altitude; nearly 36,000 km. The orbit's inclination and eccentricity may not necessarily be zero.

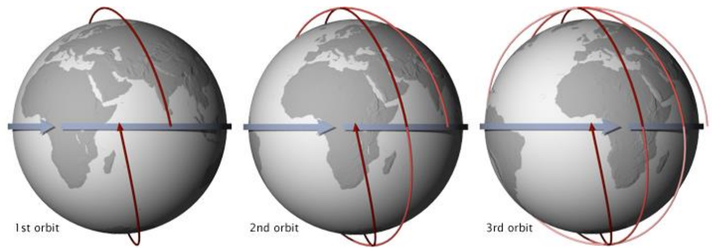
  Geo-synchronous orbits are located in the equatorial plane, i.e with an inclination of 180 degrees. Thus from a point on the equator, the satellite appears to be stationary. The satellites revolve in the same direction as that of the Earth (west to East). Example: INSAT, MeteoSAT, GOES, GMS etc.



2. **Semi-synchronous orbit:** A semi-synchronous orbit is an orbit with a period equal to half the average rotational period of the body being orbited, and in the same direction as that body's rotation. For Earth, a semi-synchronous orbit is considered a medium Earth orbit, with a period of just under 12 hours. For circular Earth orbits, the altitude is approximately 20,200 kilometres (12,600 mi).[1][2]
   Example: Semi-synchronous orbits are typical for GPS satellites.
3. **Polar orbit:** A satellite orbit in which the satellite passes over the North and South poles on each orbit, and eventually passes over all points on the earth. The angle of inclination between the equator and a polar orbit is 90 degrees. Example: The National Oceanic and Atmospheric Administration (NOAA) series of satellites like NOAA 17, NOAA 18 are all examples of polar orbiting satellites.

4. **Sun-synchronous orbit:** An orbit which combines altitude and inclination in such a way that the satellite passes over any given point of the planets's surface at the same local solar time. Such an orbit can place a satellite in constant sunlight and is useful for imaging, spy, and weather satellites.

   Example: Landsat satellites and IRS satellites are typical examples of sun-synchronous satellites.



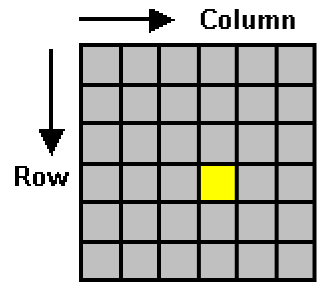
❖ Type of Satellites

- **Astronomy satellites -** An astronomy satellite is basically a really big telescope floating in space. Example: Hubble Space Telescope, SROSS series satellites.
- **Atmospheric Studies satellites -** Atmospheric studies satellites were some of the very first satellites launched into space. They generally have pretty low Earth orbits so that they can study the Earth's atmosphere. Example: NASA's Polar satellite.
- **Communications satellites -** A 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. Example: GSAT and INSAT series satellites are India's indigenously developed communications satellites.
- **Navigation satellites -** A satellite navigation system is a system that uses satellites to provide autonomous geo-spatial positioning. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision (within a few metres) using time signals transmitted along a line of sight by radio from satellites. Example: Navstar is a network of U.S. satellites that provide global positioning system (GPS) services. The Indian Regional Navigation Satellite System (IRNSS), with an operational name of NAVIC (NAVigation with Indian Constellation) is an autonomous regional satellite navigation system.
- **Remote Sensing satellites / Earth observation satellite -** Remote sensing is observing and measuring our environment from a distance. So, remote sensing satellites are usually put into space to monitor resources important for humans . Example: Landsat program ((USGS) , IRS series satellites (ISRO).
- **Weather satellites -** A weather satellite or meteorological satellites is a type of satellite that is primarily used to monitor the weather and climate of the Earth. Example: The Indian National Satellite (INSAT) system.

❖ Remote Sensing Images

Remote sensing images are representations of parts of the earth surface as seen from space. The images may be analogor digital. Aerial photographs are examples of analog images while satellite images acquired using electronic sensors are examples of digital images.

A digital image is a two-dimensional array of pixels. Each pixel has an intensity value (represented by a digital number) and a location address (referenced by its row and column numbers)



- **Pixels:** A digital image comprises of a two dimensional array of individual picture elements called pixels arranged in columns and rows. Each pixel represents an area on the Earth's surface. A pixel has an intensity value and a location address in the two dimensional image.

- **Resolution: T**he resolution is the minimum distance between two objects that can be distinguished in the image.

Four types of resolutions are defined for the remote sensing systems.

1. Spatial resolution: Spatial resolution refers to the size of the smallest object that can be resolved on the ground. In a digital image, the resolution is limited by the pixel size. It is expressed by the size of the pixel on the ground in meters.

   Very High resolution (sub metre): from 30cm – 1m
   High resolution range: 1.5m – 10m
   Low resolution: 15m – 30m

2. Spectral resolution: Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

   - Panchromatic – 1 wide Band (B&W imagery)
   - Colour – 3 bands (Red, Green, Blue)
   - Multispectral – 4-8 bands (RGBN)
   - Super spectral – 16 bands or more
   - Hyperspectral – hundreds of bands

3. Temporal resolution: The temporal resolution specifies the revisiting frequency of a satellite sensor for a specific location and the availability of archive data over a specific location.
4. Radiometric resolution : The radiometric resolution specifies how well the differences in brightness in an image can be perceived; this is measured through the number of the grey value levels

Sponsoring Program	Sensor	Spectral Bands (µm)		Spatial Resolution (M)	Radiometric Resolution (Bit)	Temporal Resolution (Day)	Swath Width (K.M)	Launch Date
Landsat-4	MSS	1	0.5-0.6 Green	79 x 57	6	18	185	1982
		2	0.6-0.7 Red					
		3	0.7-0.8 NIR					
		4	0.8-1.1 NIR	30	8	16	185	1984
Landsat-5	TM	1	0.45-0.52 Blue					
		2	0.52-0.60 Green					
		3	0.52-0.60 Green					
		4	0.76-0.90 NIR					
		5	1.55-1.75 SWIR1	30				
		6	10.4-12.5 TIR	120				
		7	2.08-2.35 SWIR2	30				
Landsat-7	ETM+		TIR 61 & 62	60	8	816	185	1999
IRS-1D	LISS-III	B2	0.52-0.59 Green	23.5	7	24	141	1997
		B3	0.62-0.68 Red					
		B4	0.77-0.86 NIR					
		B5	1.55-1.70 SWIR					
	PAN		0.50-0.75	5.8	6	5	70	
	WIFS	B3	0.62-0.68 Red	188	7	5	810	
		B4	0.77-0.86 NIR					
IRS-P6	LISS-III			23.5	7	24	141	2003
	LISS-IV	B2	0.52-0.59 Green	5.8	7		23.9	
		B3	0.62-0.68 Red					
		B4	0.77-0.86 NIR					
	AWIFS	B2	0.52-0.59 Green	56	10	5	740	
		B3	0.62-0.68 Red					
		B4	0.77-0.86 NIR					
		B5	1.55-1.70 SWIR					
CartoSat 2	PAN		0.50-0.85	0.81	10	4	9.6	2007

❖ Multispectral Image

A multispectral image consists of several bands of data. For visual display, each band of the image may be displayed one band at a time as a grey scale image, or in combination of three bands at a time as a colour composite image.

- <u>Spectral band:</u> Spectral band means a type of filter that can make only pass desired wavelength. An EMR (Electro magnetic radiation) has vast range of energy consists of different wavelength. Whenever any sensor can make filter a specific wavelength induced energy/light then it called spectral band. Example, 0.4–0.5 micrometer called blue, 0.5–0.6 micrometer called as green and 0.6–0.7 called as red. Apart from that 0.7 to 1 micrometer is called as infrared. Those are spectral bands. An image is a form of overlaying of different bands.

❖ <u>Earth observation satellites</u>

Earth observation satellites are satellites specifically designed for Earth observation from orbit, similar to spy satellites but intended for non-military uses such as environmental monitoring, meteorology, map making etc. The first satellite designed specifically to monitor the Earth's surface, Landsat-1, was launched by NASA in 1972. Most Earth observation satellites carry instruments that should be operated at a relatively low altitude below 500-600 kilometers. Most are in sun-synchronous orbits.

➢ <u>Landsat program</u>

The Landsat program is the longest-running enterprise for acquisition of satellite imagery of Earth. On July 23, 1972 the Earth Resources Technology Satellite was launched. This was eventually renamed to Landsat. The most recent, Landsat 8, was launched on February 11, 2013. The instruments on the Landsat satellites have acquired millions of images. The images, archived in the United States and at Landsat receiving stations around the world, are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional
planning, surveillance and education, and can be viewed through the U.S. Geological Survey (USGS) 'EarthExplorer' website. Landsat 7 data has eight spectral bands with spatial resolutions ranging from 15 to 60 meters; the temporal resolution is 16 days.

➢ <u>India's remote sensing(IRS) programme</u>

India's remote sensing programme under the Indian Space Research Organization (ISRO) started off in 1988 with the IRS-1A, the first of the series of indigenous state-of-art operating remote sensing satellites. Subsequently, IRS-1B, having similar sensors, was launched in august 1991. The LISS-III, PAN and WiFS sensors on IRS-1C (December 1995) and IRS-1D (September 1997) further strengthened the scope of remote sensing, with increased coverage and foray into application areas like resource survey and management, urban planning, forest studies, disaster monitoring and environmental studies.

Satellite	Date of Launch	Launch Vehicle

IRS-1A	17 March 1988	Vostok, USSR
IRS-1B	29 August 1991	Vostok, USSR
IRS-1C	28 December 1995	Molniya, Russia
IRS-P3	21 March 1996	PSLV-D3
IRS 1D	29 September 1997	PSLV-C1
IRS-P4 (Oceansat-1)	27 May 1999	PSLV-C2
IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5
IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6
IRS P7 (Cartosat 2)	10 January 2007	PSLV-C7
Cartosat 2A	28 April 2008	PSLV-C9
Oceansat-2	23 September 2009	PSLV-C14
Cartosat-2B	12 July 2010	PSLV-C15
Resourcesat-2	20 April 2011	PSLV-C16
RISAT-1	26 April 2012	PSLV-C19
Cartosat-2D	15 Feb 2017	PSLV-C37
Cartosat-2E	23 June 2017	PSLV-C38

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- Visual Image Interpretation

The visual interpretation of satellite images is a complex process. It includes the meaning of the image content but also goes beyond what can be seen on the image in order to recognise spatial and landscape patterns. This process can be roughly divided into 2 levels:

The recognition of objects such as streets, fields, rivers, etc. The quality of recognition depends on the expertise in image interpretation and visual perception.

A true interpretation can be ascertained through conclusions (from previously recognized objects) of situations, recovery, etc. Subject specific knowledge and expertise are crucial.

- **Elements of Visual Interpretation**

Analysis of remote sensing imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features which consist of points, lines, or areas. Targets may be defined in terms of the way they reflect or emit radiation. This radiation is measured and recorded by a sensor, and ultimately is depicted as an image product such as an air photo or a satellite image.

The following are elements of aerial photographic and satellite image interpretation.

Tone refers to the relative brightness or colour of objects in an image. Generally, tone is the fundamental element for distinguishing between different targets or features. Variations in tone also allow the elements of shape, texture, and pattern of objects to be distinguished.

Shape refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

Size of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly. For example, if an interpreter had to distinguish zones of land use, and had identified an area with a number of buildings in it, large buildings such as factories or warehouses would suggest commercial property, whereas small buildings would indicate residential use.

Pattern refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Orchards with evenly spaced trees and urban streets with regularly spaced houses are good examples of pattern.

Texture refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

Shadow is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

Association takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. In the example given above, commercial properties may be associated with proximity to major transportation routes, whereas residential areas would be associated with schools, playgrounds, and sports fields. In our example, a lake is associated with boats, a marina, and adjacent recreational land.