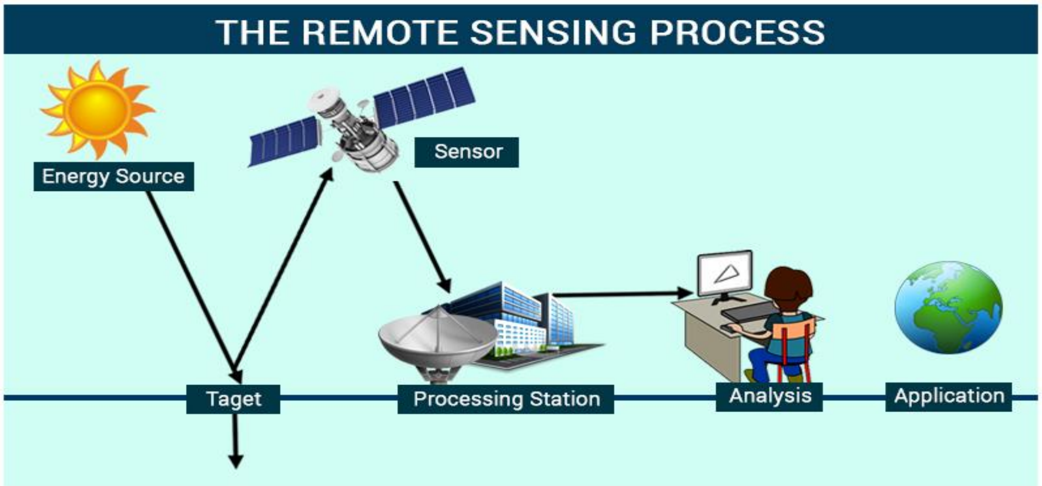
2.Remote sensing types

- Remote Sensing is a technology to gather information and analyzing an object or phenomenon without making any physical contact.
- This technology is used in numerous fields like geography, hydrology, ecology, oceanography, glaciology, geology.
- Three essential elements for Remote Sensing :
  - ❖ A platform to hold the instrument
  - ❖ A target or object
  - ❖ An instrument or sensor (to observe the target)

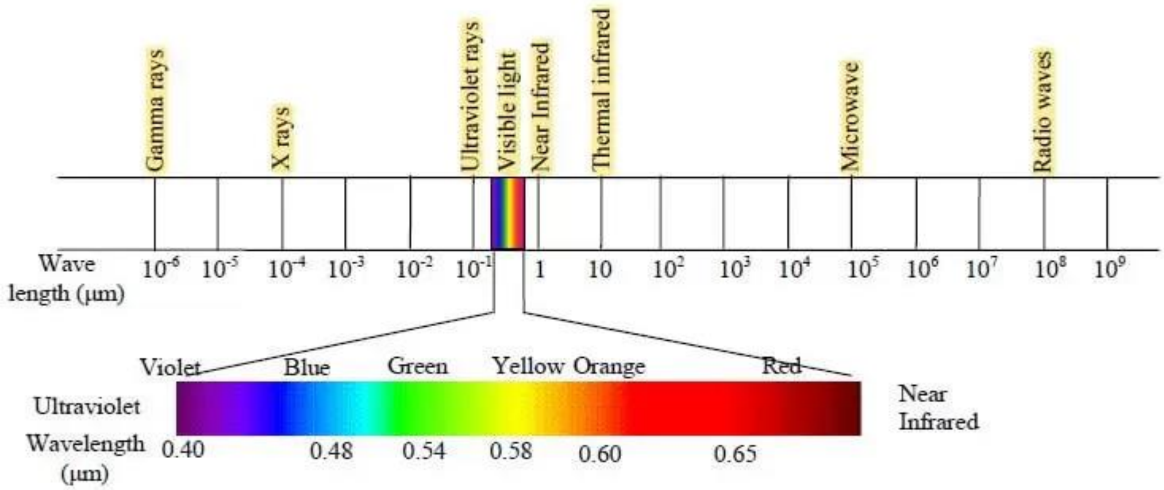


- Basic Processes in Remote Sensing
  - ❖ Data acquisition (energy propagation, platforms)
  - ❖ Processing (conversion of energy pattern to images)
  - ❖ Analysis (quantitative and qualitative analysis)
  - ❖ Accuracy assessment (radiometric and geometric correction)
  - ❖ Information distribution to users
- Remote Sensing Applications
  - ❖ Land Use Mapping
  - ❖ Weather Forecasting
  - ❖ Environmental Study

- Study of Natural hazards
- Resource exploration

- Types of Remote Sensing Systems
  - Visual Remote Sensing System such as human visual system
  - Optical Remote Sensing
  - Infrared Remote Sensing
  - Microwave Remote Sensing
  - Radar Remote Sensing
  - Satellite Remote Sensing
  - Airborne Remote Sensing
  - Acoustic and near-acoustic remote sensing

- EMR and remote sensing
  - Electromagnetic Radiation (EMR)
  - is a wave that propagates (radiates vacuum at the speed of light ( ) through just under **300 000 m/s** and transfers energy from one place to another .
  - these waves carry energy as synchronized oscillations of electric and magnetic fields that are perpendicular to each other and perpendicular to the direction of travel
  - Although it is a wave, it also can be detected as discrete ‘particles’ of light called **photons.**
  - Electromagnetic energy is generated by several mechanisms
    - changes in the energy levels of electrons
    - acceleration of electrical charges
    - nuclear decay of radioactive substances
    - nuclear reactions (fission and fusion)
    - thermal motion of atoms and molecules



- The **Electromagnetic Spectrum** is represented by **Electromagnetic waves.**
- It's characterized by their wavelength or frequency, linked by the speed of light.
- The frequency is associated with energy.
- **High frequency is high energy.**
- Elements of Remote Sensing
    - A. Emission of electromagnetic radiation. (The Sun or an EMR source located on the platform)
    - B. The Transmission of energy from the source to the object. (Absorption and scattering of the EMR while transmission)
    - C. Interaction of EMR with the object and subsequent reflection and emission
    - D. Transmission of energy from the object to the sensor
    - E. Recording of energy by the sensor. (Photographic or non-photographic sensors)
    - F In Transmission of the recorded information to the ground station
    - G. Processing of the data into digital or hard copy image
    - H. Analysis of data

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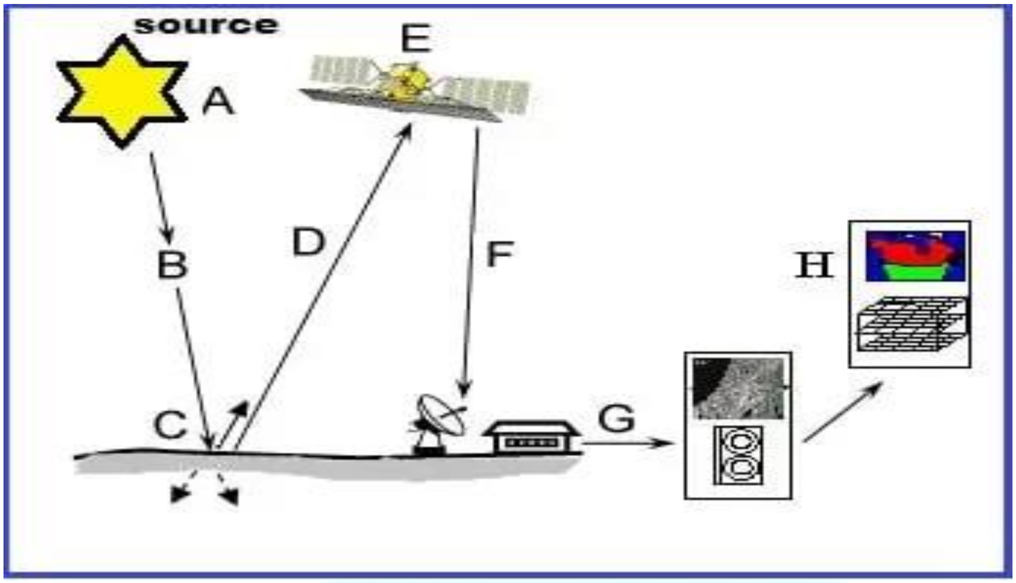


- Remote Sensing Platforms
  - ❖ RS platforms can be classified as follows, based on the elevation from the Earth's surface at which these platforms are placed.
  - ➢ **Ground borne Remote Sensing**
    - ➔ Ground-level remote sensors are very close to the ground.
    - ➔ They are used to develop and calibrate sensors for different features on the Earth's surface.
    - ➔ **Mobile hydraulic platforms (up to 15 m height)**

- ➔ **Portable Masts**

➔ **<u>Towers</u>**

➔ **<u>Weather Surveillance Radar</u>**

➢ Airborne Remote Sensing

➔ Low altitude aerial remote sensing

➔ High altitude aerial remote sensing

➔ **<u>Balloons based</u>** :

★ Altitude range is 22-40 km

- ★ Tool to probing the atmosphere •
- ★ Useful to test the instruments under development

➔ **<u>Radiosonde:</u> Measure Temperature pressure, and Relative humidity in the atmosphere**

➔ **<u>Rawinsonde</u>:** Measure wind velocity, temperature, pressure and relative humidity

➔ **<u>Aircraft</u>**:

- ★ High spatial resolution (20 cmorless)
- ★ Analog photography is possible (analog photo gives high resolution)
- ★ Easily schedule change to weather problems their avoid
- ★ Sensor maintenance and repair is easy

➢ **<u>Spaceborne Remote Sensing</u>**

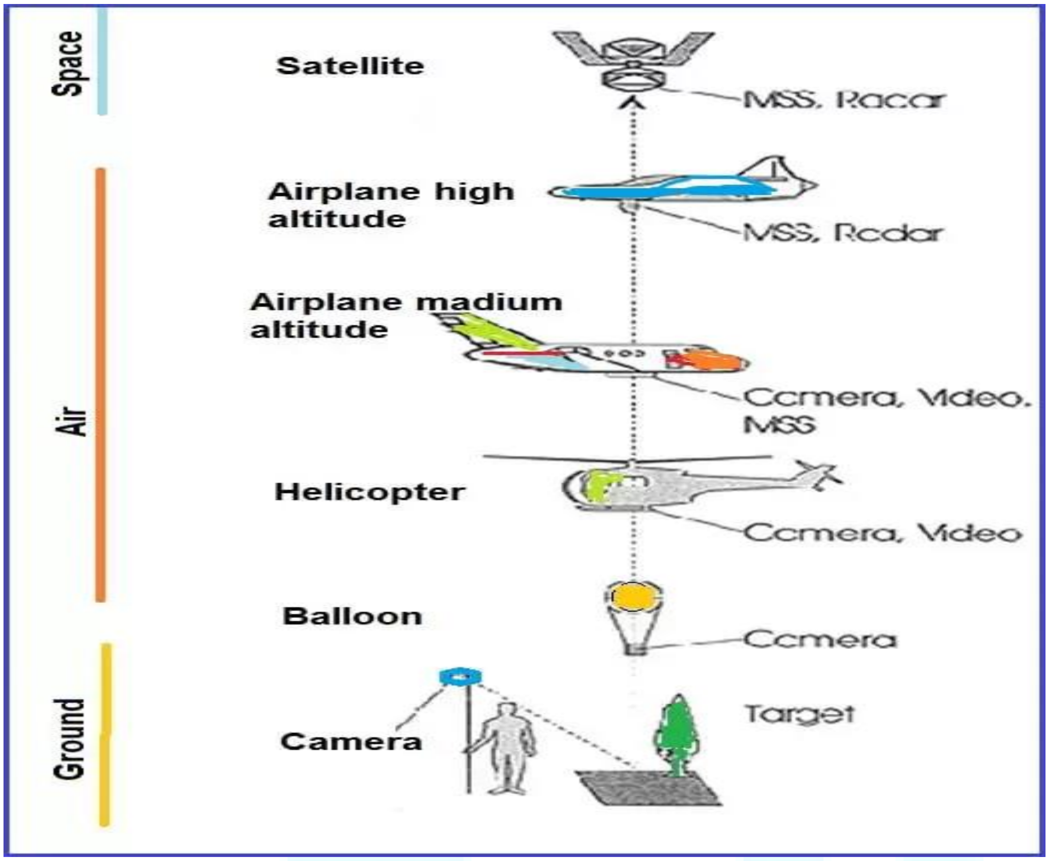
➔ Space shuttles

➔ Polar-orbiting satellites

➔ Geo-stationary satellites

➔ **<u>Space borne platforms:</u>**

- ★ Sensors are mounted on-board a spacecraft
- ★ Rockets , satellites and space shuttles



- Aerial remote sensing
  - ❖ Aerial Remote Sensing Photography has been defined as the **science of taking a photograph from a point from the satellite for the purpose of making some type of the study of the surface of the earth.**
  - ❖ ADVANTAGES OF AERIAL PHOTOGRAPHY
  - ➢ **Improved vantage point:** Aerial photography provides a bird's eye view of large areas, enabling us to see features of the earth surface in their spatial context.
  - ➢ **Time freezing ability:** An aerial photograph is a record of the surface features at an instance of exposure. It can, therefore, be used as a historical record.
  - ➢ **Broadened Sensitivity:** The sensitivity of the film used in taking aerial photographs is relatively more than the sensitivity of the

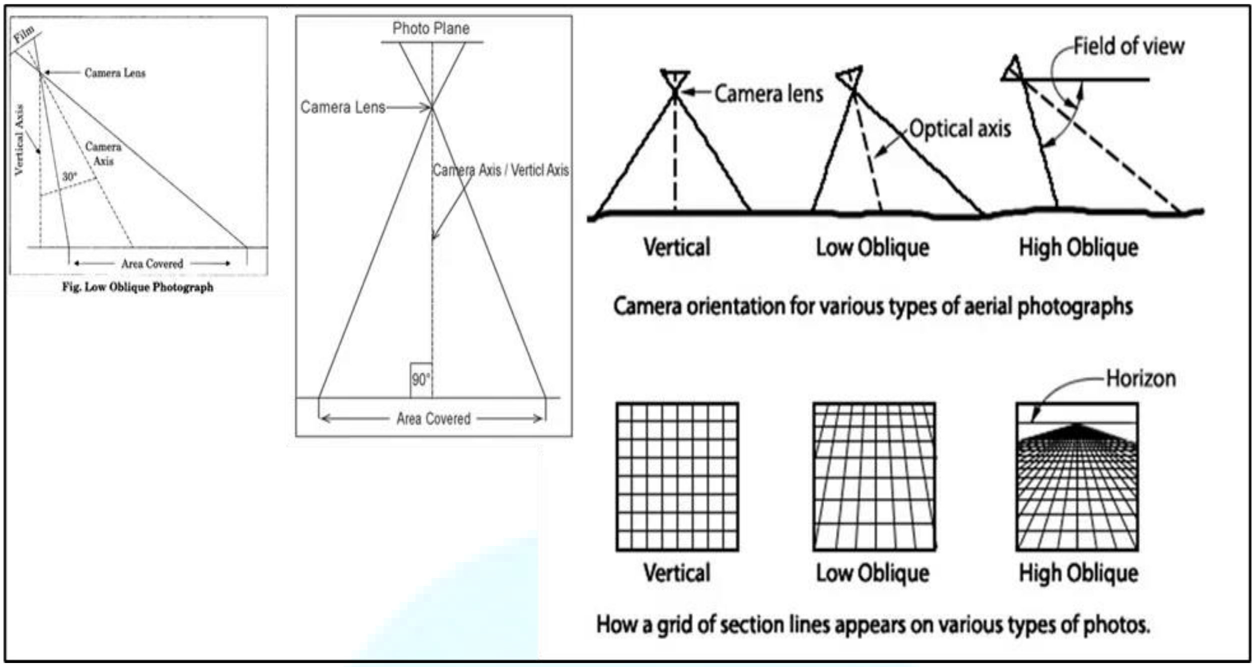
human eyes. Our eyes perceive only in the visible region of the electromagnetic spectrum.

- **Three Dimensional Perspective:** Aerial photographs are normally taken with uniform exposure interval that enables us in obtaining stereo pair of photographs

❖ Types of Aerial Photographs Based on the Position of the Camera Axis:

- Vertical photographs
- Low oblique photographs
- High oblique photographs

Attributes	Vertical	Low Oblique	High Oblique
Optical Axis	Tilt < 3° i.e. exactly or nearly coincides with the Vertical axis.	Deviation is <30° from the Vertical axis.	Deviates by axis > 30° from vertical axis.
Characteristics	Horizon does not appear.	Horizon does appear.	Horizon appears
Coverage	Small area	Relatively larger area	Largest area
Shape of the area	Square	Trapezoidal	Trapezoidal
Photographed scale	Uniform, if the terrain is flat	Decreases from foreground to background	Decreases from the foreground to the background
Difference in comparison to the map	Least	Relatively greater	Greatest
Advantages	Useful in topographical and thematic mapping	Reconnaissance Survey	Illustrative



- ❖ Types of Aerial Photographs Based on Scale:
  - ➢ **Large Scale Photographs:** When the scale of an aerial photograph is **1 : 15,000** and larger.
  - ➢ **Medium Scale Photographs:** The aerial photographs with a scale ranging **between 1 : 15,000 and 1 : 30,000.**
  - ➢ **Small Scale Photographs:** The photographs with the scale being **smaller than 1 : 30,000**

- Photogrammetry
  - ❖ Photogrammetry uses **imaging rather than collecting light wavelength data**.
  - ❖ It involves determining the spatial properties and dimensions of objects captured in photographic pictures.
  - ❖ **Albrecht Meydenbauer,** a Prussian architect who made some of the first elevation drawings and topographic maps, **first used the term in 1867.**
  - ❖ Today, an airplane, satellite, drone or even a close-range camera might record digital images for photogrammetric use.
  - ❖ Photogrammetry relies on a technique known as **aerial triangulation to measure changes in position.**

- This method involves taking aerial photographs from **more than one location and using measurements from both places to pinpoint locations and distances more accurately.**
- The various photographs provide different lines of sight or rays from the camera to specific points.
- The trigonometric intersection of these lines of sight can then produce accurate 3D coordinates for those points.
- Modern photogrammetry also sometimes relies on laser scanning as a complement to traditional images.
- **Light detection and ranging (LIDAR),** for instance, which uses pulsed lasers to measure distances, often assists in photogrammetry performed from aircraft and satellites, as well as on the ground.
- Photogrammetry breaks down into two main branches

➢ **Metric photogrammetry:**

- This branch of the field involves taking exact measurements and frequently finds use in technical industries like engineering and surveying.
- Metric photogrammetry uses a metric camera to make precise computations and evaluate exact sizes, shapes and positions of objects or topographical features.
- It is also useful for determining coordinates and relative positions.

➢ **Interpretive photogrammetry:**

- This branch of the field involves identifying general image features like sizes, shapes and patterns.
- It is useful for adding ancillary information to photographs rather than making direct calculations.

- COMPARISON OF PHOTOGRAMMETRY AND REMOTE SENSING

- ➢ **Data type:** One of the main differences between photogrammetry and remote sensing lies in the kind of **information collected. Remote sensing collects data in the form of light and color.** By detecting different wavelengths of light radiation, it can generate maps. Instead of measuring wavelengths of radiation, on the other hand, photogrammetry uses imagery to measure coordinates in space.
- ➢ **Number of dimensions:** These differences also mean remote sensing tends to work in two dimensions while photogrammetry tends to work in three dimensions. **Remote sensing can create informative 2D maps, while photogrammetry is ideal for more complex 3D modeling.**
- ❖ <u>Applications that frequently use remote sensing and photogrammetry</u>
- ➢ EMERGENCY MANAGEMENT
- ➢ ENVIRONMENTAL IMPACT ASSESSMENT
  - ➔ Environmental science often uses remote sensing to gain concrete data about how ecological changes have progressed.
- ➢ EARTHWORKS DEVELOPMENT
- ➢ MINING MONITORING AND EXPANSION
- ➢ ARCHAEOLOGICAL RECREATION
- ➢ FORENSICS ANALYSIS
- ➢ ARCHITECTURAL RECORDING

- Satellite remote sensing
  - ❖ Remote sensing is the **acquisition of information about an object from a distance without physically coming into contact with the object.**
  - ❖ **Remote Sensing (RS)** refers to the science of identification of earth surface features and estimation of their geo-biophysical

properties using electromagnetic radiation as a medium of interaction

- **Spectral, spatial, temporal and polarization** signatures are major characteristics of the sensor/target, which facilitate target discrimination.
- The characteristics of an object can be determined using **electromagnetic radiation reflected** or **emitted from the object.**
- Remote sensing is a technique of detecting and perceiving an object through reflection or emission.
- Remote sensing satellites are also called **Earth observation satellites or Earth remote sensing satellites.**
- <u>Advantages of remote sensing satellites</u>
  - The advantages of the satellite based remote sensing are its wide coverage, saving in time and tremendous cost effectiveness over other techniques.
  - Large area coverage enabling regional survey of a variety of themes and identification of large features.
  - Repetitive coverage, allowing monitoring of dynamic themes like water, agriculture, etc.
  - Data acquisition at multiple heights
  - Data acquisition over inaccessible areas
- Sputnik 1.
  - The first occurrence of remote sensing satellites on **October 4, 1957**, with the launch of the first artificial satellite
  - It sent back radio signals scientists used to study the ionosphere
- Most remote sensing satellites carry instruments that should be operated at a relatively **low altitude.**
- Altitudes below **500-600** kilometers are generally avoided because the significant air-drag at low altitudes means they have to re-boost orbits more often.

- ❖ orbits used for remote sensing satellites

➢ There are three main types of orbits in which satellites reside: **polar, non-polar low-Earth orbit, and geostationary.**

➢ Polar orbits

- ➔ can be ascending or descending.
- ➔ In ascending orbits, satellites move south to north when their path crosses the equator.
- ➔ In descending orbits, satellites move north to south.

➢ Non-polar orbits

- ➔ Satellites in non-polar, low-Earth orbits are at an altitude of usually less than 2,000 km above Earth's surface.
- ➔ For reference, the International Space Station orbits at an altitude of about 400 km.
- ➔ These orbits do not have global coverage but instead cover only a partial range of latitudes.

➢ Geostationary satellites

- ➔ Geostationary satellites follow Earth's rotation and move at the same rotation rate.
- ➔ Because of this, the satellites appear to observers on Earth to be fixed in one location.
- ➔ As a result, these satellites capture the same view of Earth with each observation, providing almost continuous coverage of one area.

❖ **India's remote sensing satellites**

➢ RESOURCESAT-2A

- ➔ A follow-up to the missions of **RESOURCESAT-1** and **RESOURCESAT-2** which were launched in **October, 2003 and April, 2011 respectively.**
- ➔ It will provide regular micro and macro information on farm land and crop volume, forest, mineral deposits, coastal

information, rural, and urban sprawl, underground and water bodies, along with helping in disaster management.

- Cartosat
  - The Cartosat is a series of Indian optical earth observation satellites built and operated by the Indian Space Research Organization (ISRO).
  - The Cartosat series is a part of the Indian Remote Sensing Program.
  - They are used for Earth's resource management, defense services and monitoring.
- Oceansat-2
  - Oceansat-2 is the second Indian satellite built **primarily for ocean applications**.
  - It was a part of the **Indian Remote Sensing Programme satellite series.**
  - Oceansat-2 is an Indian satellite designed to provide service continuity for operational users of the Ocean Color Monitor (OCM) instrument on Oceansat-1.
- RISAT-2B
  - 2BR1 is a radar imaging earth observation satellite.
  - This satellite will provide services in the fields of **agriculture, forestry and disaster management.**
- SARAL Satellite
  - An Indo-French joint mission for oceanographic studies.
  - Designed for altitude measurements for simple ocean movement and ocean surface elevation studies.

- Sensors
  - RS sensors are instruments that measure the properties of EM radiation leaving a surface/medium due to scattering or emission.

- Generally, radiance is the property measured as a function of wavelength but could also include other parameters such as polarization

- **<u>Active sensors</u>**
- Each active sensor in remote sensing directs its signal to the object and then checks the response – the received quantity.
- The majority of devices employ microwaves since they are relatively immune to weather conditions.
- Active remote sensing techniques differ by what they transmit **(light or waves)** and what they determine.
- <u>Different types of active sensors</u>
    - **<u>Radar</u>**
        - is a sensor assisting in ranging with radio signals. Its specific feature is the antenna emitting impulses.
        - When the energy flow in radar active remote sensing meets an obstacle, it scatters back to the sensor to some degree.
        - Based on its amount and traveling time, it is possible to estimate how far the target is.
    - **<u>Lidar</u>**
        - determines distance with light. Lidar active remote sensing implies transmitting light impulses and checking the quantity retrieved.
        - The target location and distance are understood by multiplying the time by the speed of light.
    - **<u>Ranging</u>**
        - instruments estimate the range either with one or two identical devices on different platforms sending signals to each other.
    - **<u>Sounder</u>**

- ★ studies weather conditions vertically by emitting impulses, in case it falls to the active category

➔ Scatterometer

- ★ is a specific device to measure bounced (backscattered) radiation.

❖ **Passive sensors**

➢ Passive sensors in remote sensing do not streamline energy of their own to the researched object or surface, unlike active ones.

➢ Passive remote sensing depends on natural energy (sunrays) bounced by the target.

➢ For this reason, it can be applied only with proper sunlight, otherwise there will be nothing to reflect

➢ Passive remote sensing employs multispectral or hyperspectral sensors that measure the acquired quantity with multiple band combinations. These combinations differ by the number of channels(two wavelengths and more).

➢ Different types of passive sensors

➔ **Spectrometer** distinguishes and analyzes spectral bands.

➔ **Radiometer** determines the power of radiation emitted by the object in particular band ranges (visible, IR, microwave).

➔ **Spectroradiometer** finds out the power of radiation in several band ranges.

➔ **Hyperspectral radiometer** operates with the most accurate type of passive sensor that is used in remote sensing. Due to extremely high resolution, it differentiates hundreds of ultimately narrow spectral bands within visible, NIR and MIR regions.

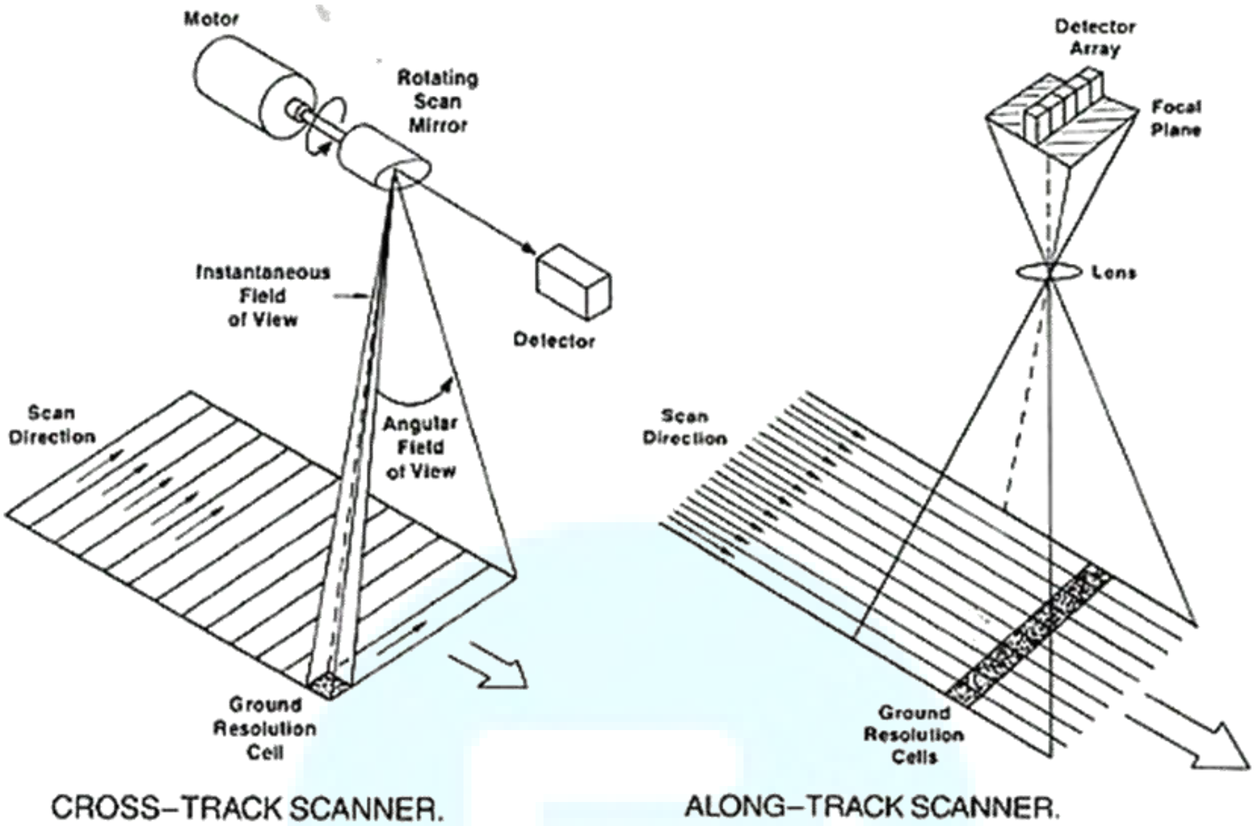
➔ **Imaging radiometer** scans the object or a surface to reproduce the image.

➔ **Sounder senses** the atmospheric conditions vertically.

- ➔ **Accelerometer** detects changes in speed per unit of time (e.g., linear or rotational).

- Scanning and orbiting mechanism
  - ❖ A scanning system employs a detectorwith a narrow field of view that is swept across the terrain to produce an image.
  - ❖ A scanning system used to collect data over a variety of different wavelength ranges is called a **multispectral scanner (MSS),** and is the most commonly used scanning system
  - ❖ Types of scanners
    - ➢ **Cross-Track Scanners(whiskbroom)**
      - ➔ Across-track scanners scan the **Earth in a series of lines.**
      - ➔ The lines are oriented perpendicular to the direction of motion of the sensor platform (i.e. across the swath).
      - ➔ Each line is scanned from one side of the sensor to the other, using a rotating mirror

    - ➢ **Along-track scanners(pushbroom)**
      - ➔ Along-track scanners also use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction.
      - ➔ These systems are also referred to as pushbroom scanners, as the motion of the detector array is analogous to the bristles of a broom being pushed along a floor.



➢ **<u>Circular Scanner</u>**

➔ In a circular scanning system, the scan **motor and mirror** are mounted with a vertical axis of rotation that sweeps a circular path on the terrain.

➔ Only the forward portion of the sweep is recorded to produce images.

➔ An advantage of this system is processing and display systems are designed for linear scan data, therefore the circular scan data must be extensively reformatted prior to processing.

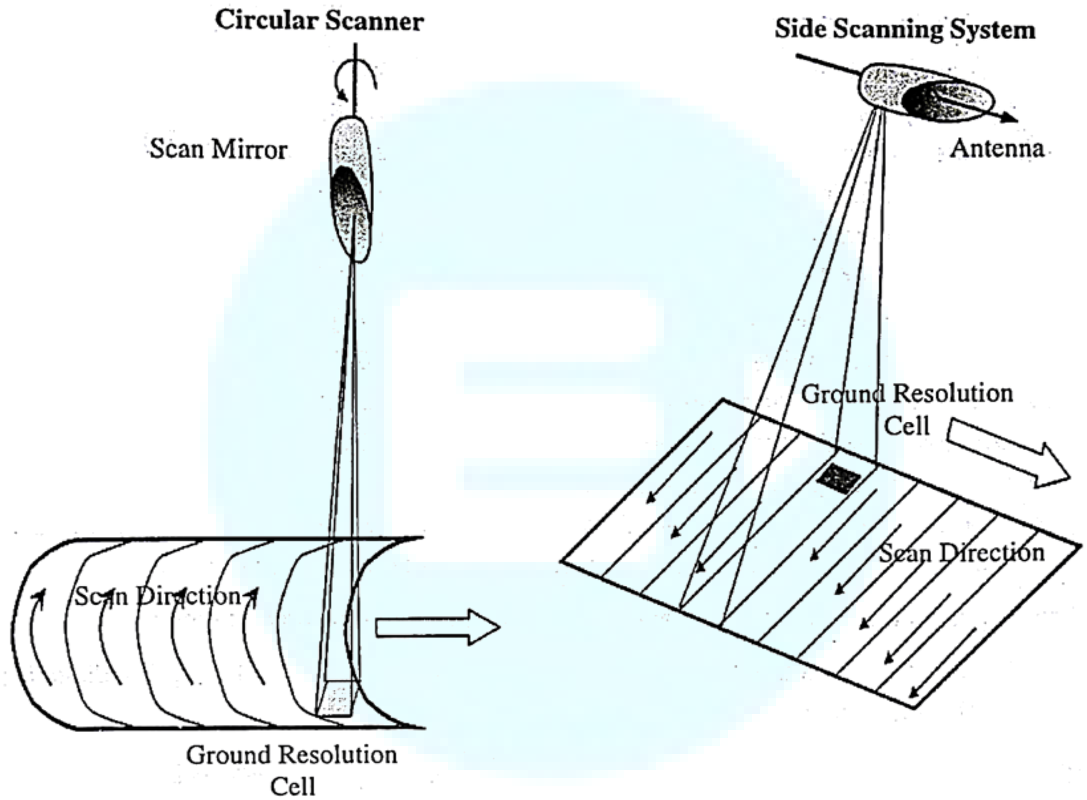
➔ Circular scanners have short dwell times comparable to those of cross-track scanners.

➔ Circular scanners are used for reconnaissance purposes in **helicopters and low-flying aircraft.** The axis of rotation is tilted to point forward and acquires images of the terrain well in advance of the aircraft position.The images are displayed in real time on a **screen in the cockpit to guide the pilot.**

➢ **<u>Side Scanning System</u>**

➔ The three types of scanners just described are passive systems, since they detect and record energy naturally reflected or radiated from the terrain.

➔ Active systems, which provide their own energy sources, operate primarily in the side-scanning mode.



Circular and Side Scanning Systems for acquiring remote sensing images.

❖ Orbiting mechanism

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

➢ **<u>Classifications of Orbit (Altitude classifications)</u>**

➔ **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.**

➔ Medium Earth orbit (MEO)

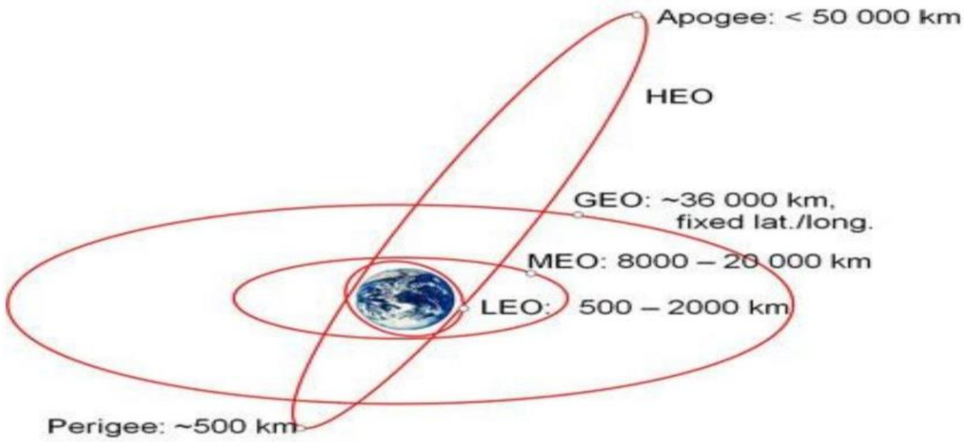
- ★ MEO is the region of space around the Earth above low Earth orbit and below geostationary orbit.
- ★ The most common use for satellites in this region is for navigation, such as the **GPS** constellations.
- ★ **MEO** extends from **2000km** and ends right below **35,786km.**

➔ 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.**

➔ High Earth orbit (HEO)

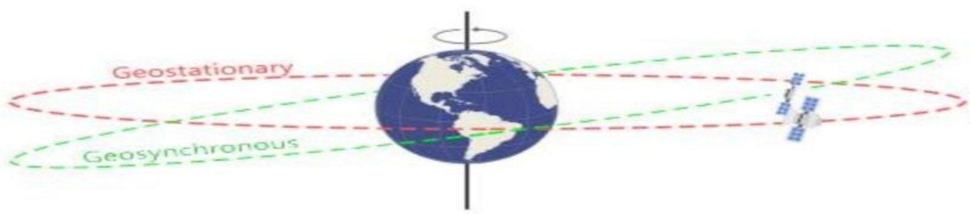
- ★ Any orbit beyond the geostationary orbit is known as **high earth orbit.**
- ★ High earth orbit is loosely attributed to any orbit beyond **35,786km**.
- ★ Satellites in the HEO are useful to study our planet's magnetosphere and for other astronomical observations.



➢ **Synchronicity classifications**

➔ **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.



➔ **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 kilometers** (**12,600 mi**)

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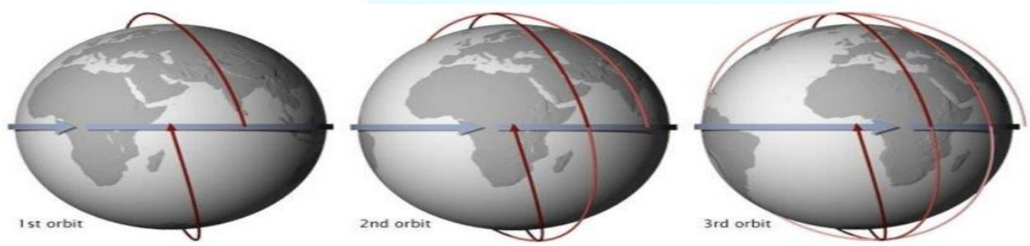
➔ Polar orbits

- ★ 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.

➔ Sun-synchronous orbit

- ★ An orbit which combines altitude and inclination in such a way that the satellite passes over any given point of the planet'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.



- Resolution
    - ❖ In general, the resolution is the minimum distance between two objects that can be distinguished in the image.

- ❖ In qualitative terms resolution is the amount of details that can be observed in an image.
- ❖ Thus an image that shows finer details is said to be of finer resolution compared to the image that shows coarser details.
- ❖ **Four types** of resolutions are defined for the remote sensing systems.
- ❖ **<u>Spatial resolution</u>**
- ➢ A digital image consists of **an array of pixels**. Each pixel contains information about a small area on the land surface, which is considered as a single object.
- ➢ Spatial resolution is a measure of the area or size of the smallest dimension on the Earth's surface over which an independent measurement can be made by the sensor.
- ➢ It is expressed by the size of the pixel on the ground in meters.

High Spatial Resolution

Medium Spatial Resolution

Low Spatial Resolution

- ➢ Based on the spatial resolution, satellite systems can be classified as
  - ➔ Low resolution systems
    - ★ Remote sensing systems with spatial resolution **more than 1km** are generally considered as low resolution systems
    - ★ **MODIS and AVHRR** are some of the very low resolution sensors used in the satellite remote sensing
  - ➔ Medium resolution systems
    - ★ When the spatial resolution is **100m – 1km,** such systems are considered as moderate resolution systems

- High resolution systems
  - Remote sensing systems with spatial resolution approximately in the range **5-100m** are classified as high resolution systems.
  -
  - **Landsat ETM+ (30m)**, **IRS LISSIII (23m MSS and 6m Panchromatic)** and **AWiFS (56-70m)**, **SPOT 5(2.5-5m Panchromatic)** are some of the high resolution sensors.
- Very high resolution systems
  - Very high resolution systems are those which provide less than **5m spatial resolution.**
  - **GeoEye (0.45m for Panchromatic and 1.65m for MSS)**, **IKONOS** (**0.8-1m Panchromatic**), and **Quickbird** (**2.4-2.8 m**) are examples of very high resolution systems.

❖ <u>**Radiometric resolution**</u>

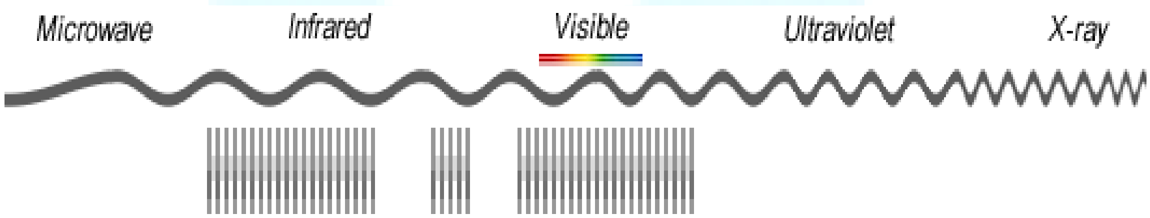
- Radiometric resolution of a sensor is a measure of **how many gray levels are measured between pure black (no reflectance) to pure white.**
- In other words, radiometric resolution represents the sensitivity of the sensor to the magnitude of the electromagnetic energy.
- The finer the radiometric resolution of a sensor the more sensitive it is to detecting small differences in reflected or emitted energy or in other words the system can measure more grey levels.

❖ **Spectral resolution**

➢ Spectral resolution describes the amount of spectral detail in a band.

➢ High spectral resolution means its bands are more narrow. Whereas low spectral resolution has broader bands covering more of the spectrum.

➢ For example, a multispectral image breaks light into 4 to 36



bands. Then, it assigns those bands names such as red, green, blue, and near-infrared. Each band may span 0.05 um in the electromagnetic spectrum.

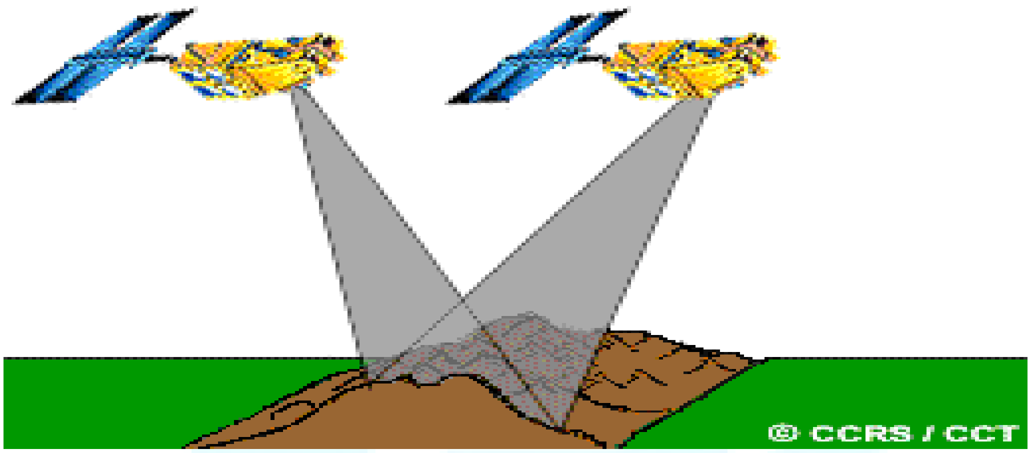
➢ Similarly, hyperspectral imaging captures a spectrum of light. But it divides the light into hundreds of narrow spectral bands. For hyperspectral images, spectral resolution is very high.

❖ **Temporal resolution**

➢ Temporal resolution is defined as the amount of time needed to revisit and acquire data for the exact same location.

➢ When applied to remote sensing, this amount of time depends on the orbital characteristics of the sensor platform as well as sensor characteristics.

➢ The temporal resolution is **high** when the revisiting delay is **low and vice-versa. Temporal resolution is usually expressed in days.**



- Satellite photographic system
    - ❖ Satellite images **(also Earth observation imagery, spaceborne photography, or simply satellite photo)** are images of Earth collected by imaging satellites operated by governments and businesses around the world.
- Image interpretation
    - ❖ Once a satellite image is acquired it is very important to make sure the interpretation of the image is accurate for its intended purpose.
    - ❖ For a novice the image might just look like a fusion of color and some structures; however a trained person will be able to identify and delineate the feature.

- ❖ Image interpretation and analysis uses some pointers or keys to identify the features. Some of them are - **Shape, Size, Color, Shadow, Texture, Pattern, Association, Site, Time and Resolution.**

- ➢ **Shape**:
  - ➔ As the name suggests a shape of the feature helps in identifying a feature.
  - ➔ A round or oval shape feature could be a stadium. A straight line with very few turns could be a railway track.
  - ➔ An assimilation of various elements of recognition will help to ascertain/identify the feature.
  - ➔ A natural water body is more likely to have irregular shape.
- ➢ **Size:**
  - ➔ Size of a feature in relation to the nearby feature plays an important role in successful identification of a feature.
- ➢ **Shadow:**
  - ➔ Shadow of a feature helps in delineating the boundary of the feature.
  - ➔ A big object would cast a large shadow as compared to smaller ones.
  - ➔ The shadow is also used to measure the height of an object.
- ➢ **Color/Tone**:
  - ➔ Color or tone of an object is the relative brightness/darkness of an object.
  - ➔ A dark blue to black colored huge feature could be water. If there is a shade of red color on top of the water body then it could be mangroves.
  - ➔ Variation in the tone could be attributed to reflectance, remittance, absorption or transmission of the feature.
- ➢ **Texture:**

- ➔ Texture is the frequency of the tonal changes of the surface. This element is quite important in the case of agriculture and forestry.
- ➔ A group of trees may have a specific texture and that will help to distinguish between a species of tree.
- ➔ A rocky mountain will have a different texture than a mountain with lots of plantation.

➢ **Pattern:**
- ➔ Spatial arrangement of features in a particular format is a pattern.
- ➔ A river will have a number of tributaries and on the basis of arrangement of these tributaries you can identify them.
- ➔ A city area with well defined rectangular plots could help you to identify the sectors in the city.

➢ **Association**
- ➔ The relationship between different features at the area of interest is the association.
- ➔ A long canal/pipeline along the wide spread area of agricultural fields.
- ➔ If there is a water body with well defined edges then it could be a man made water body, like a dam.

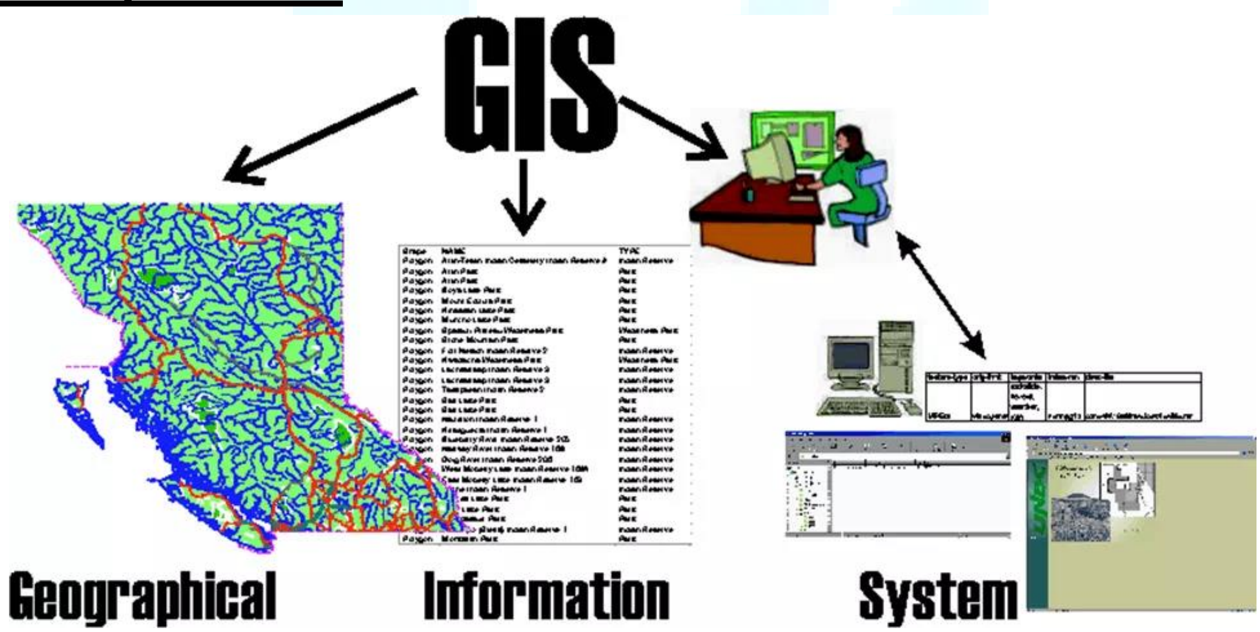
➢ **Site:**
- ➔ A site is the presence of a feature at a particular geographical location.
- ➔ A large vessel or lighthouse will be associated with the sea..

➢ **Time**
- ➔ A temporal change in a feature over a period of time can provide a lot of information for image interpretation.
- ➔ Volume of water in a pond, river etc can be used to analyze the water supply of a city.

- ➔ Temporal images of an agricultural field can be used to determine the health of the crop.

- Image processing
  - ❖ Preprocessing functions involve those operations that are normally required prior to the main data analysis and extraction of information, and are generally grouped as radiometric or geometric corrections.
  - ❖ Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor.
  - ❖ Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates **(e.g. latitude and longitude)** on the **Earth's surface**.

3.Concept of GIS



- A **geographic information system (GIS)** is a system that **creates, manages, analyzes, and maps all types of data.**

- GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there).
- This provides a foundation for mapping and analysis that is used in science and almost every industry.
- GIS helps users understand **patterns, relationships, and geographic context.**
- The benefits include improved communication and efficiency as well as better management and decision making.
- **GIS can be used as a tool in both problem solving and decision making processes, as well as for visualization of data in a spatial environment.**
- **Applications of GIS**
    - Environmental and Natural Resource
    - Agriculture
    - Land use planning
    - Street Network
    - Planning
    - Mapping
    - Transportation
    - Urban Planning
- Spatial data
    - spatial data is the **physical representation of earth features**.
    - It represents the l**ocation, size, and shape of the object in the earth i.e., building, ponds, mountains, administration, boundaries, etc.**
    - Spatial Data is available in two primary formats **1. Vector and, 2.Raster**
    - **Raster**

➢ A raster data is a representation of **images in a matrix of cells/ pixels into rows and columns.**

➢ The raster data set and data values are stored in **rows and columns.**

➢ To have high accuracy data, **GIS professionals** use **high-resolution raster datasets**.

➢ As it comes with its own challenges and difficulties to manage, Map info advancement introduces a specially designed data format, **multi- Resolution Raster (MRR)**.

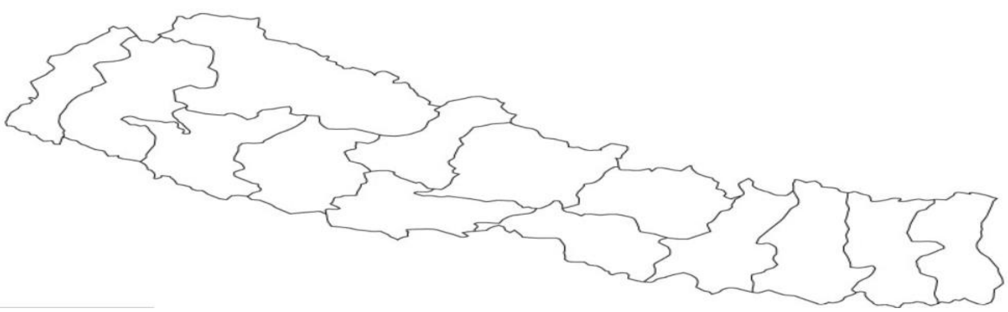
➢ Popular Raster file formats

- ➔ Portable Network Graphics (PNG)
- ➔ Joint Photographic Experts Group (JPEG2000)
- ➔ JPEG File Interchange Format (JFIF)
- ➔ Multi-resolution Seamless Image Database (MrSID)
- ➔ Network Common Data Form (netCDF)
- ➔ Digital raster graphic(DRG)
- ➔ ARC Digitized Raster Graphic (ADRG)
- ➔ Enhanced Compressed ARC Raster Graphics (ECRG)
- ➔ Compressed ARC Digitized Raster Graphics (CADRG)
- ➔ Raster Product Format (RPF) etc.

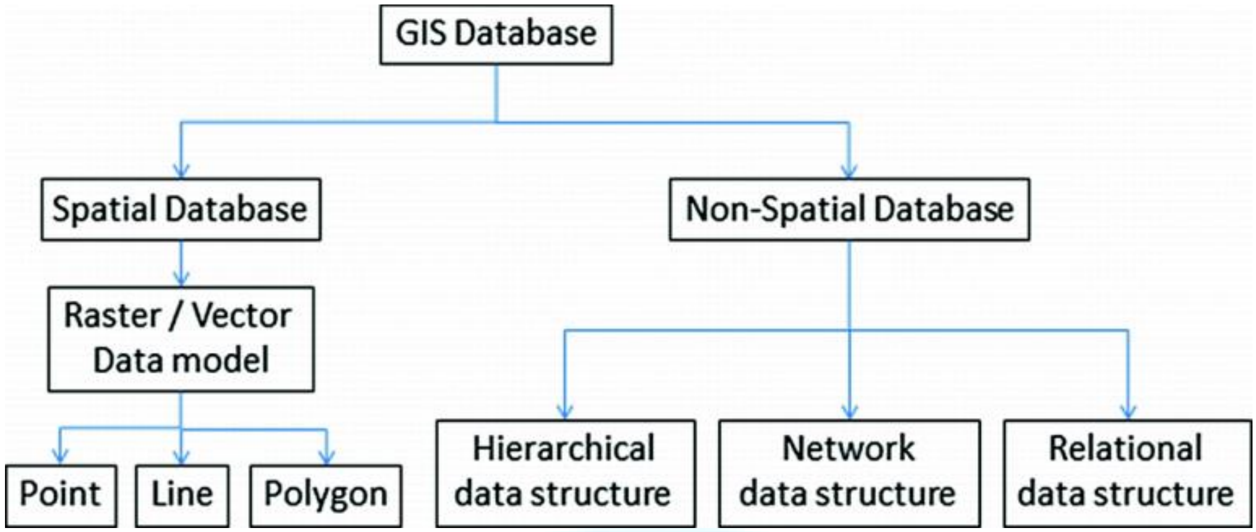
❖ <u>Vector</u>

➢ Vector data are represented in **lines and polygons.**

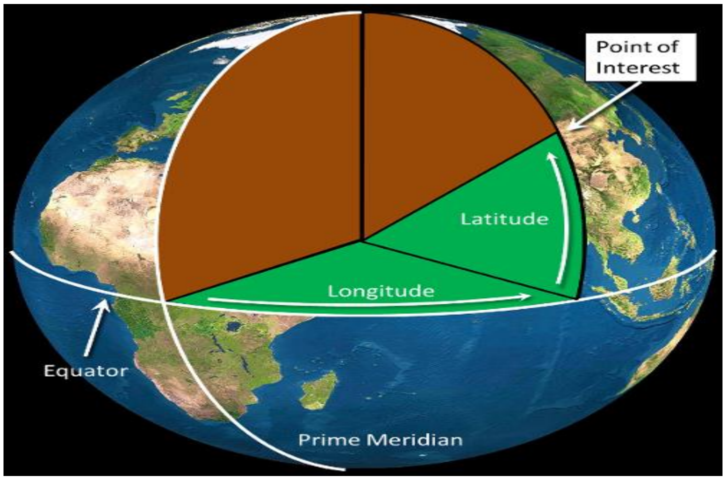
- ➢ Polygons are used to describe areas such as the boundary of a **city (on a large scale map), forest, and lakes.**
- ➢ Polygon features are **two dimensional.**
- ➢ It can be used to measure the area and perimeter of a geographic feature.
- ➢ <u>Popular Vector file formats</u>
  - ➔ Shapefiles
  - ➔ ArcInfo Coverage
  - ➔ E00 ArcInfo Interchange
  - ➔ Spatial Database engine (ArcSDE)
  - ➔ Digital Line Graph (DLG)
  - ➔ GeoJSON
  - ➔ AutoCAD DXF
  - ➔ Keyhole Markup Language (KML)
  - ➔ TIGER
  - ➔ Vector Product Format (VPF) etc.



- Non-spatial Data
  - ❖ Non-spatial data are represented in table formats.
  - ❖ For example, the administrative boundary table has p**opulation information, district name, provinces, sex ratio, etc.**



- Coordinate system and reference
  - ❖ Coordinate System is the most general term for a **system that includes coordinates.**
  - ❖ Spatial Reference System is a coordinate system used to reference spatial information, typically to the surface of the earth.
  - ❖ Spatial Reference Systems or Coordinate Systems, include two common types
  - ➢ <u>**Geographic Coordinate Systems**</u>
    - ➔ Location on an ellipsoid is defined by latitude and longitude that specifies the angle between any point and the equator, and the angle between any point and the prime meridian.
    - ➔ geographic coordinate system or GCS consists of
      - ★ Datum (which includes the ellipsoid)
      - ★ Prime Meridian (almost always Greenwich England)
      - ★ Units (always degrees)



➢ **<u>Projected Coordinate Systems</u>**

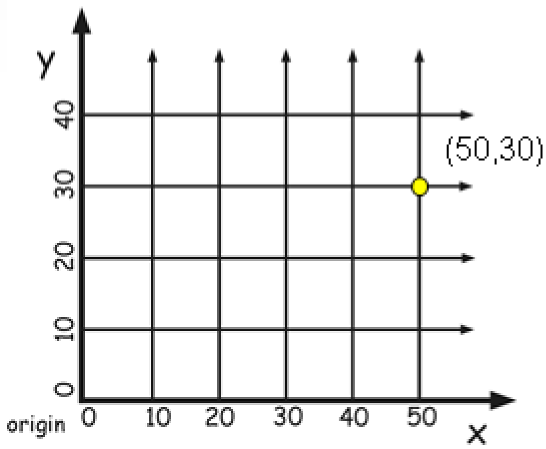
➔ Location is defined on a flat surface using Cartesian coordinates (i.e., x and y) that specify horizontal and vertical position

➔ Projected Coordinate Systems consist of

★ Projection Method

★ Projection Parameters

★ Units



- Geodetic datum

❖ A geodetic datum **(plural datums, not data)** is a reference from which spatial measurements are made.

❖ In surveying and geodesy, a datum is a set of reference points on the earth's surface against which position measurements are made, and (often) an associated model of the shape of the earth (reference ellipsoid) to define a geographic coordinate system.

- ❖ **Horizontal datums** are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system.
- ❖ **Vertical datums** measure elevations or depths.

- Spatial data modeling
- Input of data
- Capabilities of GIS
  - ❖ GIS has many applications across a vast range of industries and sectors.
  - ❖ Spatial information can play a pivotal role in project development or can simply add a touch of flare to support technical reports.
  - ❖ Integrate Sustainability's GIS specialists are also environmental professionals and have the unique perspective of using GIS to present, solve and manage spatial data in context with the natural environmental values of a site.
  - ❖ Services
  - ➢ Map generation from simple to complex, individual maps or multiple map suites
  - ➢ Spatial data management and organization
  - ➢ Digitising and spatial data generation
  - ➢ Spatial data analysis
  - ➢ Sharing our knowledge, tips and tricks from using open source software