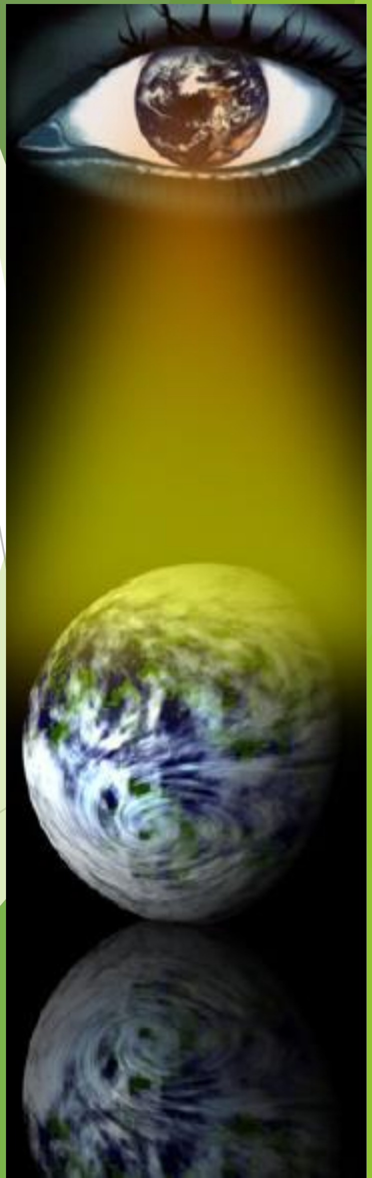
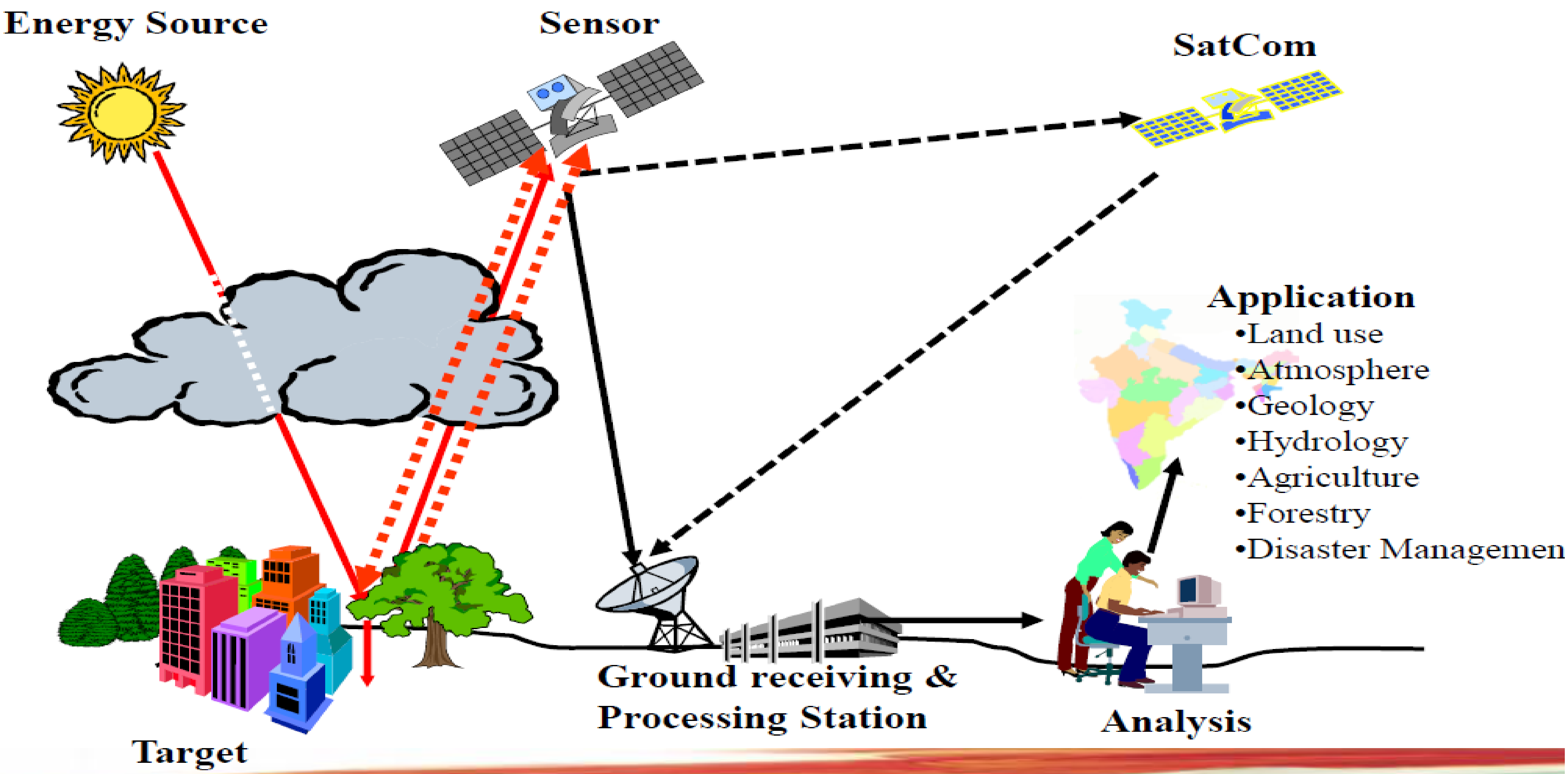
Platform and Sensors



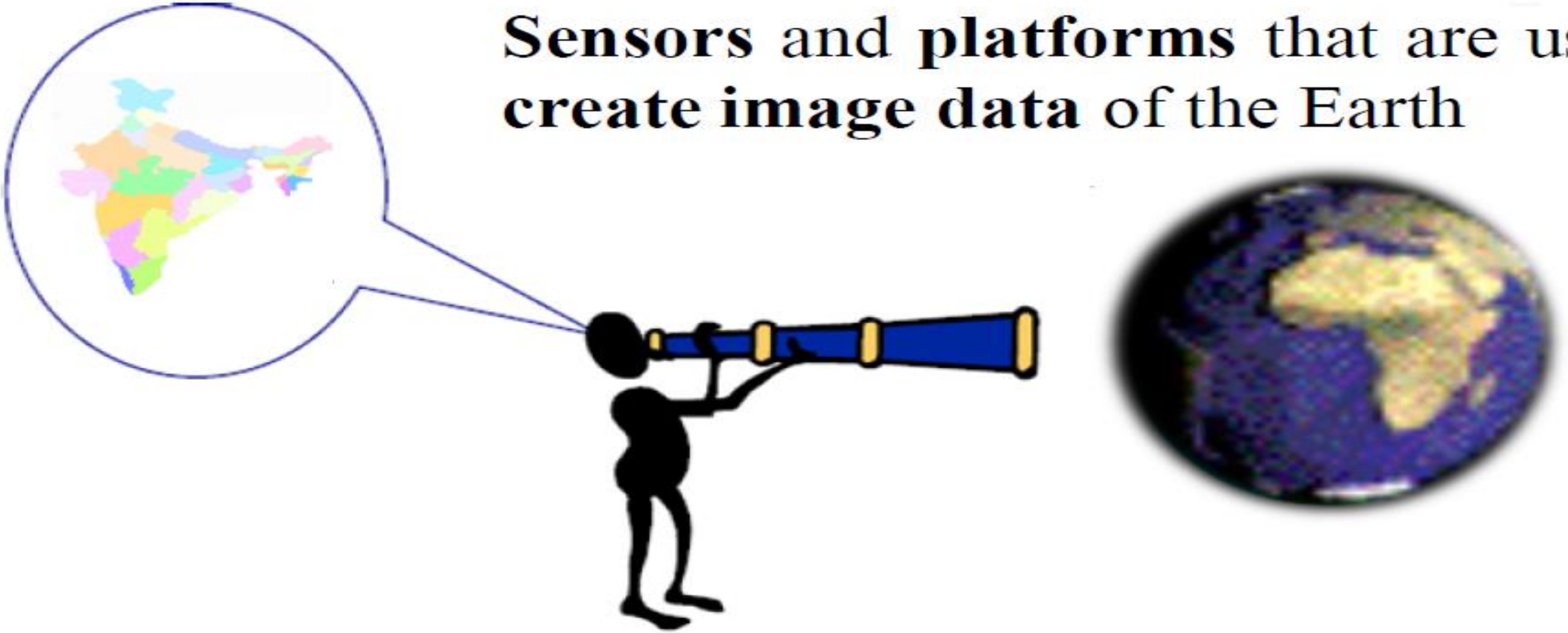
Neeraj Pandey TA GIS

Remote Sensing Process



Definition

Sensors and **platforms** that are used to **create image data** of the Earth



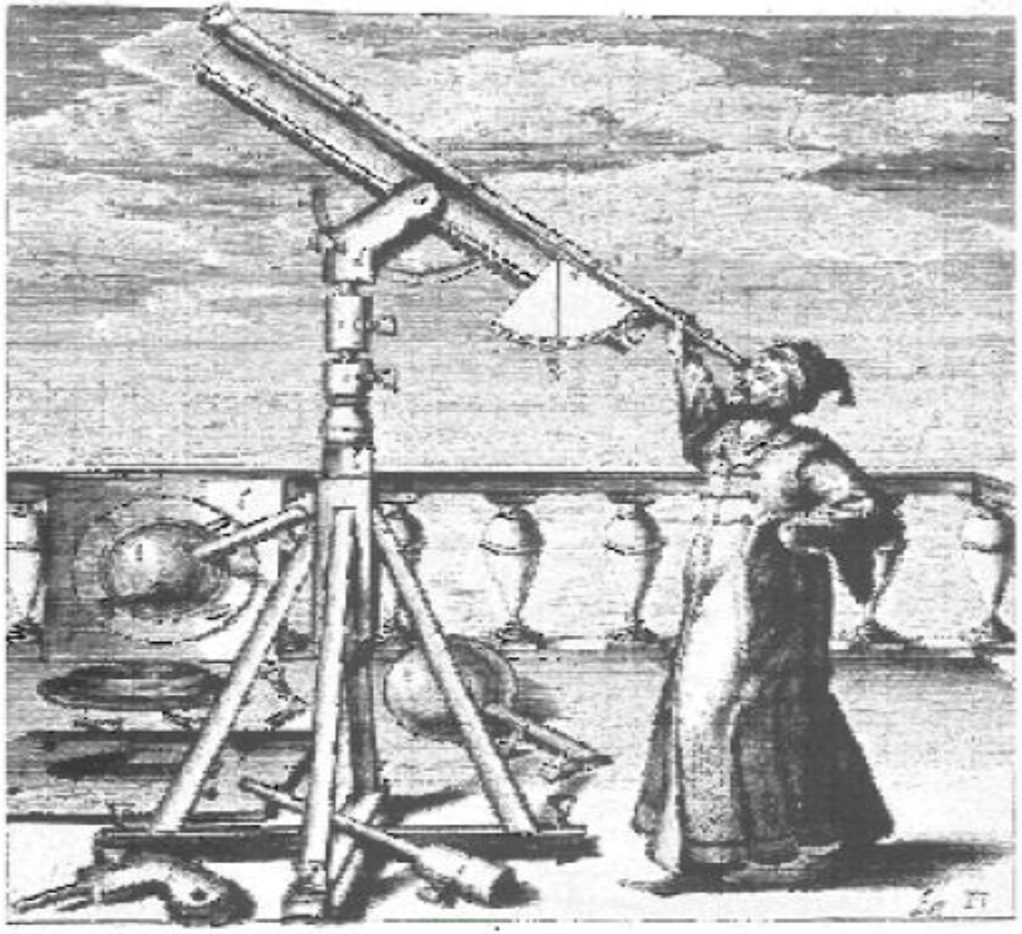
Sensors= a device that **records EM Energy**
Platforms= carrier bed used **to carry a sensor**

History

•Telescope invented by spectical-maker **Hans Lippershey** of Holland

•**Galileo** introduced the **telescope to astronomy in 1609**

- •Limited magnification – up to 30 times - and a narrow field of view
- •First to see the craters of the moon, discover sunspots, the four large moons of Jupiter, and the rings of Saturn



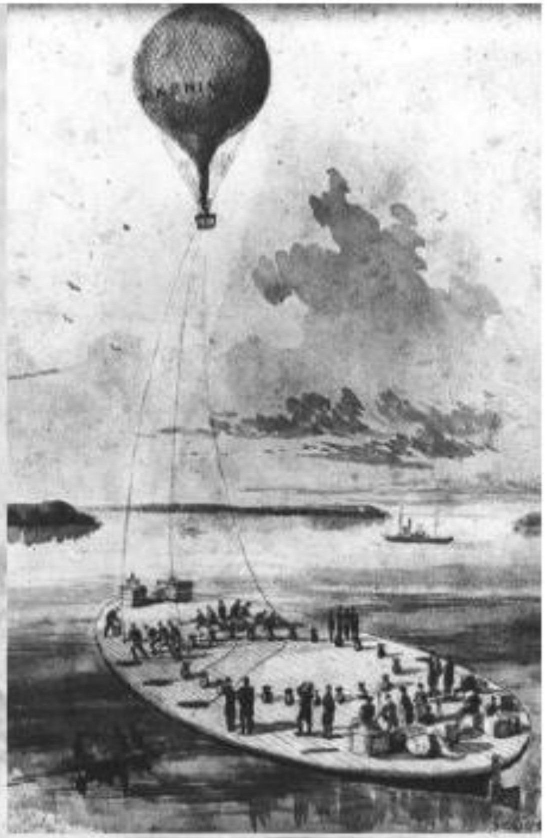
Galileo

http://www-groups.dcs.st-and.ac.uk/~history/Posters2/Galileo.html

Contd..

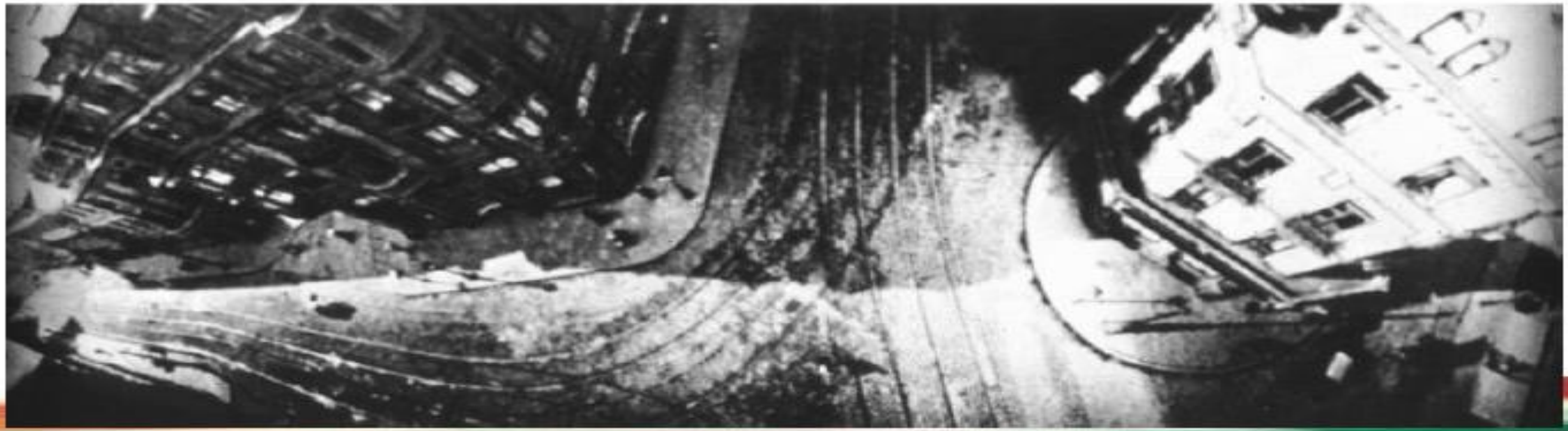
- 1827 - first photograph
- 1858 - First aerial (balloon) photographer Gaspard Felix Tournachon, also known as Nadar; picture of Paris
- 1861-1865 - Balloon photography used in American Civil War

Paris 1858



1903 -The Bavarian Pigeon Corps

Actual Pigeon Pictures



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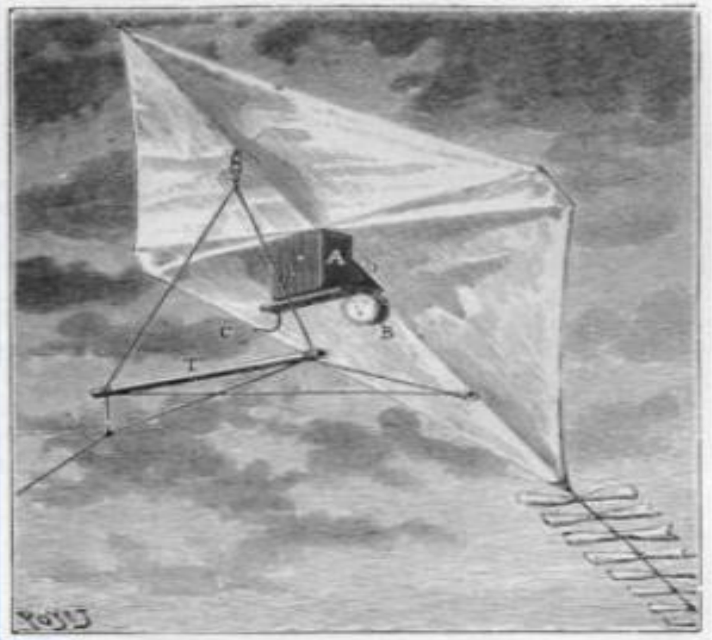
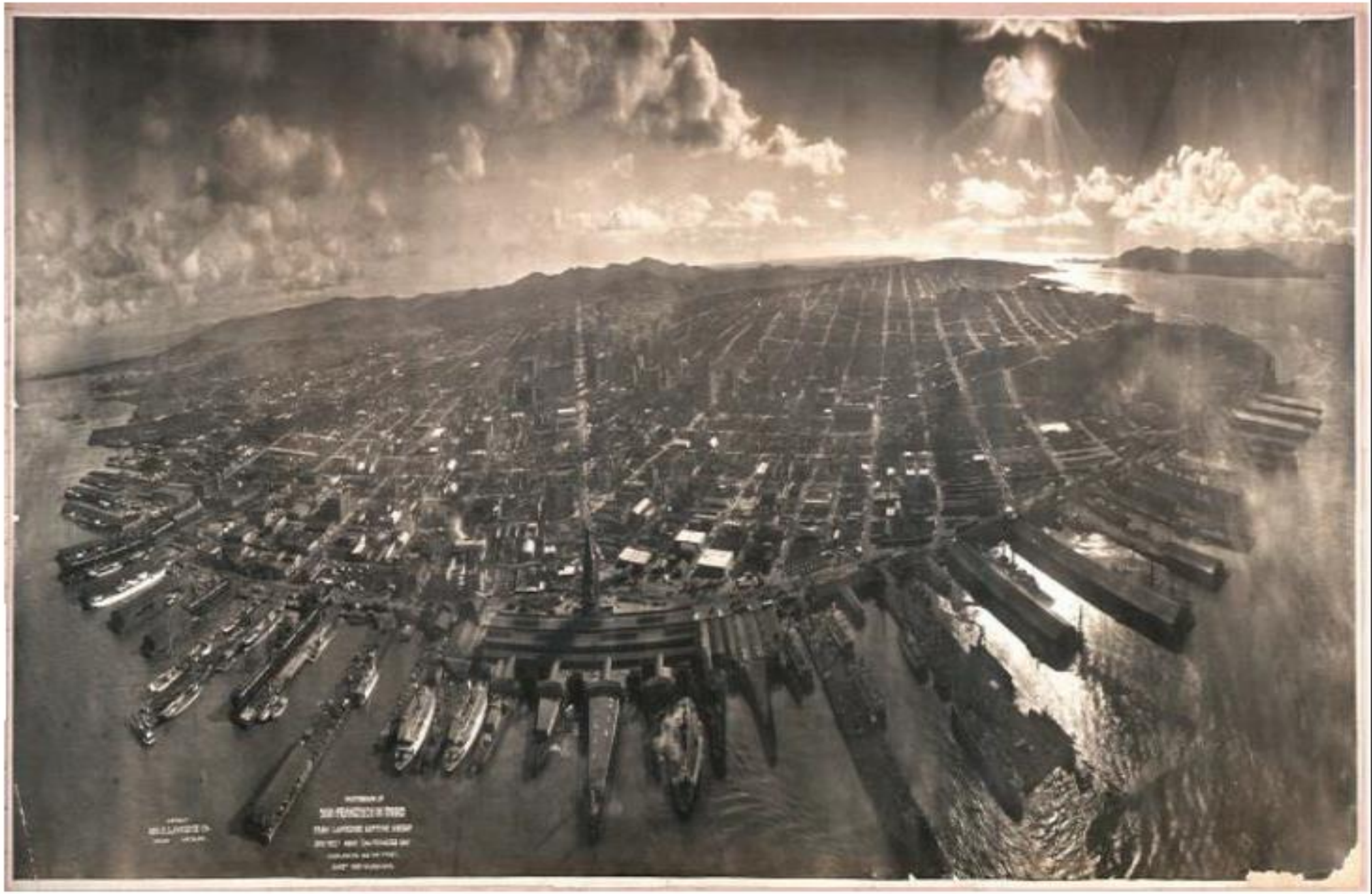
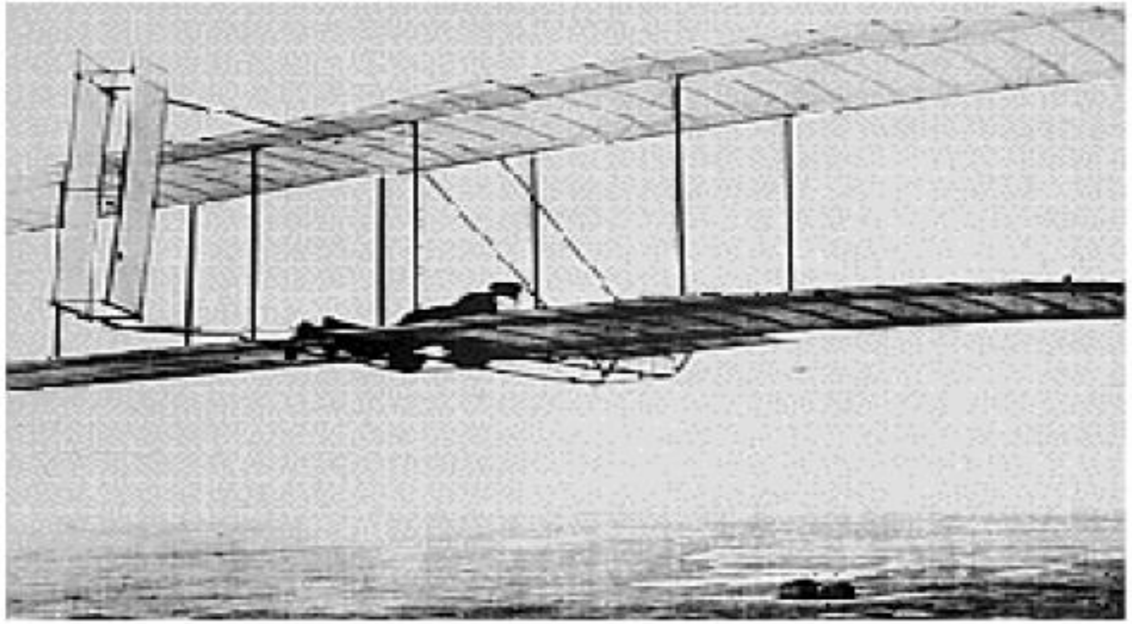


San Francisco from a kite, 1906



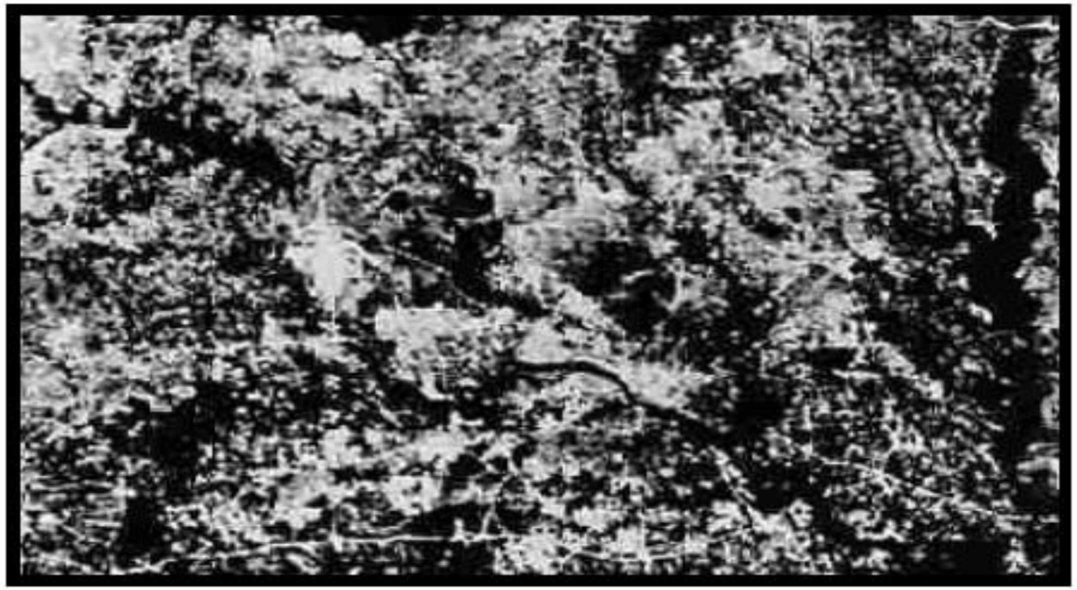
- 1908 —First photos from an airplane
- 1909—Dresden International Photographic Exhibition
- 1914-1945 — Plane mounted Cameras WWI, WWII



First flight, Wright Bros., Dec. 1903

Contd..

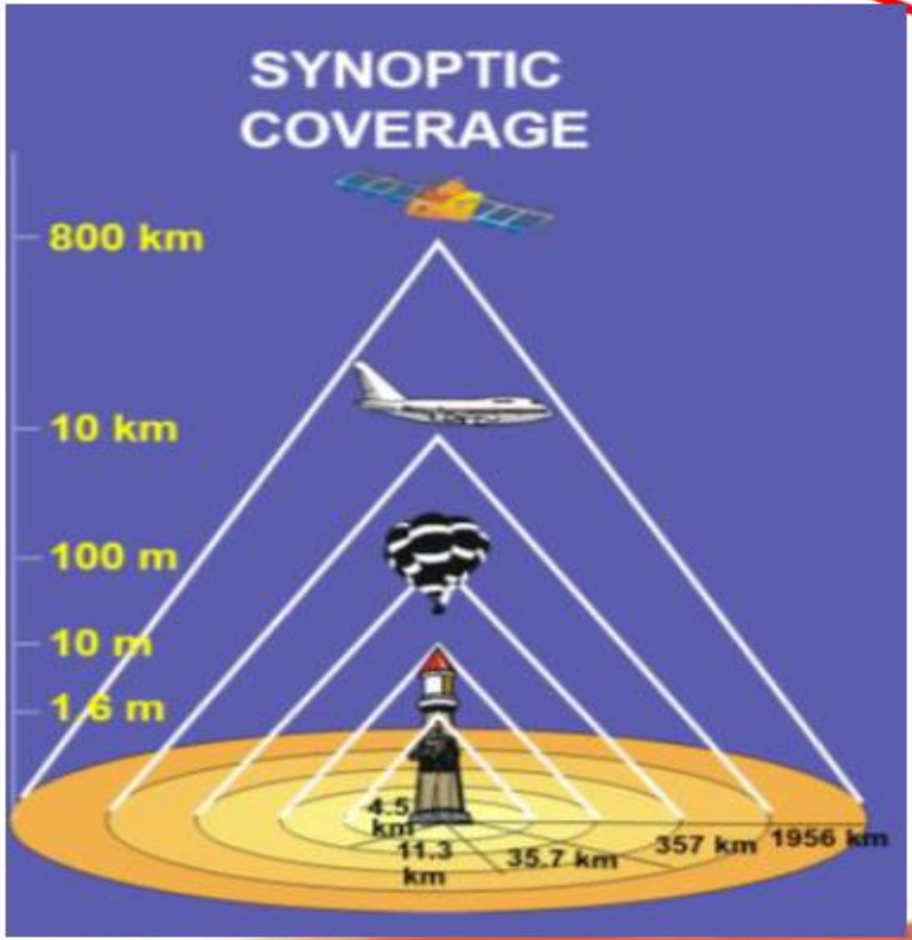
- 1956 - U2 spy planes
- 1957 - Sputnik-1
- 1960 - 1st meteorological satellite 'TIROS-1' launched
- 1967 - NASA 'Earth Resource Technology Satellite' programme
- 1972 - ERTS (Landsat) 1 launched...



First ERTS-1 image Dallas, 23 July 1973.

Platforms

- Ground based
- Airborne
- Spaceborne



Ground-based platforms

- Used to **record detailed information** about the surface which is compared with **information collected from aircraft or satellite sensors.**
- In some cases, this can be used to **better characterize the target** which is being imaged by the other sensors, making it possible to **better understand the information in the imagery.**
- Sensors may be **placed on a ladder, scaffolding, tall building, crane**, etc.

Air-borne platforms

- Are primarily **stable wing aircraft,** although **helicopters** are occasionally used.
- To collect **very detailed images** and facilitate the collection of data over **any portion of the Earth's surface at any time.**

Space-borne platforms

- **Space remote sensing** is sometimes conducted from the
  - **Space Shuttle**
  - **Satellites** (more commonly)

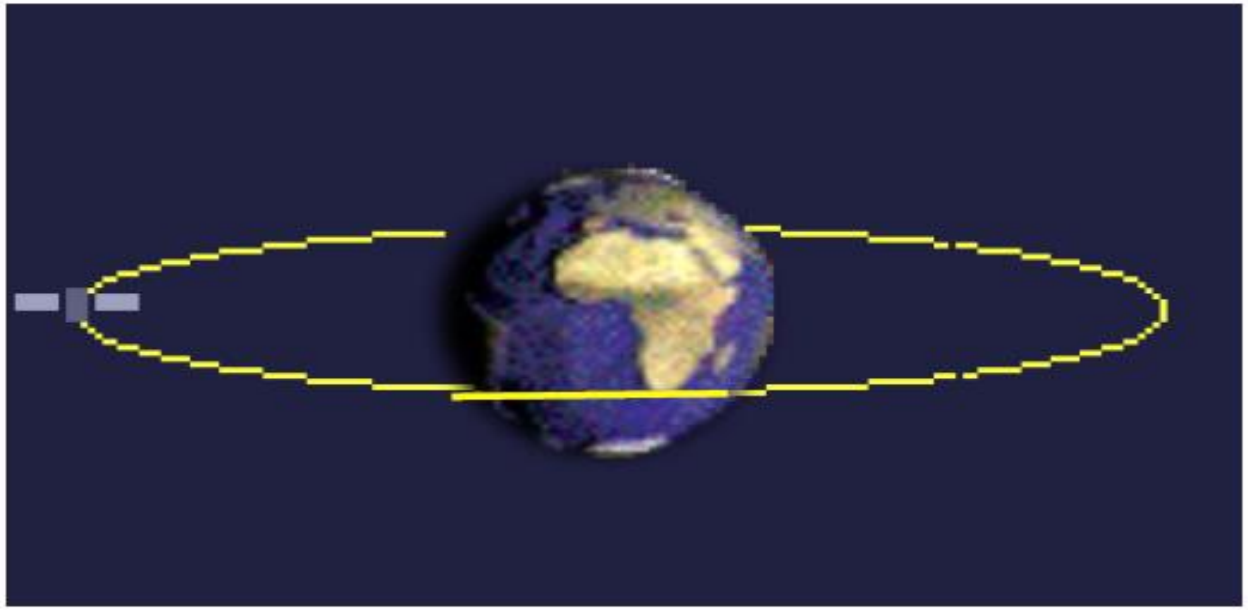
- **Satellites** are objects which **revolve around another object -** in this case, the Earth.

- e.g: the **moon is a natural satellite**, whereas **man-made satellites** include those platforms launched **for remote sensing, communication, and telemetry (location and navigation) purposes**.

- Because of their orbits, **satellites permit repetitive coverage of the Earth's surface** on a continuing basis.

Orbits

- **The path followed** by the **satellite** is called **orbit**.



- The satellite moves as per **Kepler's law**.

Path & Row

Path

- An orbit is the course of motion taken by the satellite in space and the **ground trace of the orbit** is called a **'Path‘**

Row

- The **lines joining the corresponding scene centers of different paths** are parallel to the equator and are called ‘**Rows**’.

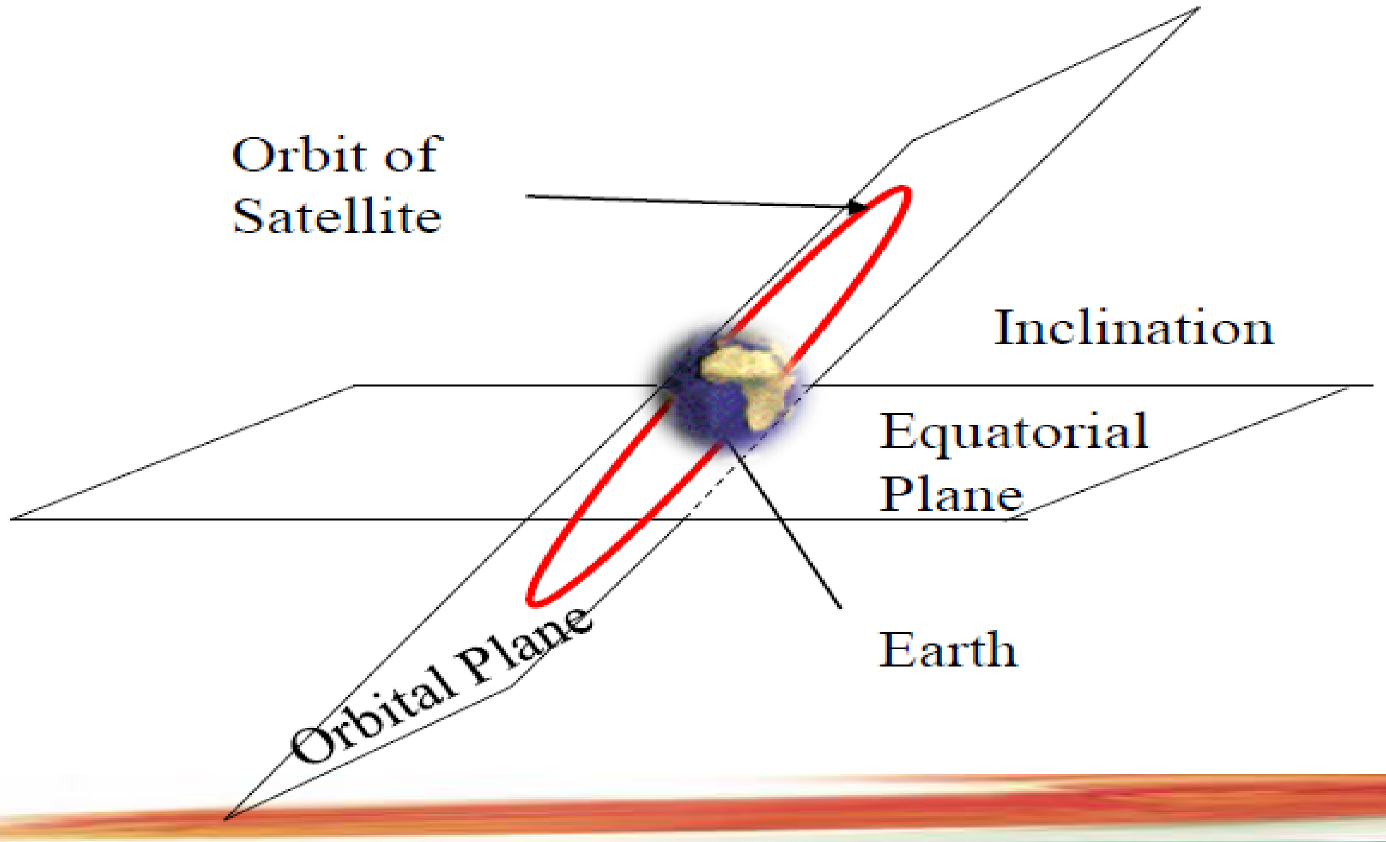
Satellite orbital characteristics

- *Altitude*
- *Inclination angle*
- *Period*
- *Repeat Cycle*
- *Swath*
- *Ascending pass and Descending pass*
- *Perigee*
- *Apogee*

Inclination angle

The angle (in degrees) between the orbit and the equator.

If the inclination angle is 60° then the satellite flies over the earth between the latitudes 60° South and 60° North, it cannot observe parts of the earth above 60° latitude.



Period

- It is the **time (in minutes) required to complete one full orbit**. A polar satellite orbiting at an altitude of 800km has a period of 90mins.

- The time taken for a satellite to make one complete orbit can be calculate by the equation

$$\mathbf{T = 2\pi\,(\{H + R\}^3/gR^2)^{1/2}}$$

Where H = height above ground

R = radius of the Earth

g = gravitational pull

- This equation tells us that **the higher the satellite is, the longer it takes to make a complete orbit!**

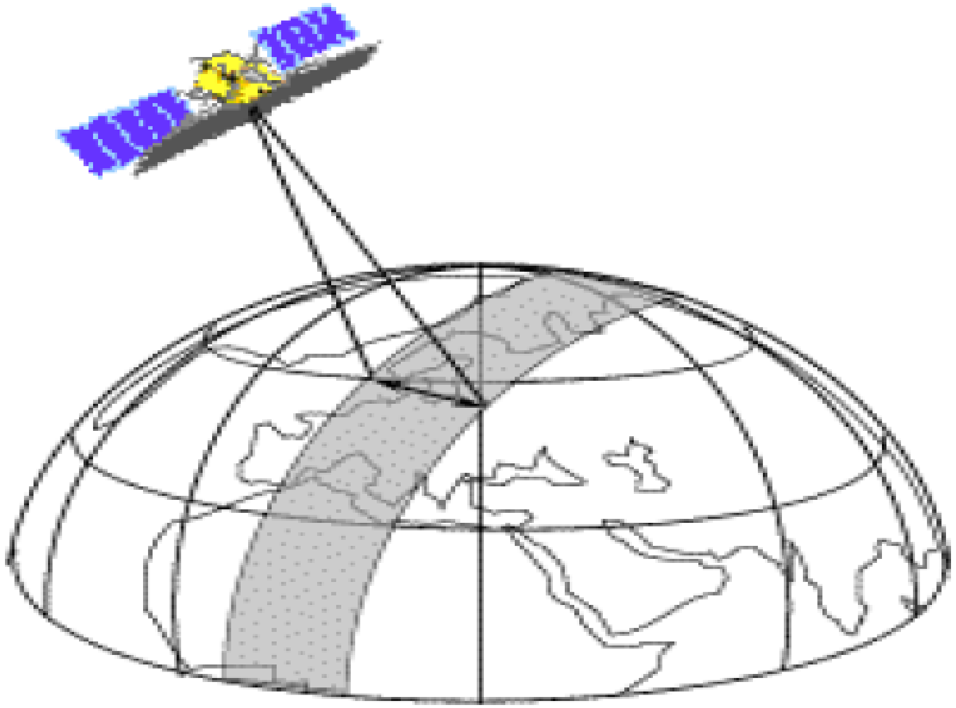
Repeat Cycle

It is the **time (in days) between two successive identical orbits**.

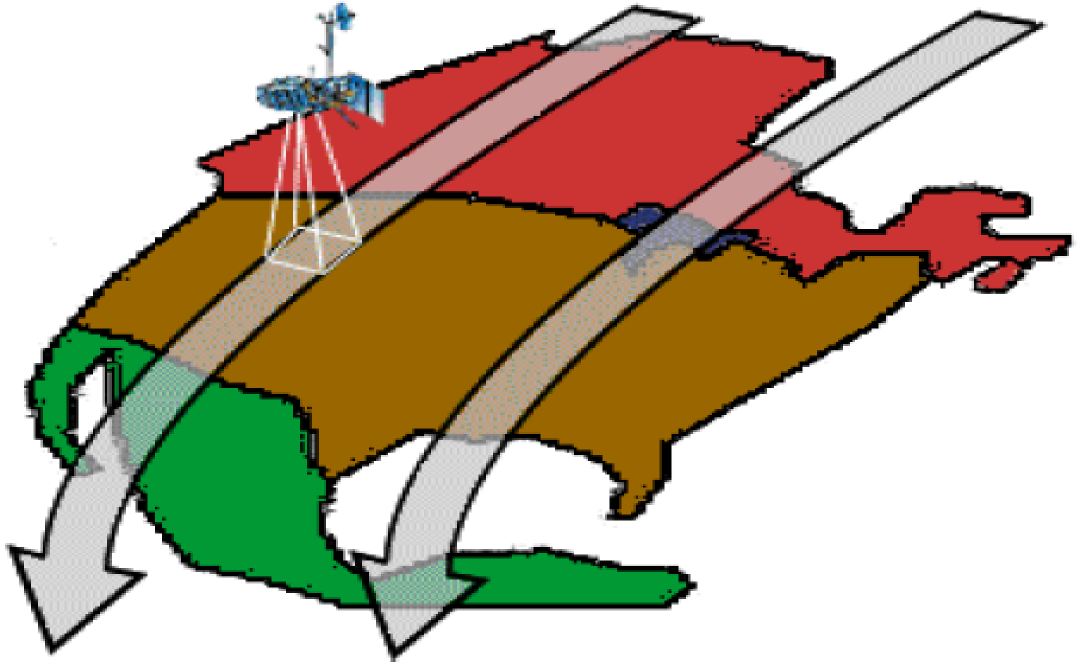
Swath

As a satellite revolves around the Earth, the **sensor sees a certain portion** of the Earth's surface. The area is known as **swath.**

The **swath** for satellite images is very large between **tens and hundreds of kilometers wide.**



SWATH



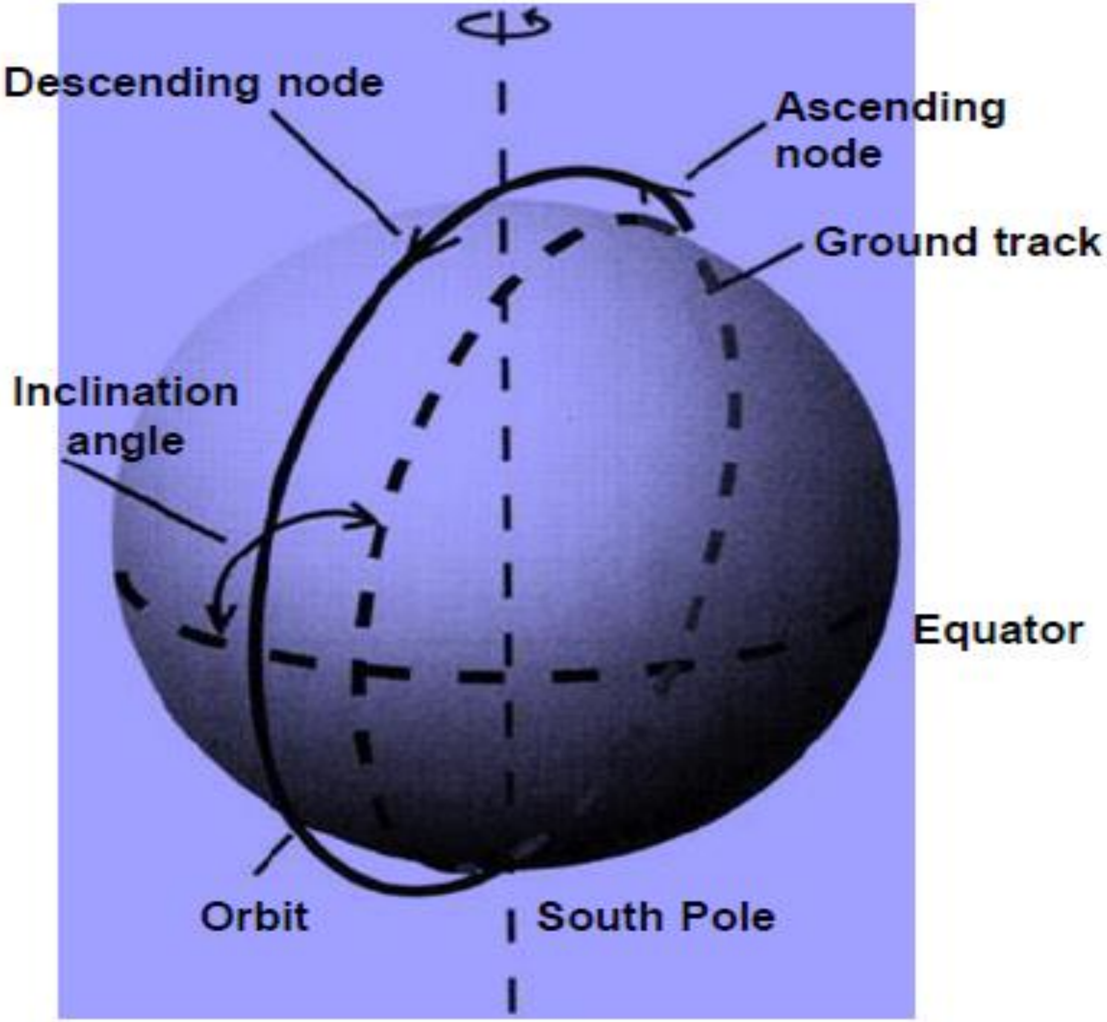
SWATH AREA

Ascending pass and Descending pass

- The near polar satellites travel northward on one side of the earth **(ascending pass)** and towards South Pole on the second half of the orbit **(descending pass).**

- The ascending pass is on the **shadowed side** while the descending pass is on the **sunlit side.**

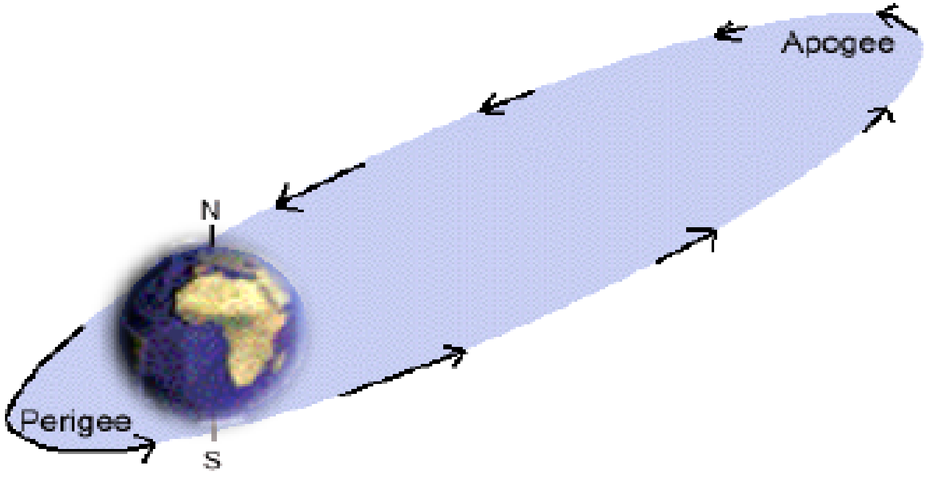
- **Optical sensors** image the surface on a descending pass, while **active sensors** and emitted **thermal and microwave radiation** can also image the surface on ascending pass.



Perigee & Apogee

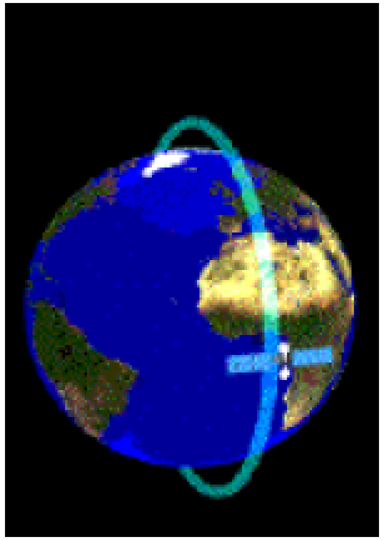
Perigee: It is the point in the orbit where an earth **satellite is closest to the earth.**

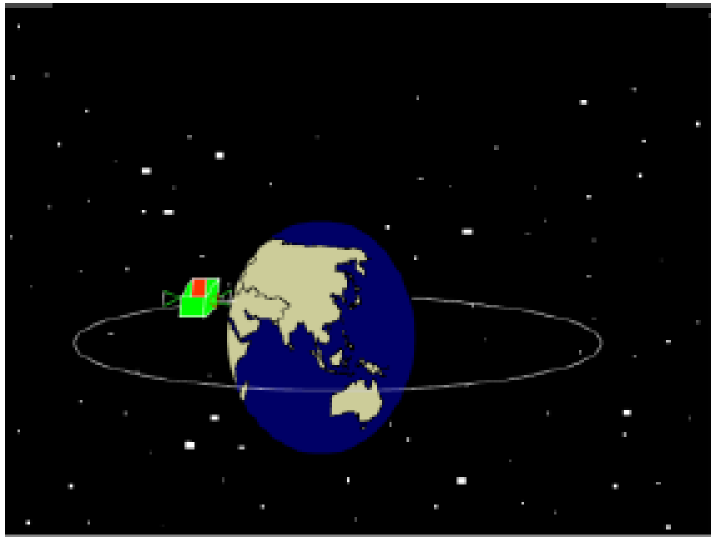
Apogee: It is the point in the orbit where an earth **satellite is farthest from the earth.**

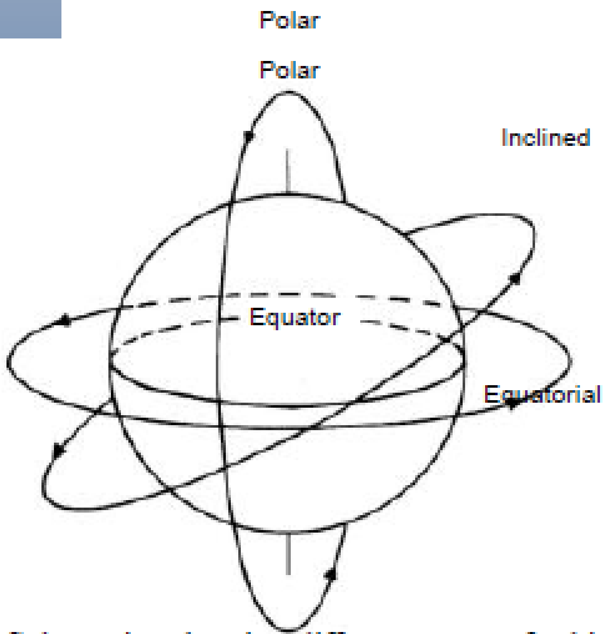


TYPES OF ORBIT

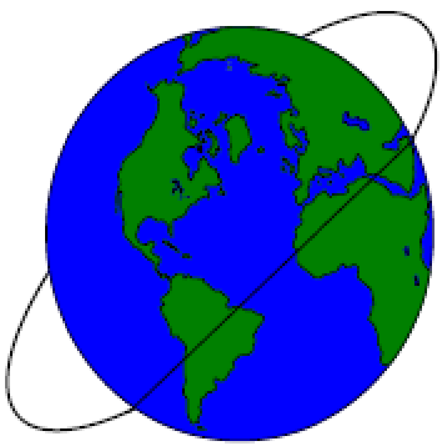
- Polar
- Equatorial
- Inclined



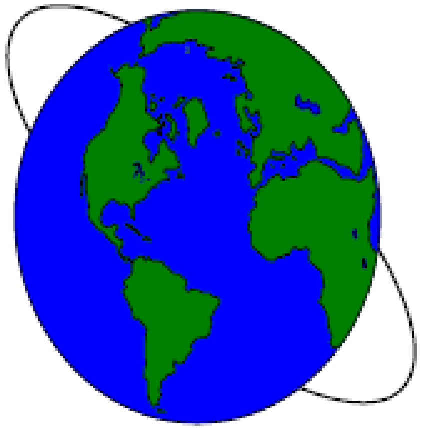




Schematics showing different types of orbits.



Prograde (inclined):
$0 < i < 90$



Retrograde (inclined):
$90 < i < 180$

Types of Satellite orbits

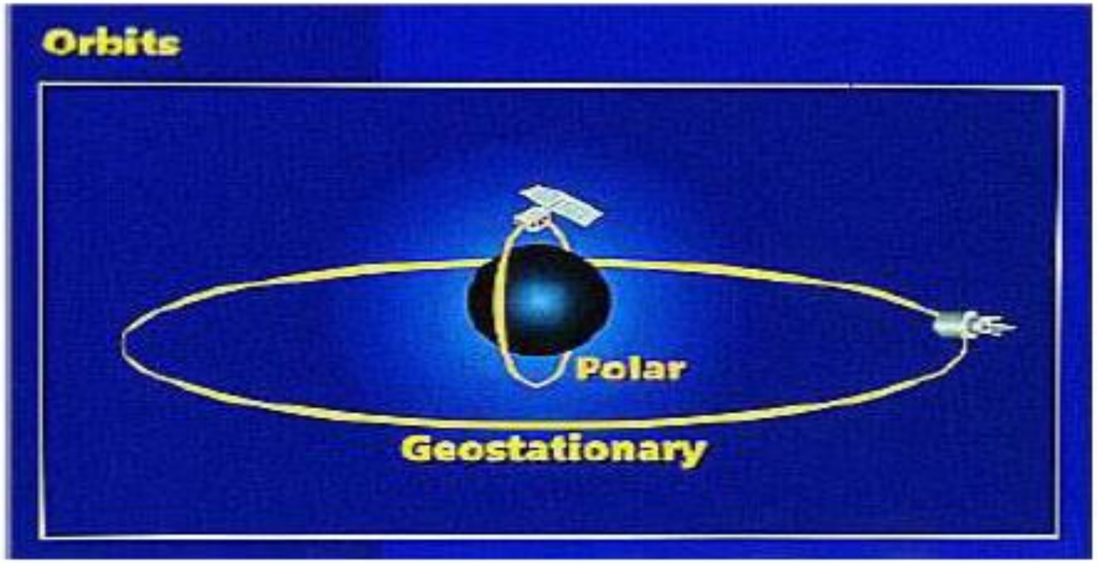
- **GEOSTATIONARY**
  Periods of Satellite equals period of earth=Fixed position

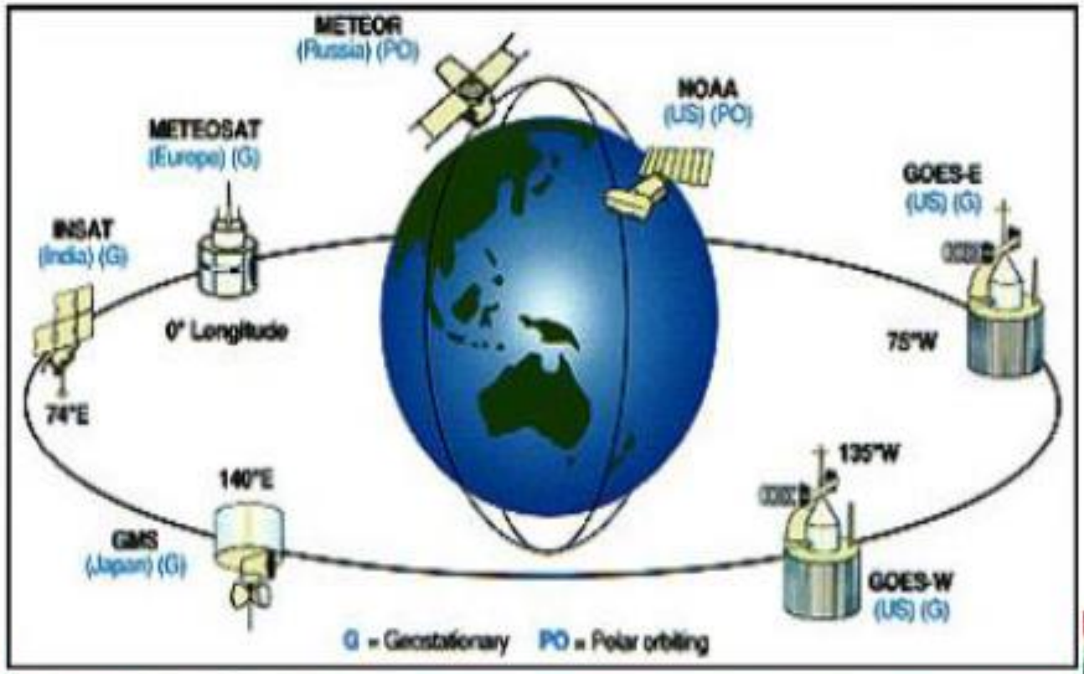
  Geosynchronous Orbit: Orbit at which the period of satellite is equal to one siderial day i.e. **23 hrs 56 mts 4.09 sec.**

  Geostationary Orbit: Geosynchronous orbit with **inclination is zero.**

- **NEAR POLAR ORBITING**
  Inclination between 90-100 degrees = global coverage

- **SUN-SYNCHRONOUS**
  Passes overhead at same local sun time of day





Geostationary satellites

•Altitude ~ **36,000 km**,

•Orbit inclination ~ **0°**

•Period of orbit = **24 hours**

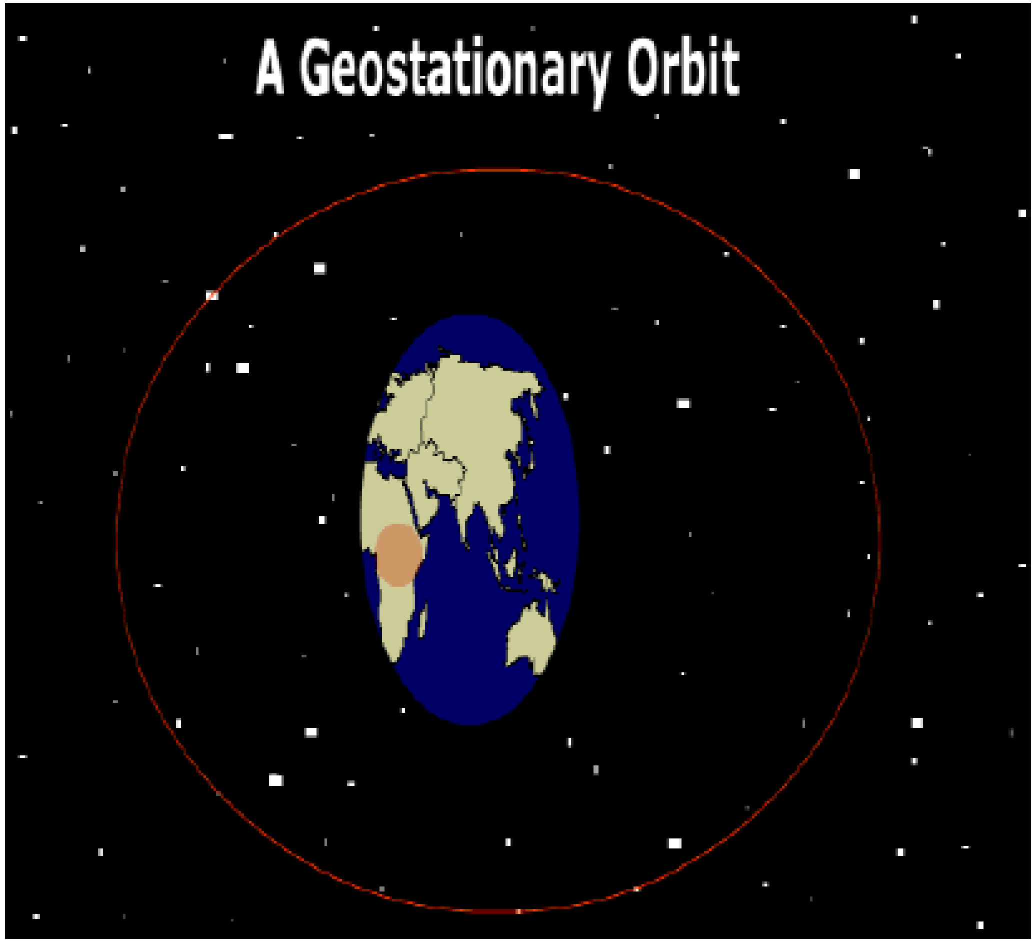
•**Global coverage requires several geostationary satellite** in orbits at different latitudes

•Good for repetitive observations, **poor for spatially detailed data**

•Large distortions at high latitudes

•**W-E** satellite orbiting Earth

•Mainly used for communication and meteorological applications – **GOES, METEOSAT, INSAT etc.**

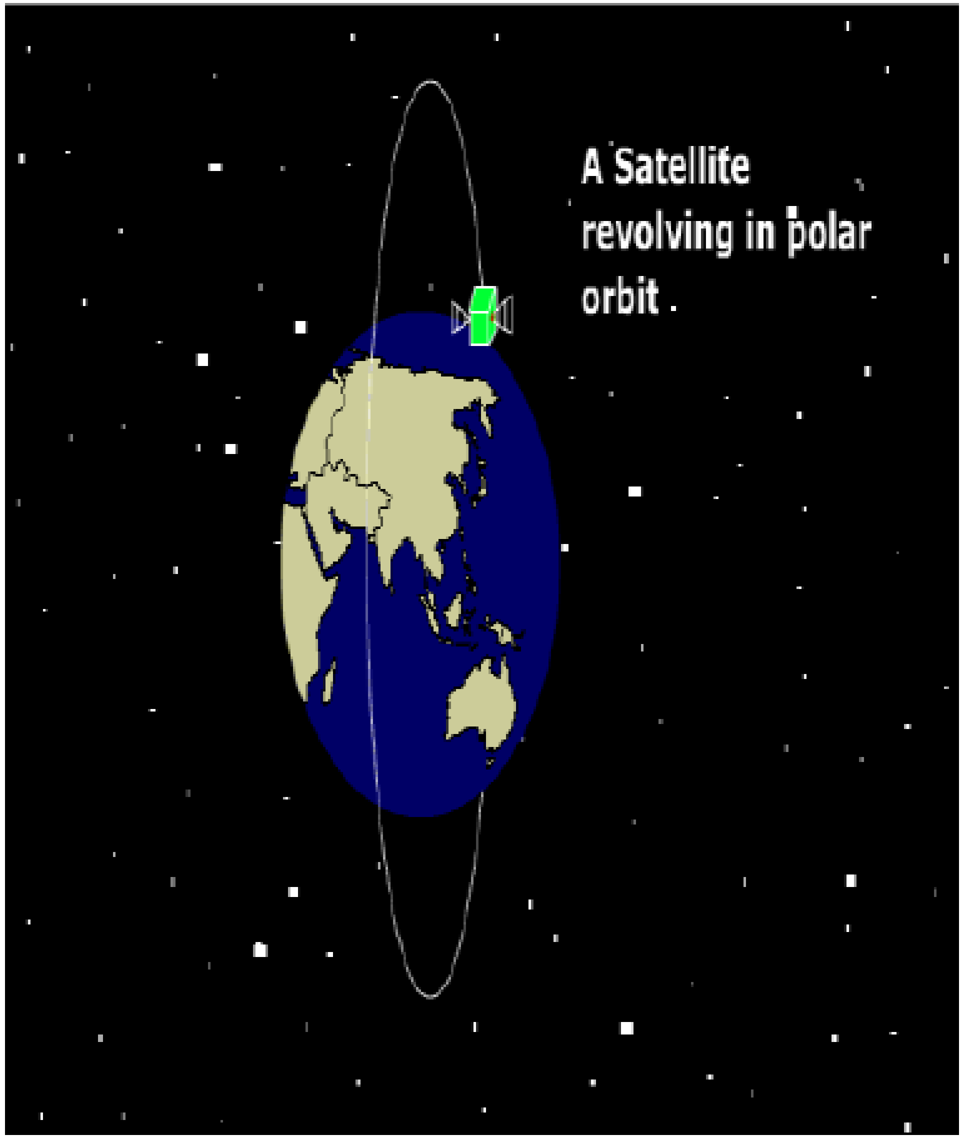


Sun-synchronous satellites

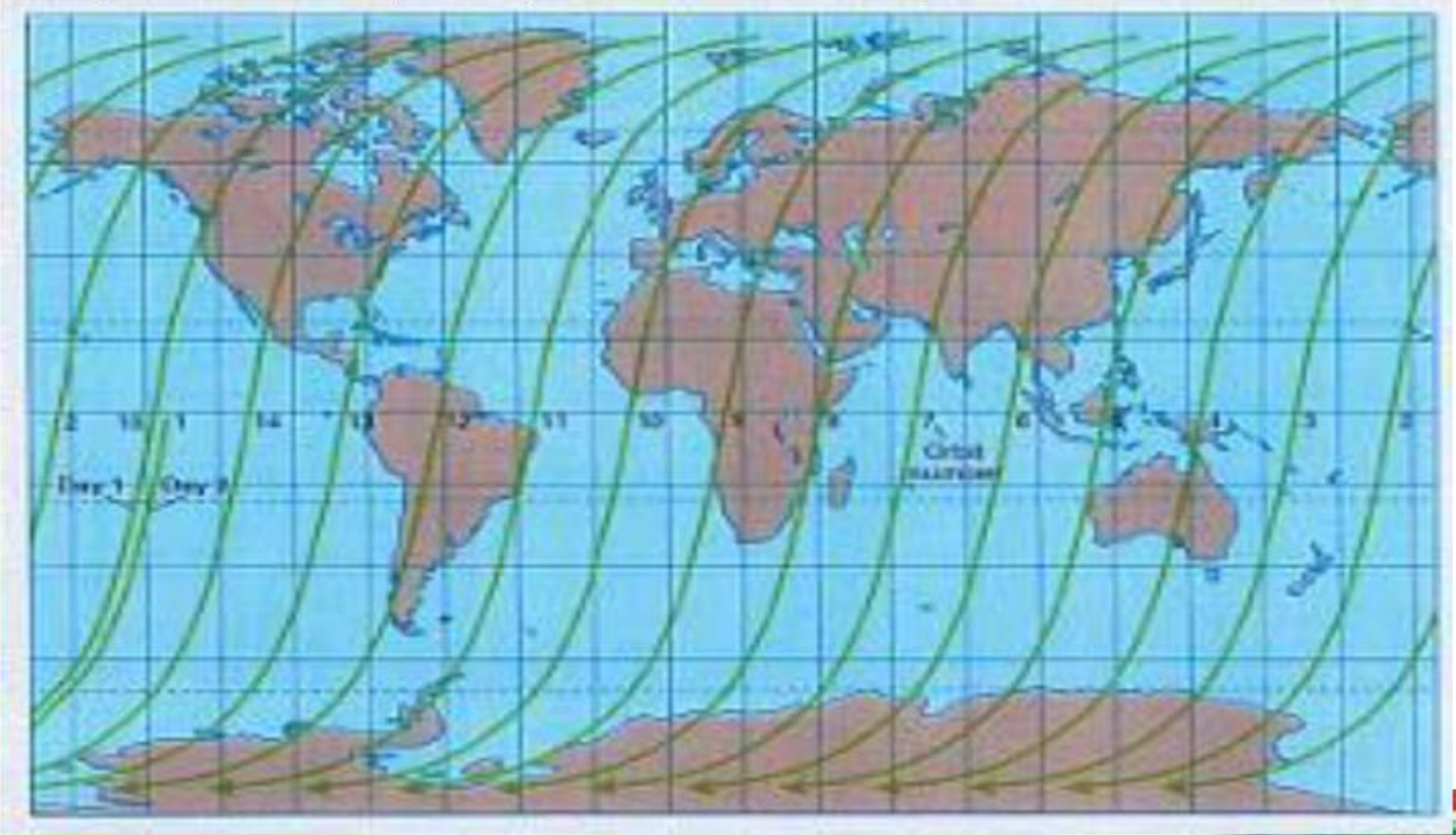
- Altitude ~**700-800 km**
- Orbit inclination ~ **98.7°**
- Orbital period ~**90 minutes**
- Sun-synchronous, near-polar, near-circular
- Satellite orbit is fixed in space (basically **north-south**): Earth rotates beneath it (west-east)
- Cross the equator (N-S) at ~**10.30am local time**

  Satellite Orbital plane is near polar and the altitude is such that the satellite passes each place at same local sun-time.

- Cover entire globe – **LANDSAT, SPOT, NOAA, IRS** etc.



The **satellite's orbit (North –South)** and the **rotation of the Earth (from west to east)** work together to allow **complete coverage of the Earth's surface**, after it has completed **one complete cycle of orbits**



Some Land Imaging Satellites

■ LANDSAT	(USA)
■ SPOT	(France)
■ **IRS**	**(India)**
■ NOAA	(USA)
■ IKONOS	(USA)
■ RADARSAT	(Canada)
■ ERS	(Europe)
■ ENVISAT	(Europe)
■ JERS	(Japan)
■ ALOS	(Japan)

Remote Sensing Sensors

- **Passive sensors-**

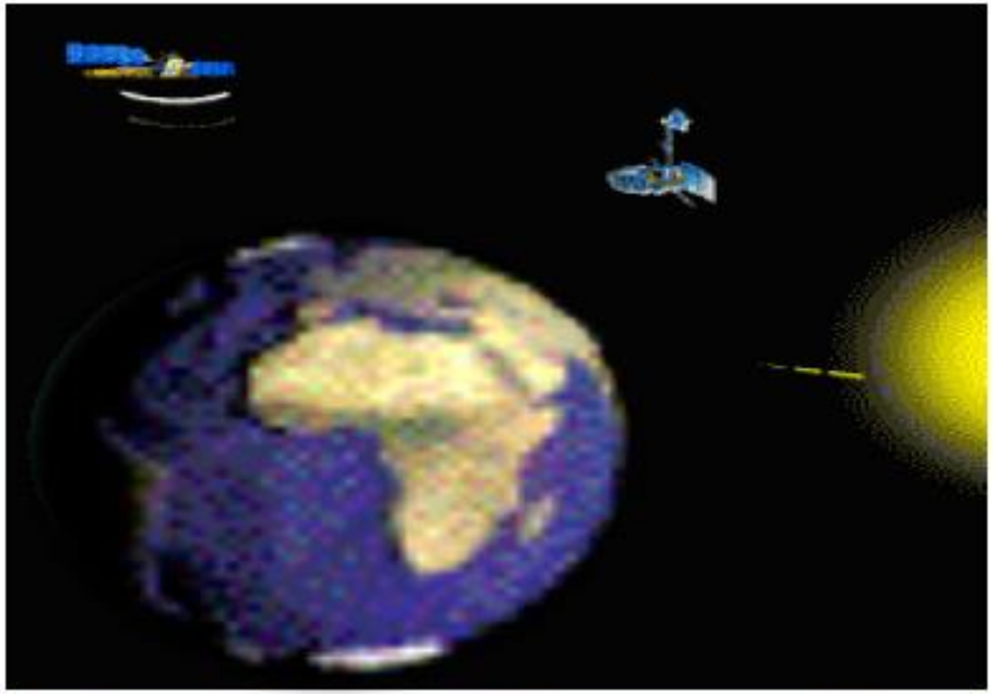
  Passive system record energy reflected or emitted by a target illuminated by sun.

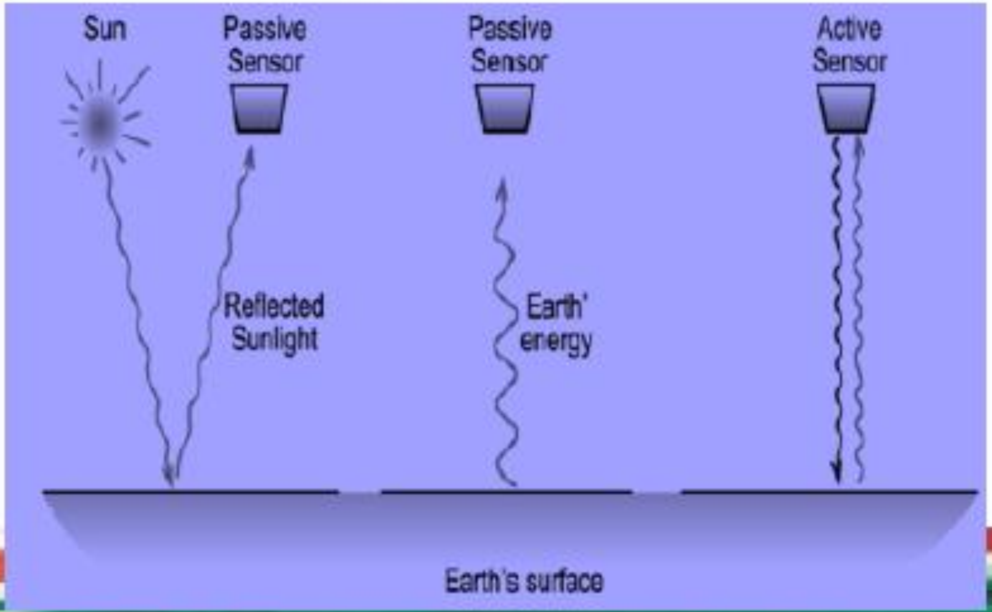
  e.g. normal photography, most optical satellite sensors

- **Active sensors-**

  Active system illuminates target with energy and measure reflection.

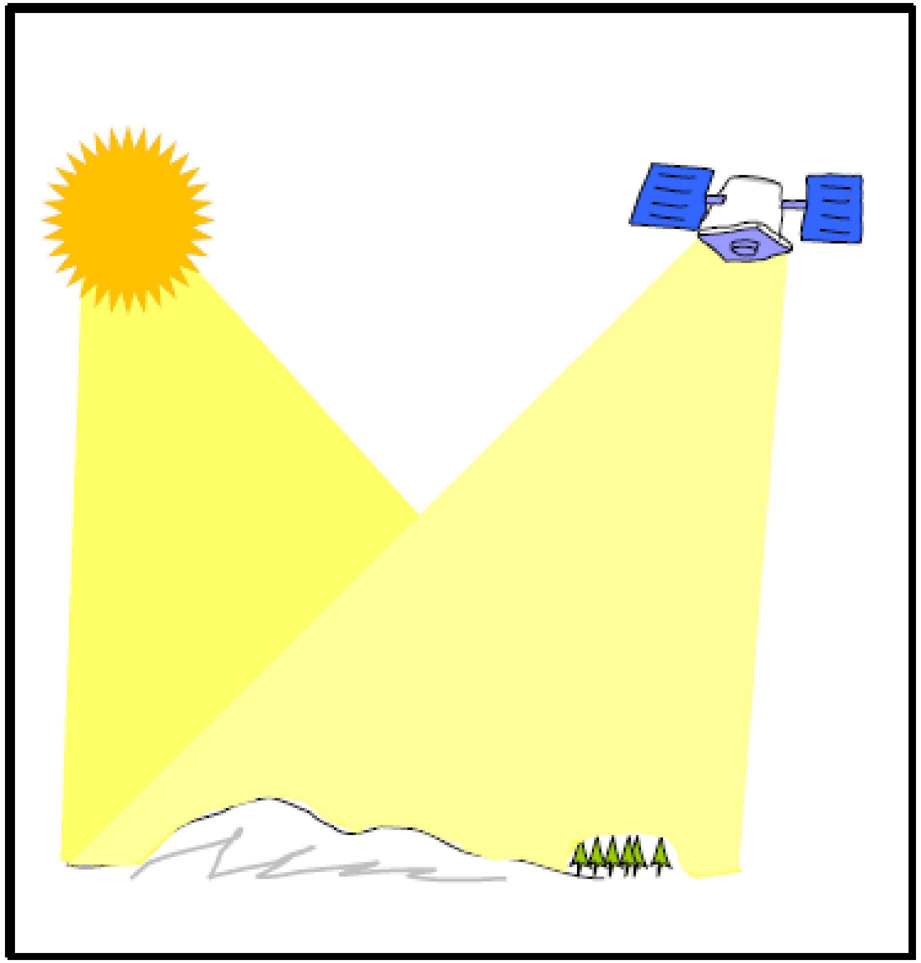
  e.g. Radar sensors, Laser altimeters



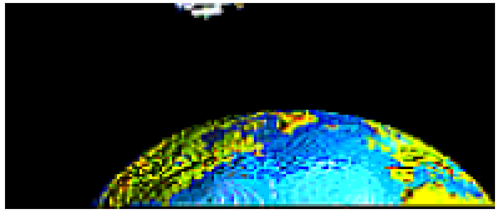


Passive Sensors

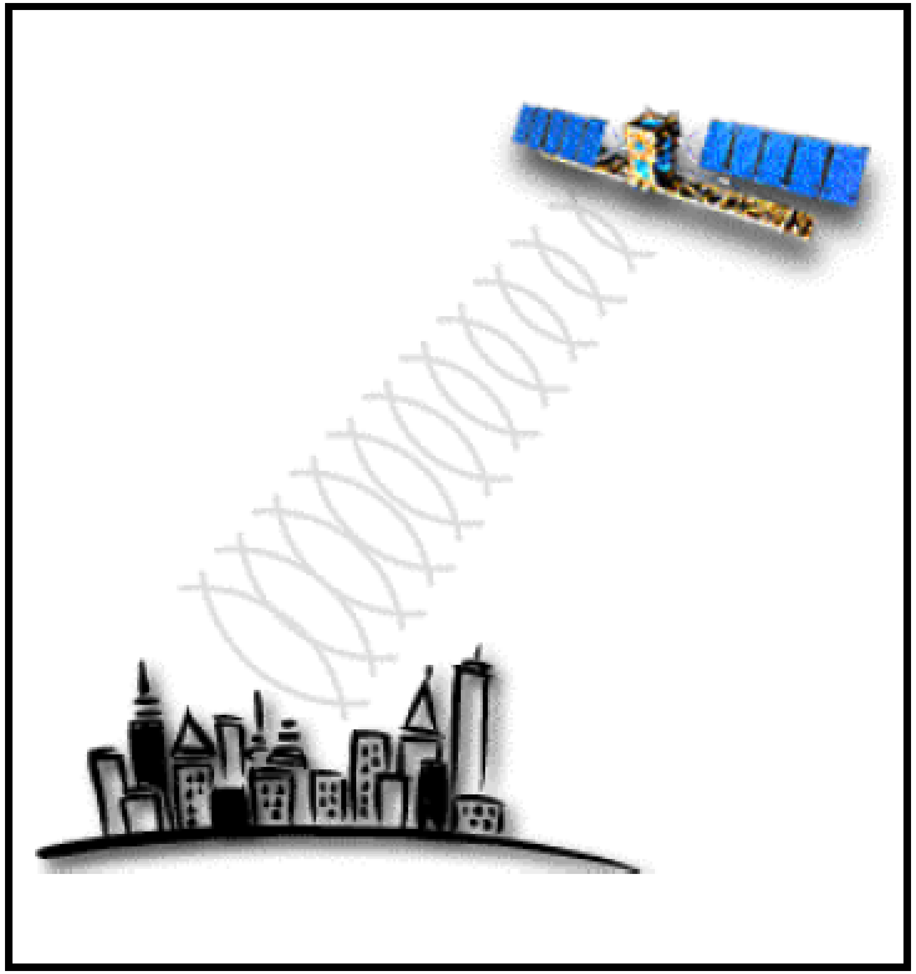
- Remote sensing systems which **measure energy that is naturally available** are called **passive sensors**.
- For all reflected energy, this can **only take place** during the time **when the sun is illuminating the Earth.**
- There is **no reflected energy** available **from the sun at night.**
- Energy that is naturally emitted (such as **thermal infrared**) can be **detected day or night**, as long as the amount of energy is large enough to be recorded.



Active Sensors



- ***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.
- Advantages for active sensors include the **ability to obtain measurements anytime**, regardless of the time of day or season.



Imaging Sensors

Passive Sensors

1. Photographic Camera
2. The Optical Scanners
   a) Across Track Scanners
   b) Along Track Scanners
3. The Thermal Scanner

Active Sensors

1. RADAR (Radio Detection and Ranging)
   a) Synthetic Aperture Radar
   b) Real Aperture Radar
2. LIDAR (Light Detection and Ranging)

Non-Imaging Sensors

Passive Sensors

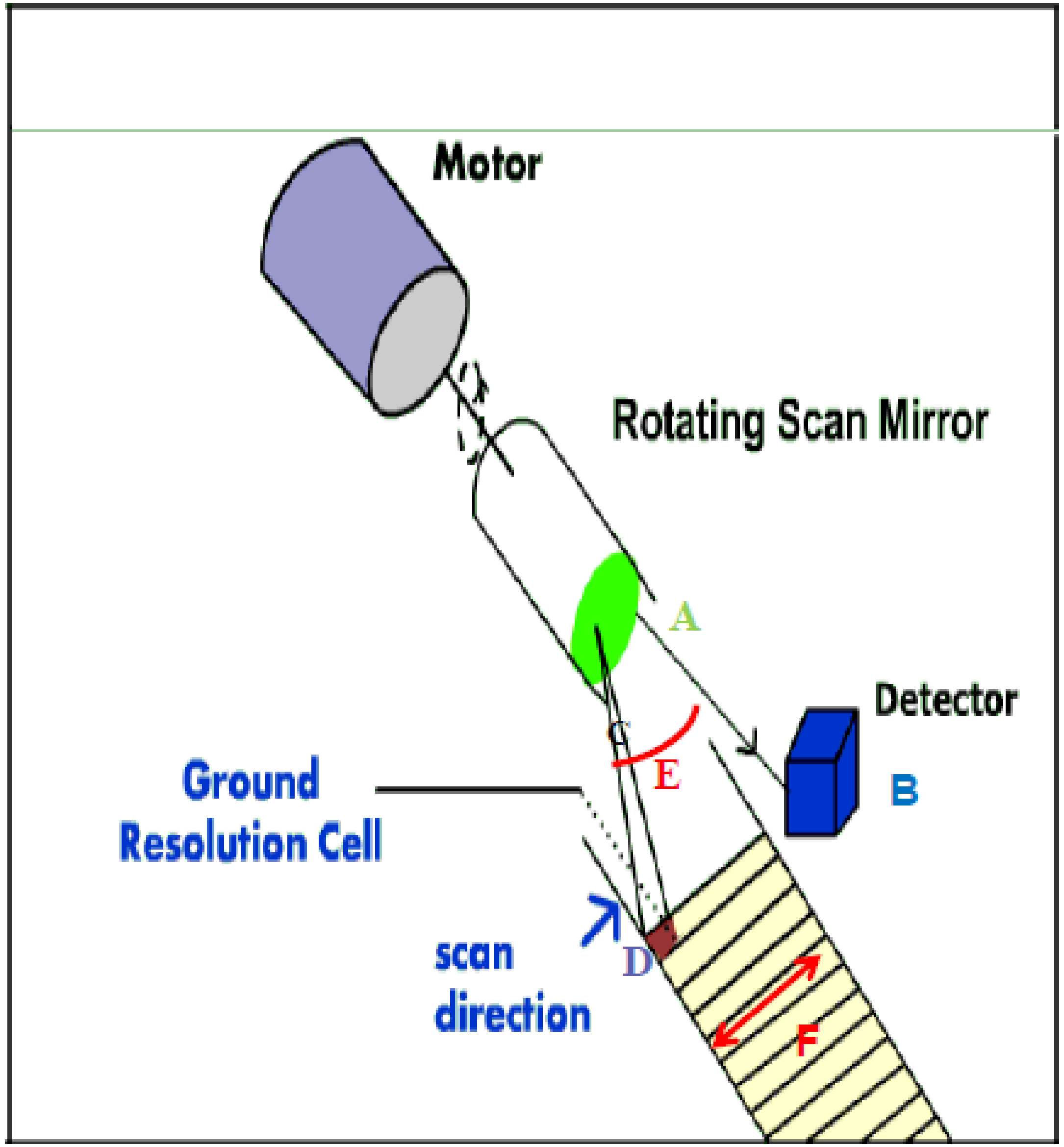
1. Spectrometers
2. Radiometers

Active Sensors

1. Laser Distance Meter
2. Laser Water Depth Meter
3. Microwave Altimeter

Across-Track Multispectral Scanning

- **Whisk broom scanning**
- 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).



Contd..

- Each line is scanned from one side of the sensor to the other, using a **rotating mirror** (A).
- As the platform moves forward over the Earth, successive scans build up a two-dimensional image of the Earth's surface
- A bank of internal **detectors** (B), each sensitive to a specific range of wavelengths, detects and measures the energy for each spectral band and then, as an electrical signal, they are converted to digital data and recorded for subsequent computer processing
- The **IFOV** (C) of the sensor and the altitude of the platform determine the **ground resolution cell** viewed (D), and thus the spatial resolution.
- The **angular field of view** (E) is the sweep of the mirror, measured in degrees, used to record a scan line, and determines the width of the imaged **swath** (F).

Contd..

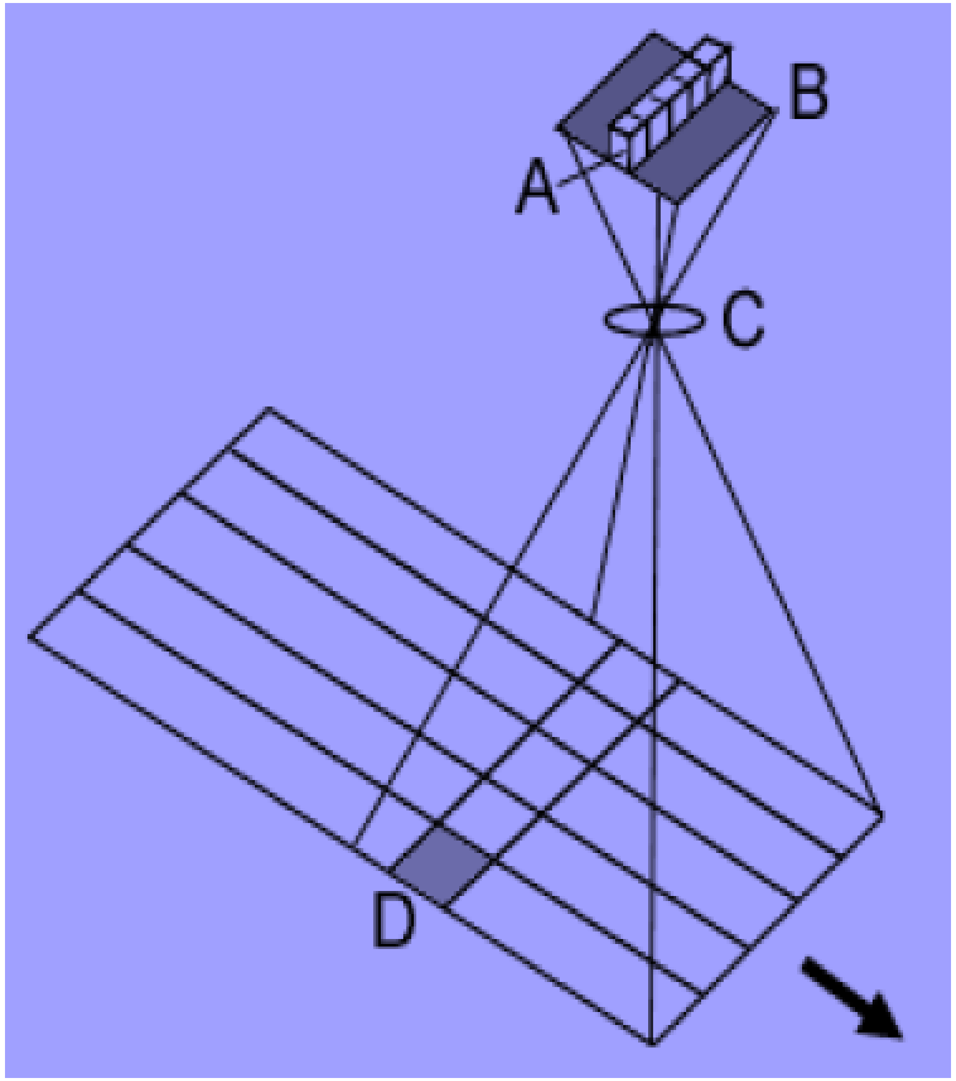
- Data are collected within an arc below the system typically of some **90° to 120°**

- **Multispectral scanner (MSS) and thematic mapper (TM) of LANDSAT,** and **Advanced Very High Resolution Radiometer (AVHRR) of NOAA** are the examples of Whisk Broom scanners

Whisk broom scanning

Along-Track Multispectral Scanning

- **Push broom scanning**
- Scan the Earth in a series of lines.
- This 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.



Contd..

- A **linear array of detectors** (A) located at the **focal plane** of the image (B) formed by **lens systems** (C) are used, which are "pushed" along in the flight track direction (i.e. along track).
- As the motion of the detector array is analogous to the bristles of a broom being pushed along a floor
- Each individual detector measures the energy for a **single ground resolution cell** (D) and thus the size and IFOV of the detectors determines the spatial resolution of the system.
- A separate linear array is required to measure each spectral band or channel.
- For each scan line, the energy detected by each detector of each linear array is sampled electronically and digitally recorded

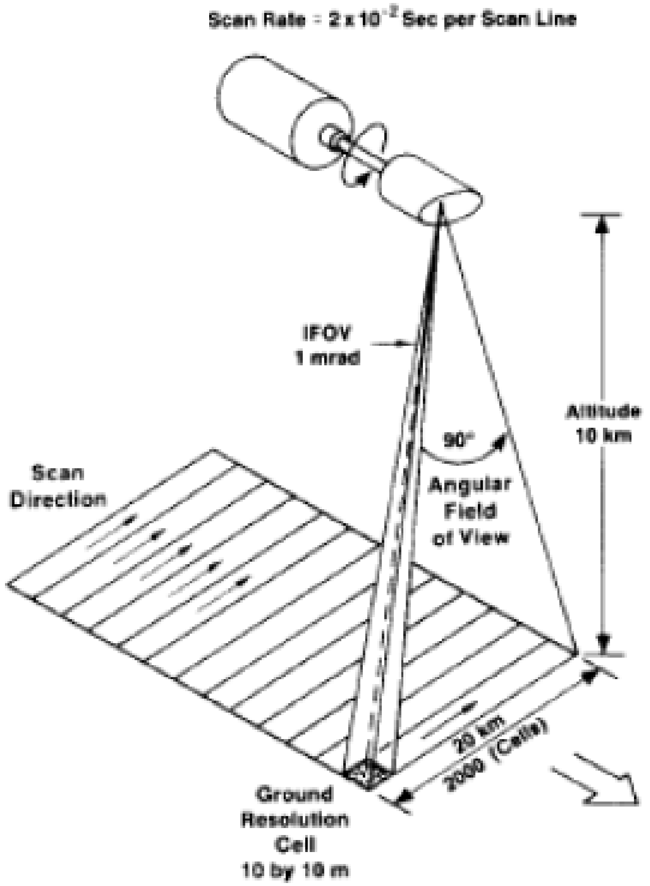
Contd..

- Linear arrays normally consist of numerous **charge-coupled devices (CCDs)** positioned end to end.

- **Linear imaging self scanning (LISS)** and **Wide Fielf Sensor (WiFS)** of **IRS Series**, and **High Resolution Visible (HRV)** of **SPOT-1** are the examples of Push broom scanners

Push broom scanning

Across Track Scanners

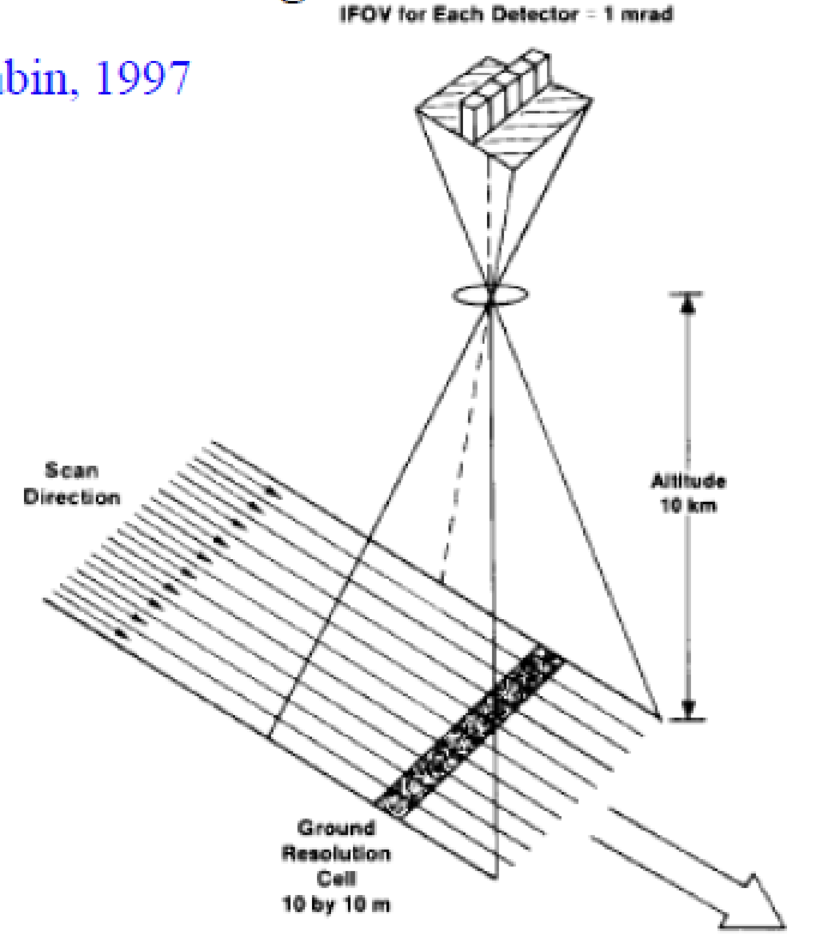


$$\text{Dwell Time} = \frac{\text{Scan Rate per Line}}{\text{Number Cells per Line}} = \frac{2 \times 10^{-2}\ \text{sec}}{2000\ \text{cells}} = 1 \times 10^{-5}\ \text{sec} \cdot \text{cell}^{-1}$$

Whiskbroom

Along Track Scanners

Sabin, 1997



$$\text{Dwell Time} = \frac{\text{Cell Dimension}}{\text{Velocity}} = \frac{10\ \text{m} \cdot \text{cell}^{-1}}{200\ \text{m} \cdot \text{sec}^{-1}} = 5 \times 10^{-2}\ \text{sec} \cdot \text{cell}^{-1}$$

Pushbroom

Field of View (FOV), Instantaneous Field of View (IFOV)

Dwell time is the time required for the detector IFOV to sweep across a ground cell. The longer dwell time allows more energy to impinge on the detector, which creates a stronger signal.

Across Track Vs Along Track

- The array of detectors combined with the pushbroom motion allows each detector to "see" and measure the energy from each ground resolution cell for a **longer period of time** (**dwell time**).
- This allows **more energy to be detected** and improves the radiometric resolution.
- The increased dwell time also facilitates **smaller IFOVs** and **narrower bandwidths** for each detector.
- Thus, **finer spatial and spectral resolution** can be achieved without impacting radiometric resolution.
- Because detectors are usually solid-state microelectronic devices, they are **generally smaller, lighter, require less power, and are more reliable and last longer** because they have no moving parts.
- On the other hand, **cross-calibrating thousands of detectors** to achieve uniform sensitivity across the array **is necessary and complicated**.

Some Sensors on Satellites

MSS	(Multi Spectral Scanner)
TM	(Thematic Mapper)
ETM+	(Enhanced Thematic Mapper +)
LISS	**(Linear Imaging Self Scanning)**
PAN	(Panchromatic)
HRV	(High Resolution Visible)
SAR	(Synthetic Aperture Radar)
WiFS	**(Wide Field Sensor)**
AWiFS	**(Advanced Wide Field Sensor)**
AVHRR	(Advanced Very High ResolutionRadiometer)
OLI	(Operational Land Imager)