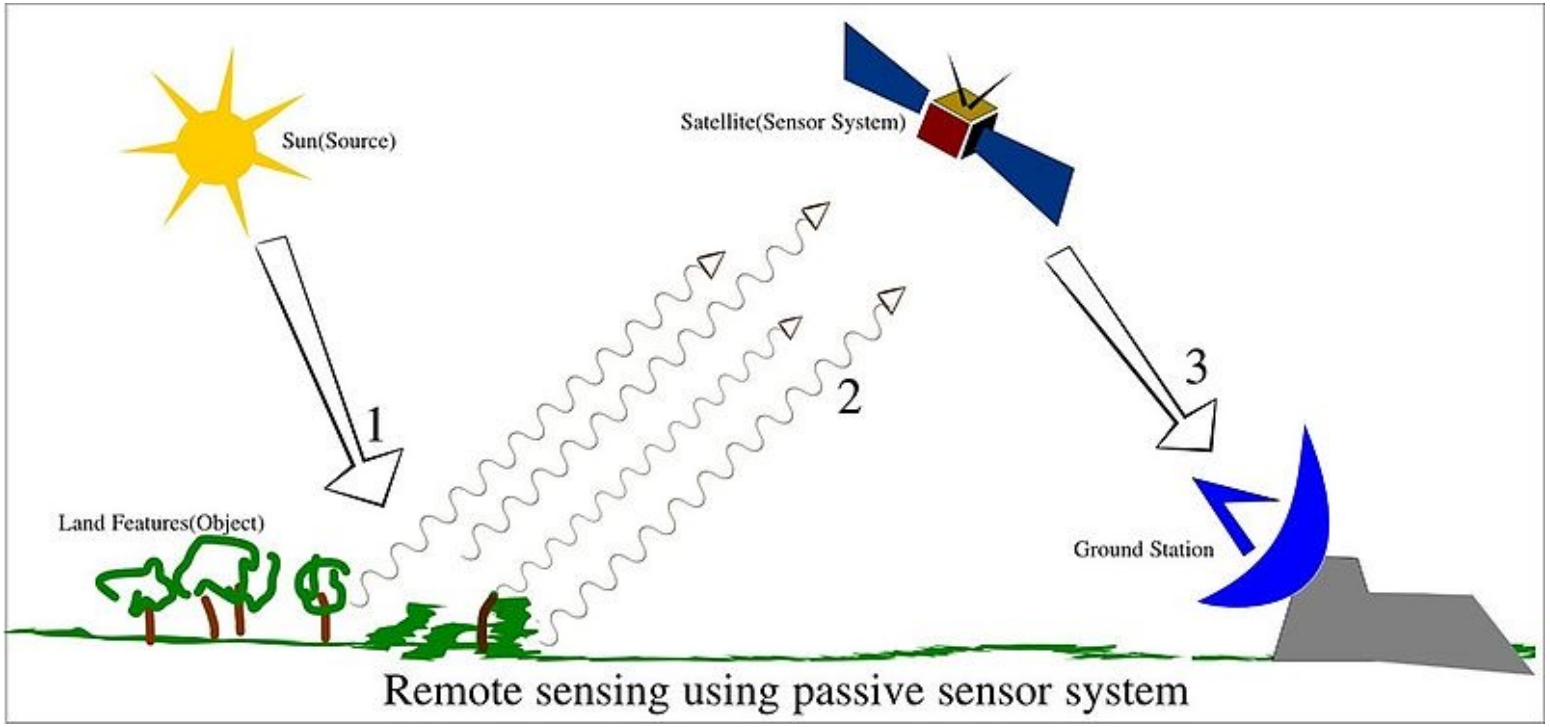
Lesson 5

- **Sensors in Remote Sensing**

Remote sensing sensors **collect data by detecting the energy that is reflected from Earth**. These sensors can be on satellites or mounted on aircraft. Remote sensors can be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the Earth's surface.



SENSORS: Passive and Active Remote Sensing Sensor

Remote sensing instruments are of two primary types

Passive (VIS, IR, MW)

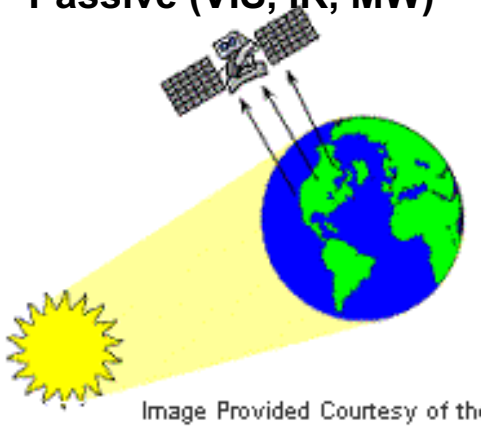
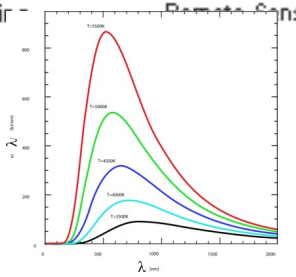


Image Provided Courtesy of the Canada Centre for Remote Sensir

Active (optical,MW)

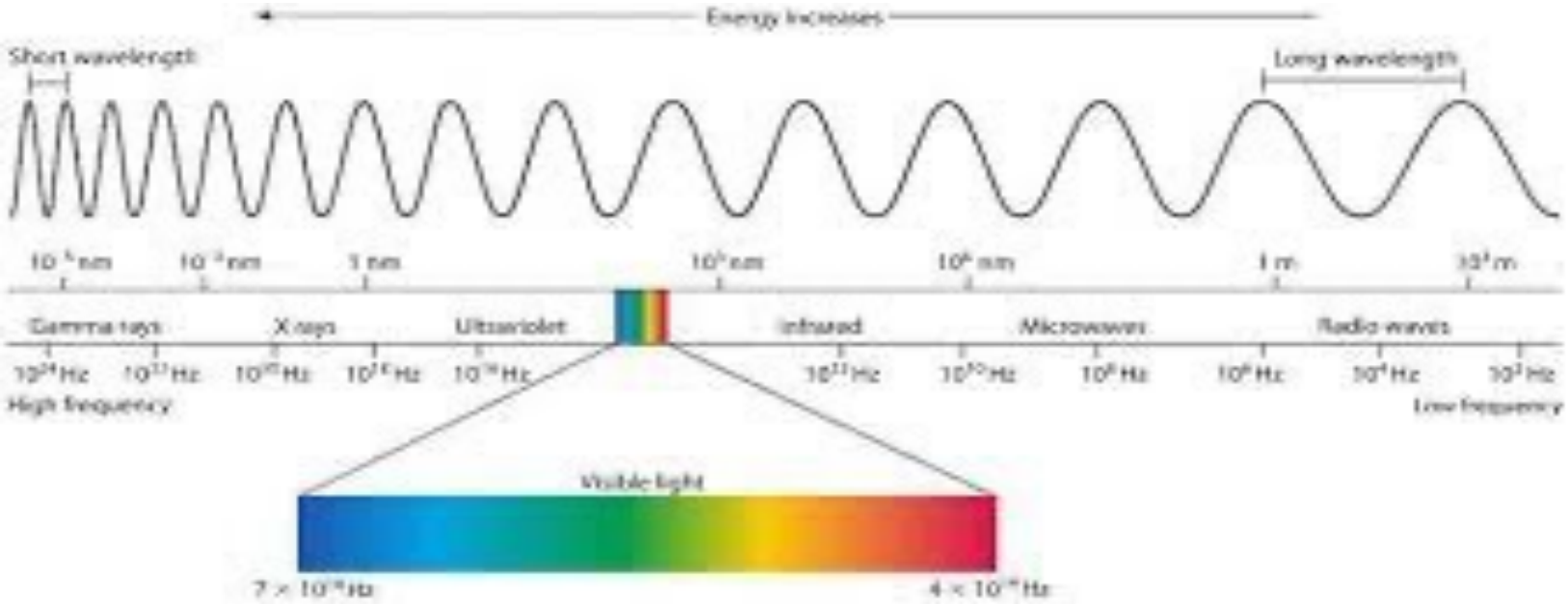
Image Provided Courtesy of the Canada Centre for Remote Sensing

Passive sensors detect natural energy (radiation) that is emitted or reflected by the object



The **sensor that detects and measures the radiation that is reflected or backscattered from the target**.

Links:
http://www.csc.noaa.gov/products/nchaz/htm/ccap5.htm

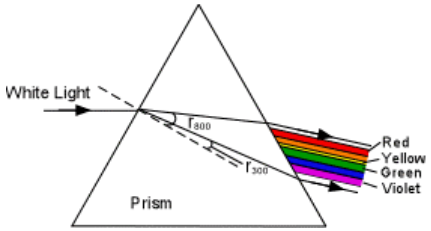


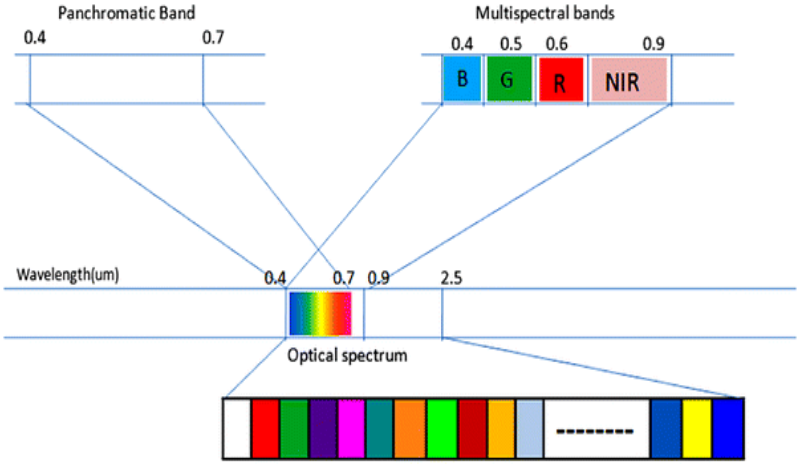
Optical/IR remote sensing (0.4 to 8.0 micrometer)
Thermal remote sensing (8 to 12 micrometer)
Microwave remote sensing (.3 to 100 GHz)

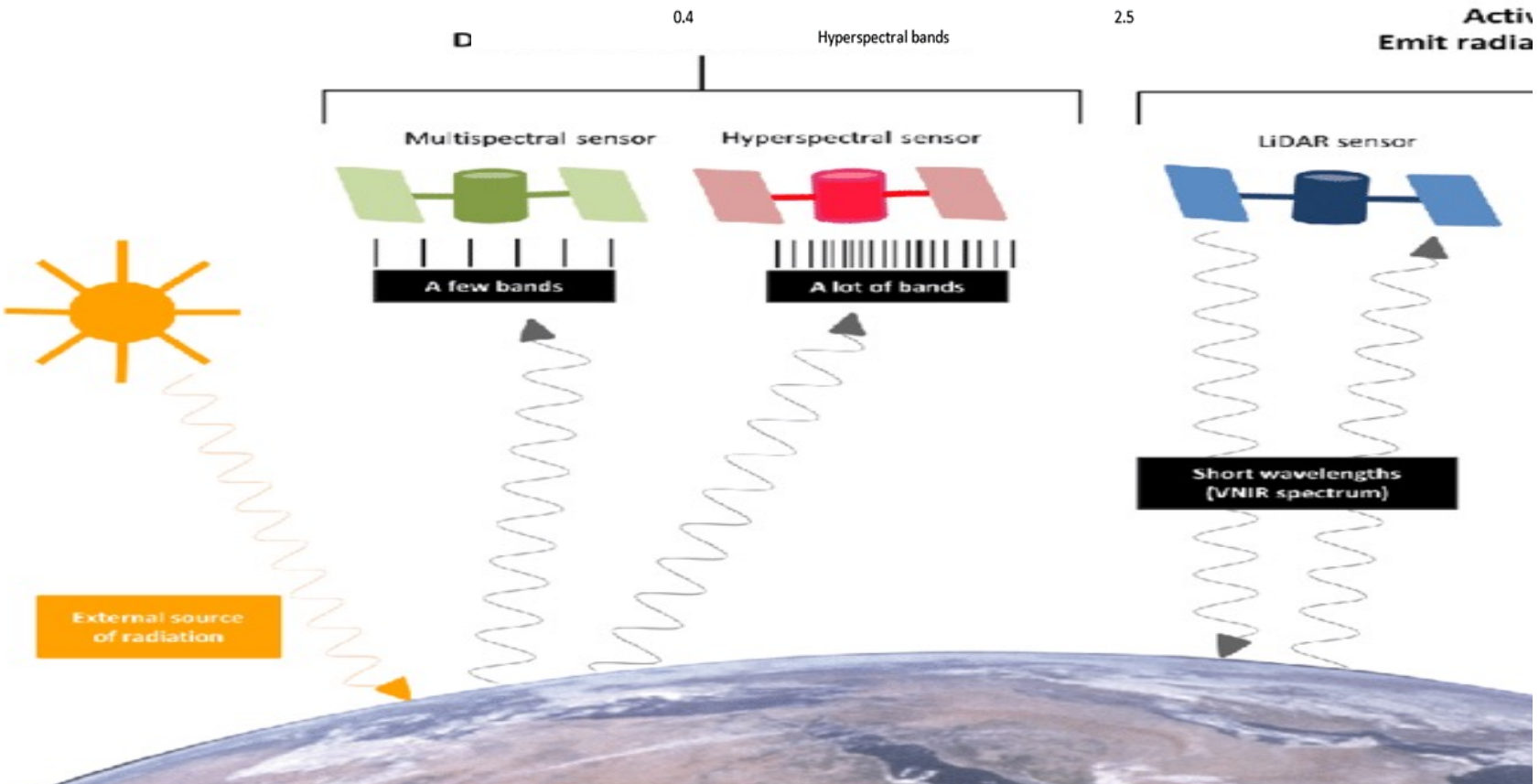
1) Visible / near / mid infrared

- **Passive measurements**
  - **solar energy reflected by the surface**
  - **determine surface (spectral) reflectance**
- **Active measurement**
  - **LIDAR - active laser pulse**
  - **time delay (height)**

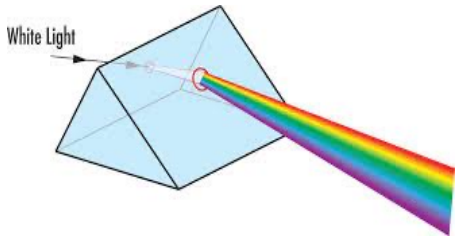
http://ecoursesonline.iasri.res.in/mod/page/view.php?id=124941

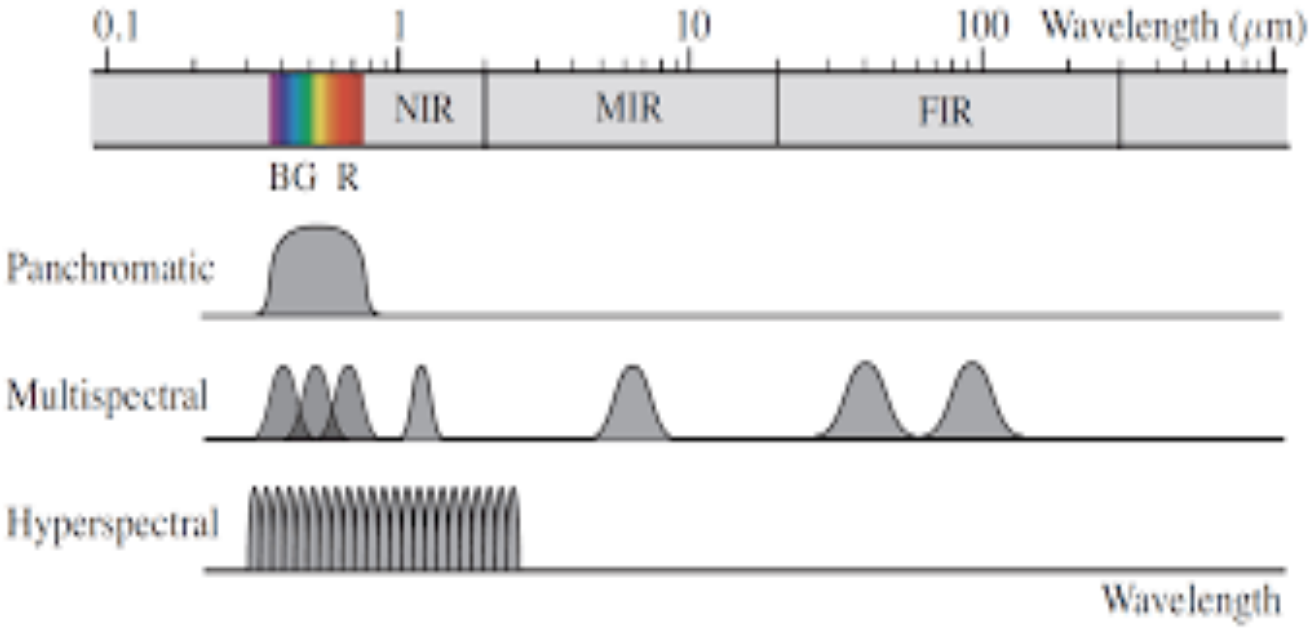

White Light
Red
Yellow
Green
Violet
Prism

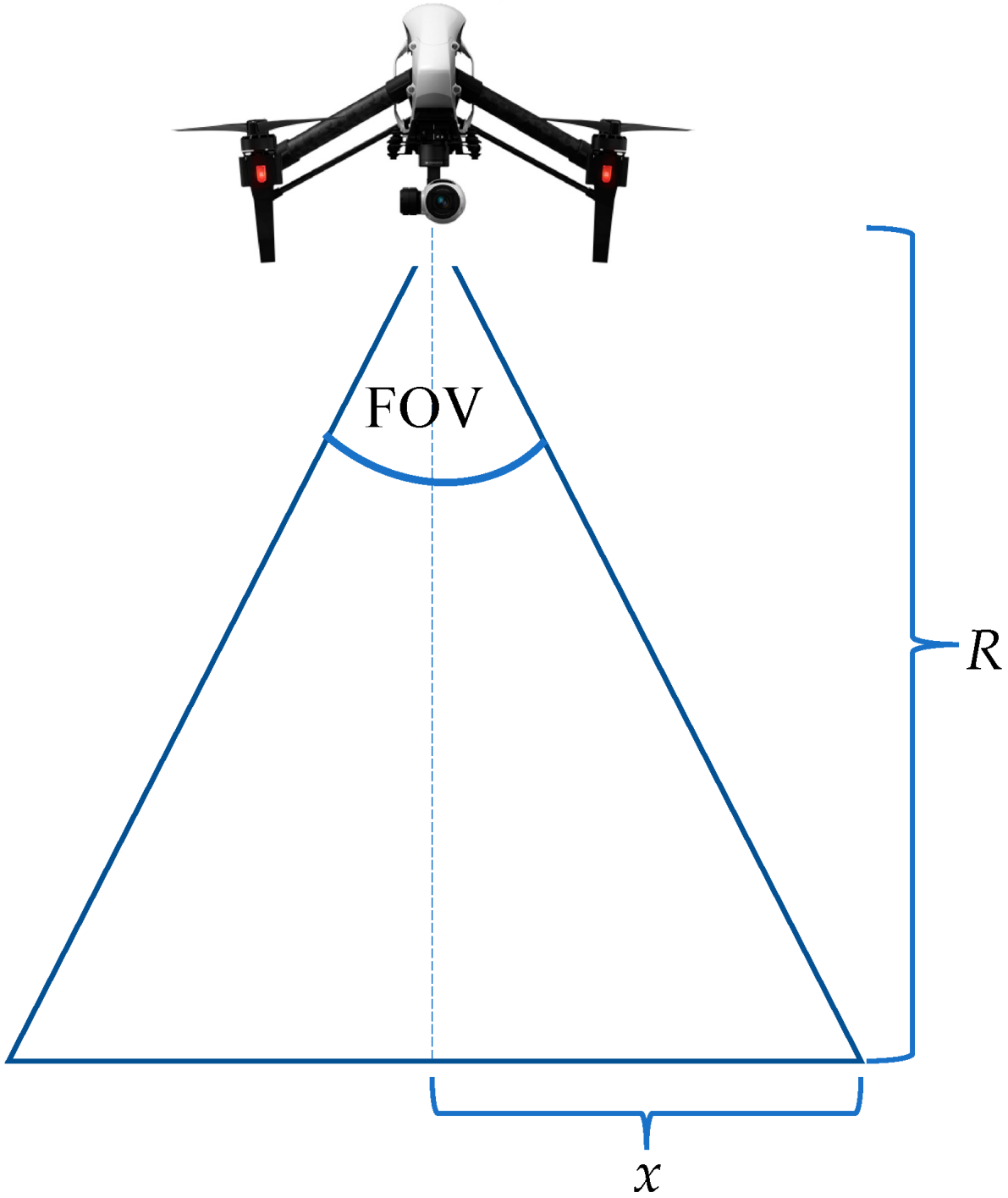

Panchromatic Band
0.4
0.7
Multispectral bands
0.4
0.5
0.6
0.9
B
G
R
NIR
Wavelength(um)
0.4
0.7
0.9
2.5
Optical spectrum
0.4
2.5


Hyperspectral bands
Multispectral sensor
Hyperspectral sensor
LiDAR sensor
A few bands
A lot of bands
Short wavelengths
(VNIR spectrum)
External source
of radiation

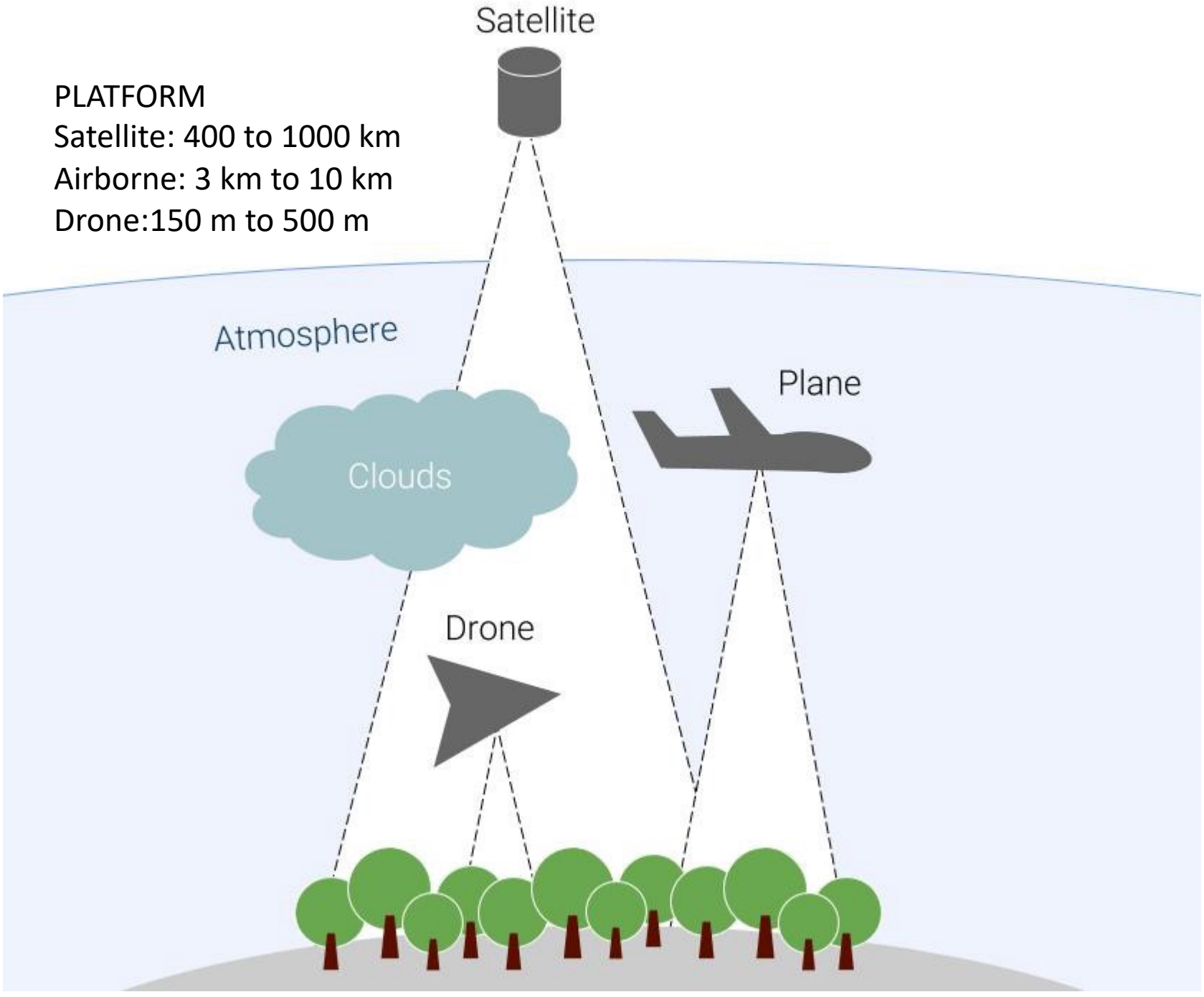
Received reflected light can be acquired in different manners

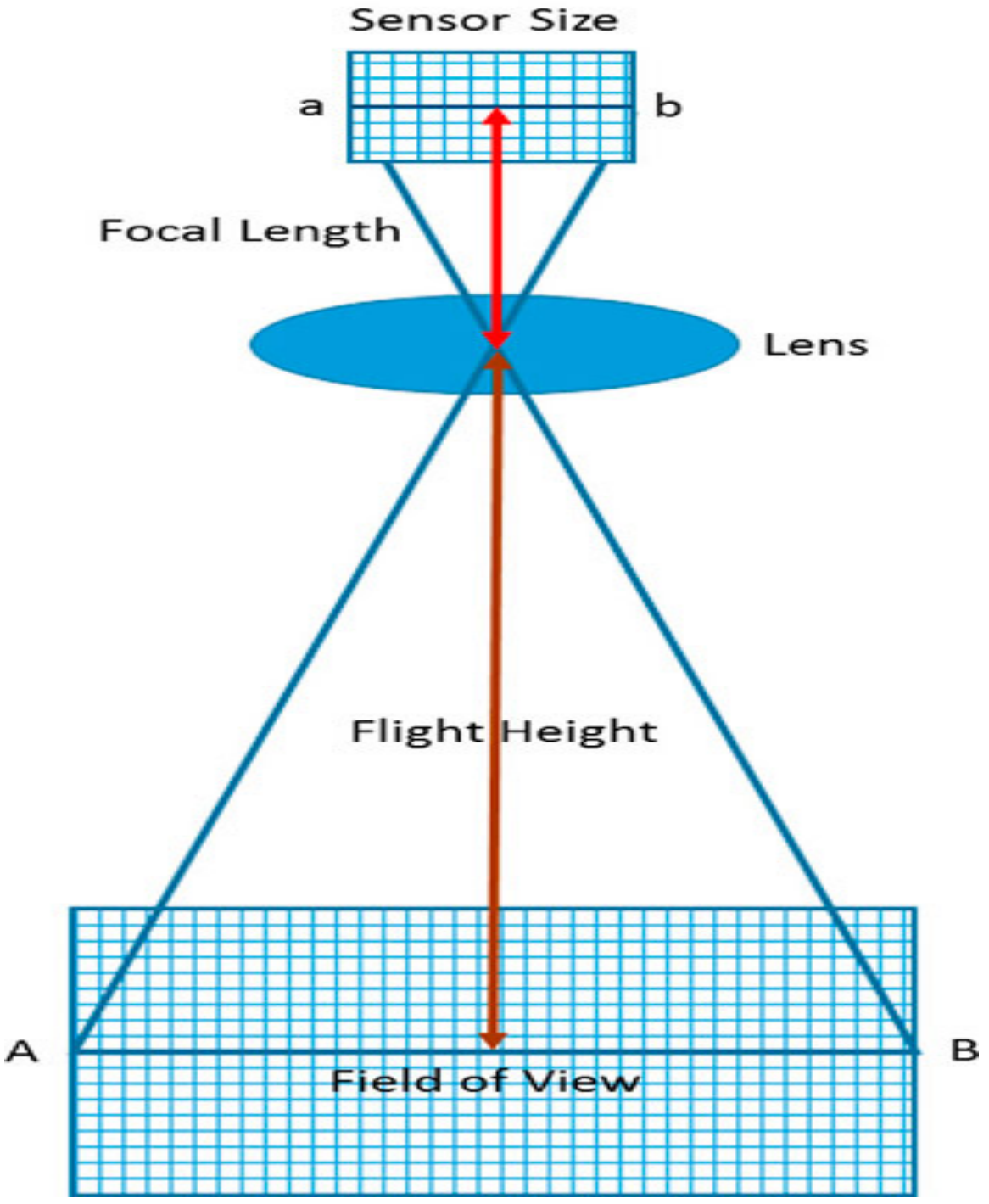





FOV
R
x

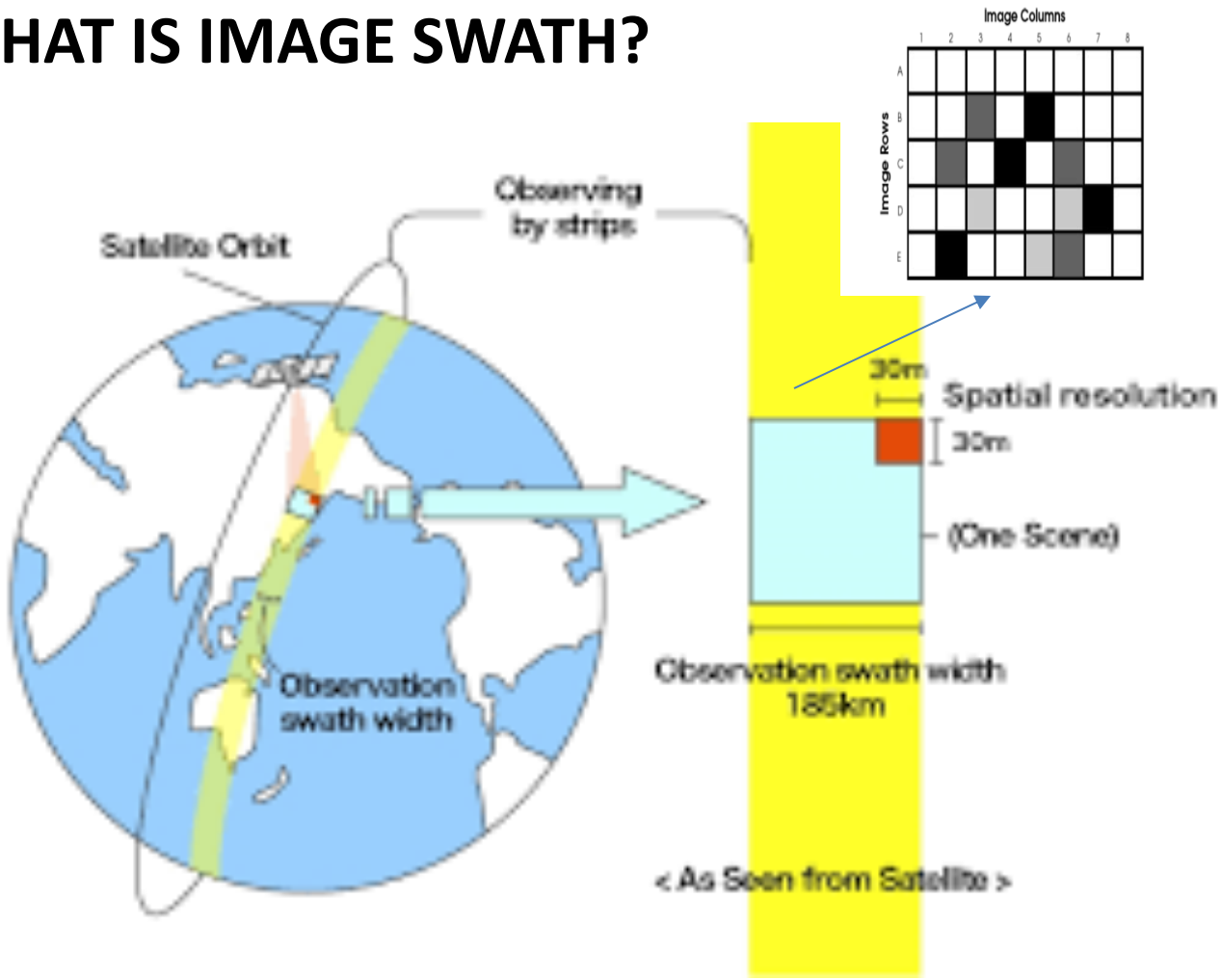
PLATFORM
Satellite: 400 to 1000 km
Airborne: 3 km to 10 km
Drone:150 m to 500 m




Sensor Size
a
b
Focal Length
Lens
Flight Height
A
B
Field of View

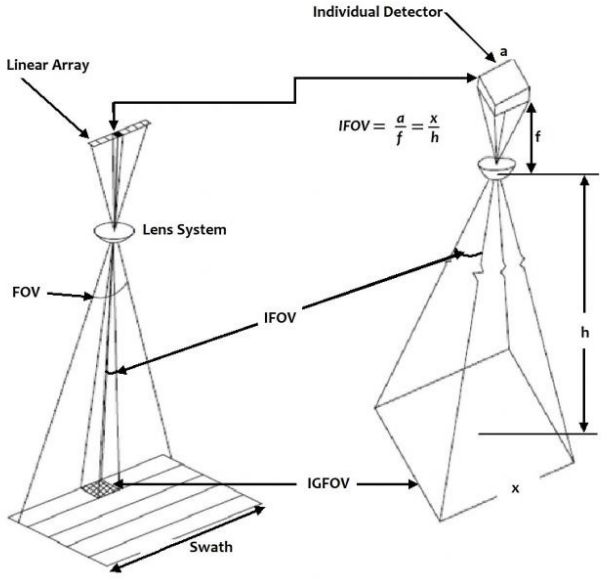
IFOV

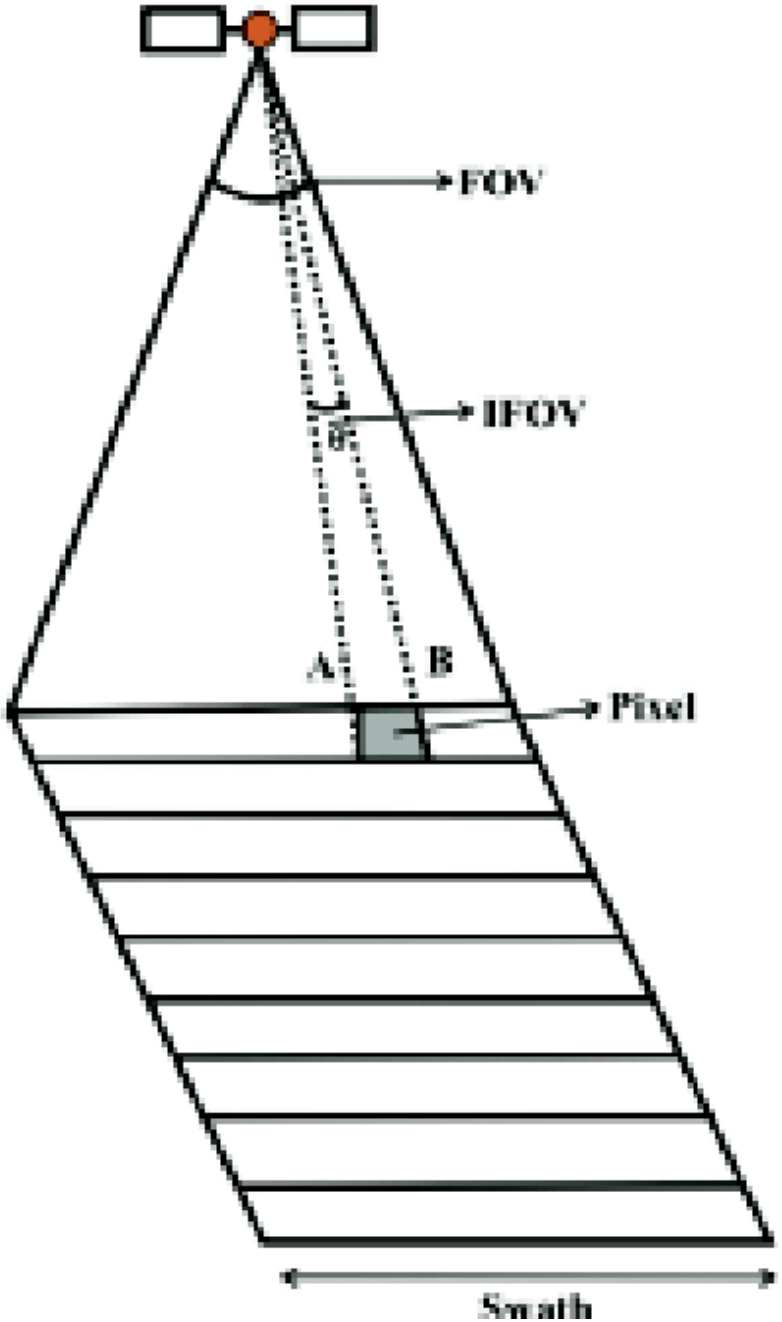
WHAT IS IMAGE SWATH?

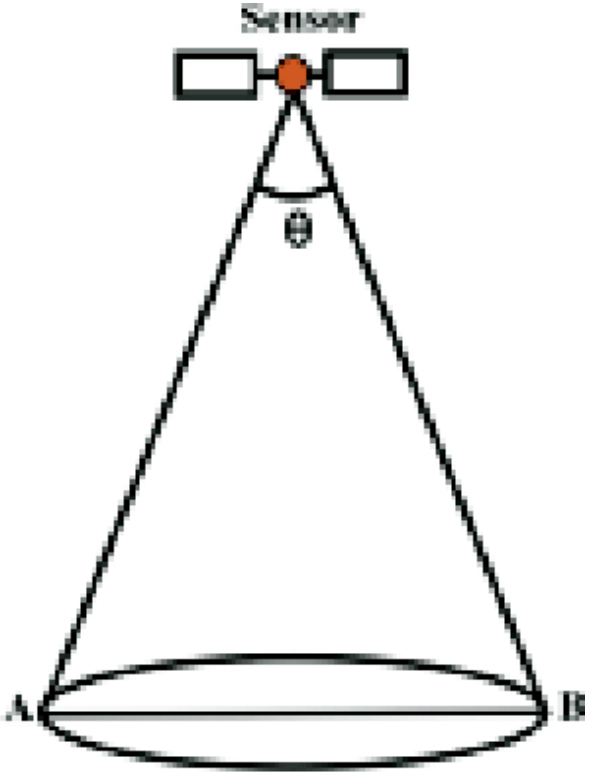


IFOV (Instantaneous Field of View) A measure of the spatial resolution of a remote sensing imaging system. Defined as the angle subtended by a single detector element on the axis of the optical system.

The IFOV characterizes the sensor, irrespective of the altitude of the platform. The field of view (FOV) is the total view angle that defines the swath

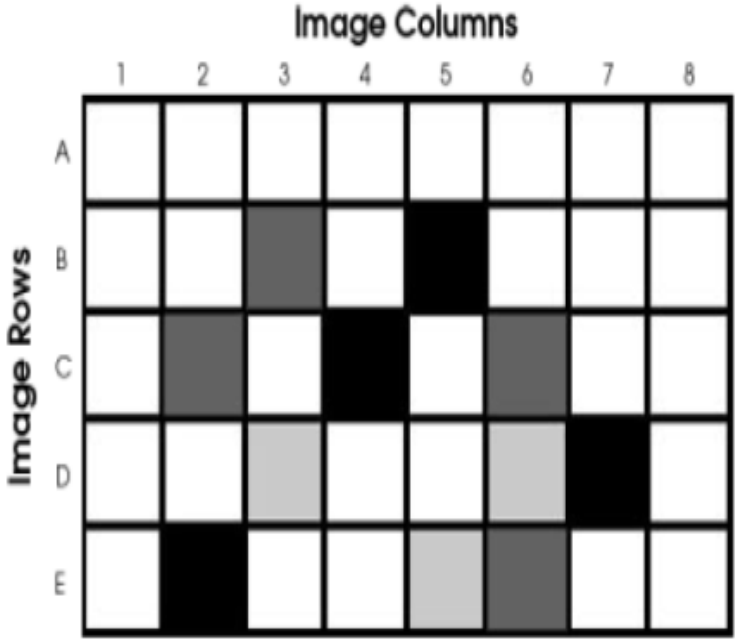


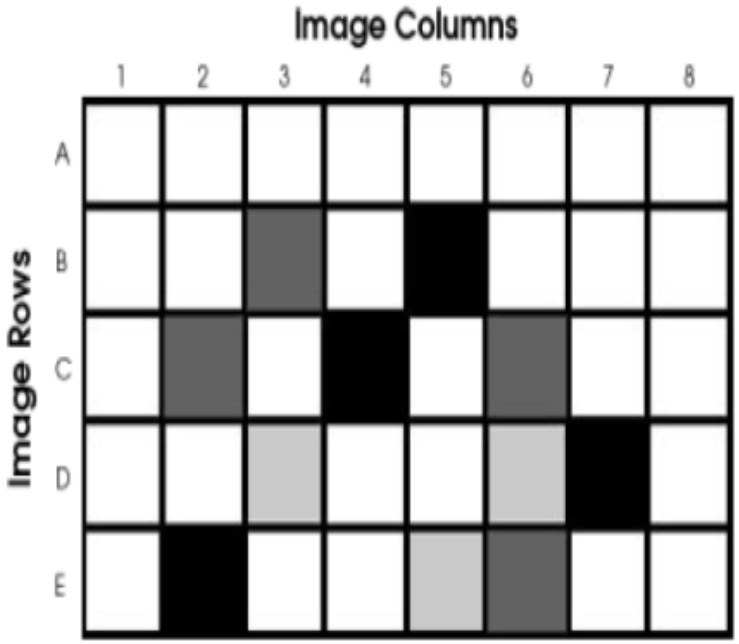




(B)

- Resolution= IFOV* Height
- For IFOV= 1 mrad, H=10 km
- Resolution= 10 m





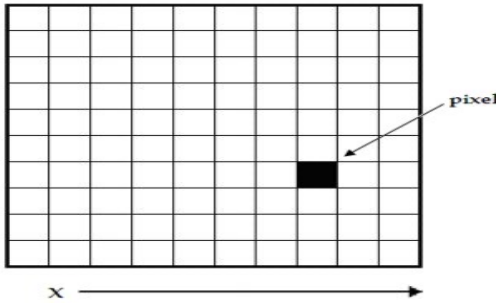
Shades are representative of DN Values in the image

What is Pixel?

The smallest unit of information in an image or raster map, usually square or rectangular. **Pixel is often used synonymously with cell.**

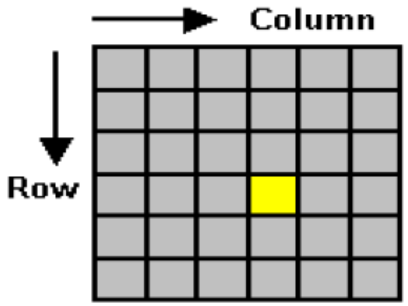
In remote sensing, the fundamental unit of data collection.

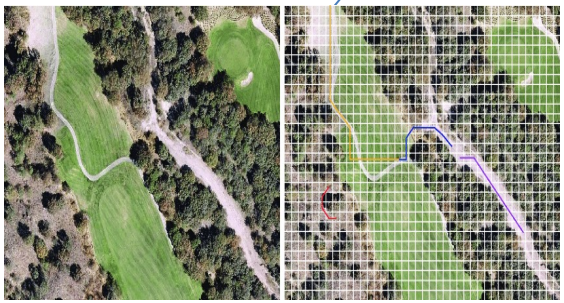
A pixel is **represented in a remotely sensed image as a cell in an array of data values**.



IMAGING METHODS

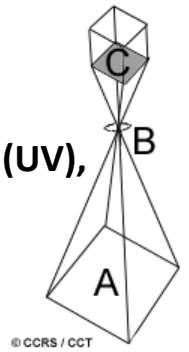
- Frame by Frame
- Pixel by pixel
- Line by line





http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9351

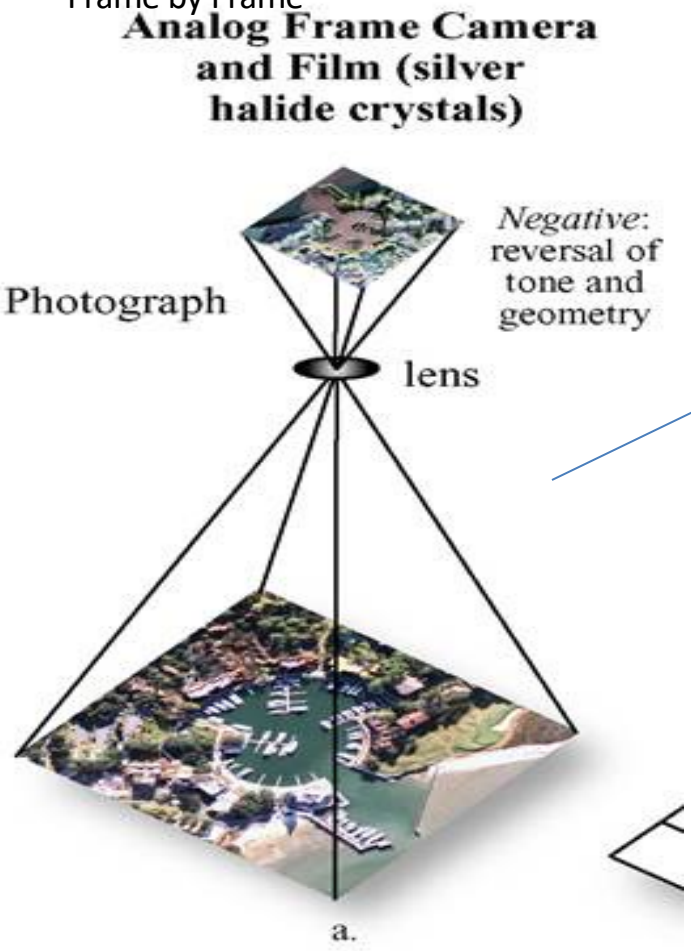
Cameras and their use for aerial photography are the simplest and oldest of sensors used for remote sensing of the Earth's surface. Cameras are framing systems which acquire a near-instantaneous "snapshot" of an area (A), of the surface. Camera systems are passive optical sensors that use a lens (B)(or system of lenses collectively referred to as the optics) to form an image at the focal plane (C), the plane at which an image is sharply defined.

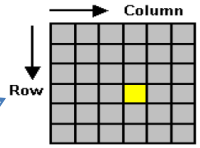


Photographic films:0.3 µm to 0.9 µm in wavelength covering the ultraviolet (UV), visible, and near-infrared (NIR).

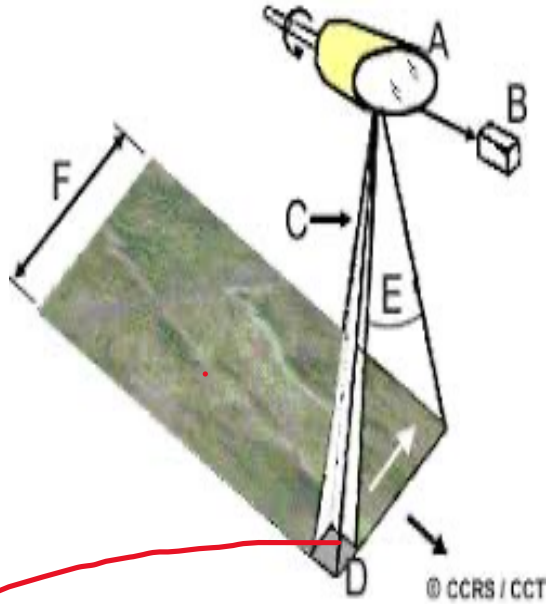
Panchromatic films are sensitive to the UV and the visible portions of the spectrum

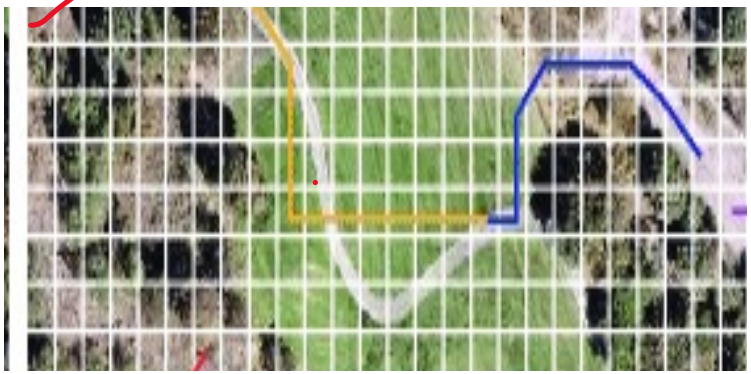
Frame by Frame



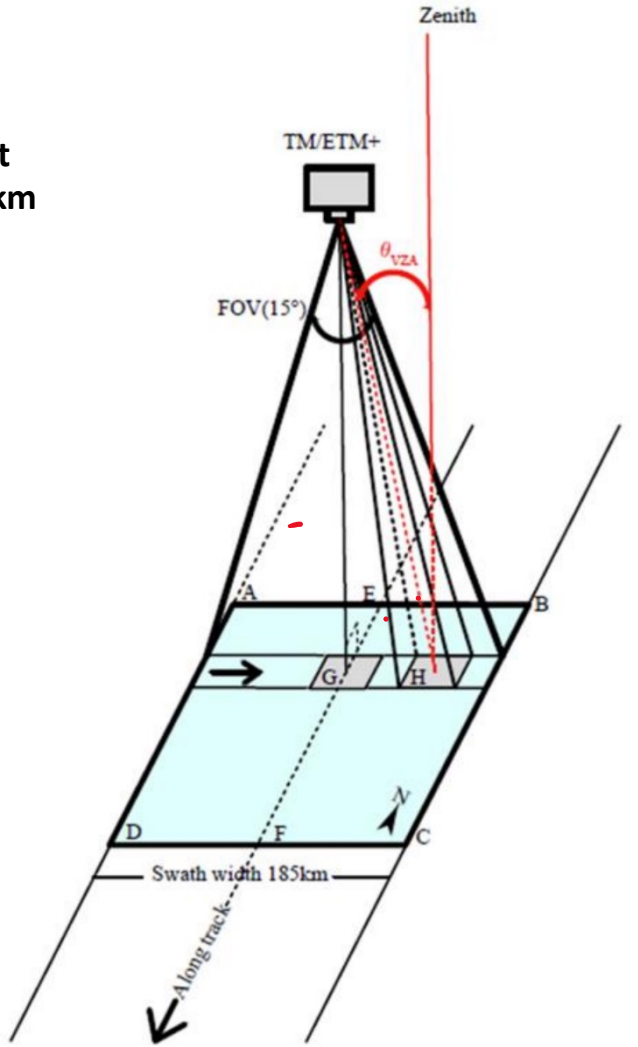


PIXEL BY PIXEL



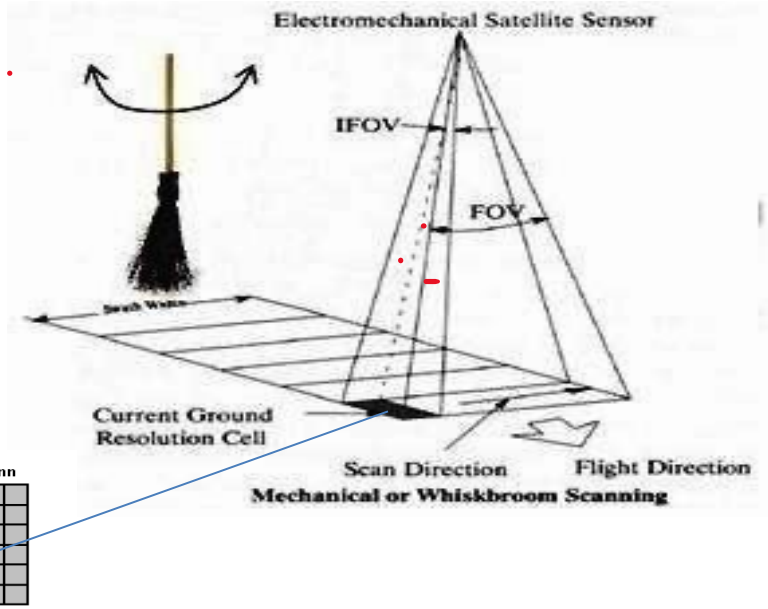


Resolution= IFOV* Height
For IFOV= 1 mrad, H=10 km
Resolution= 10 m



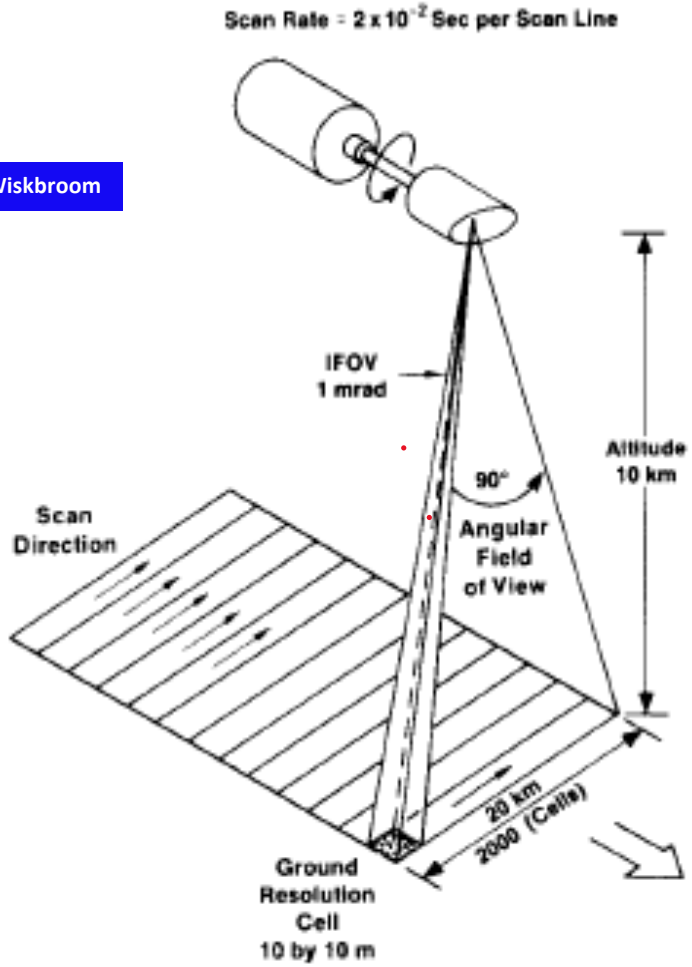
Multispectral scanners measure reflected electromagnetic energy by scanning the Earth's surface. This results in digital image data, of which the elementary unit is a picture element, a pixel. As the name multispectral suggests, the measurements are made for different ranges of the EM spectrum.

MULTISPECTRAL SCANNER



A combination of a single detector plus a rotating mirror can be arranged in such a way that the detector beam sweeps in a straight line over the Earth across the track of the satellite at each rotation of the mirror

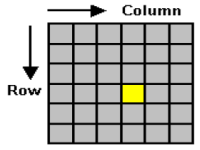
Wiskbroom



Resolution= IFOV* Height
For IFOV= 1 mrad, H=10 km
Resolution= 10 m

Across track scanner

A combination of a single detector plus a rotating mirror can be arranged in such a way that the detector beam sweeps in a straight line over the Earth across the track of the satellite at each rotation of the mirror



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

A. Cross-track scanner.

Sabin, 1997

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

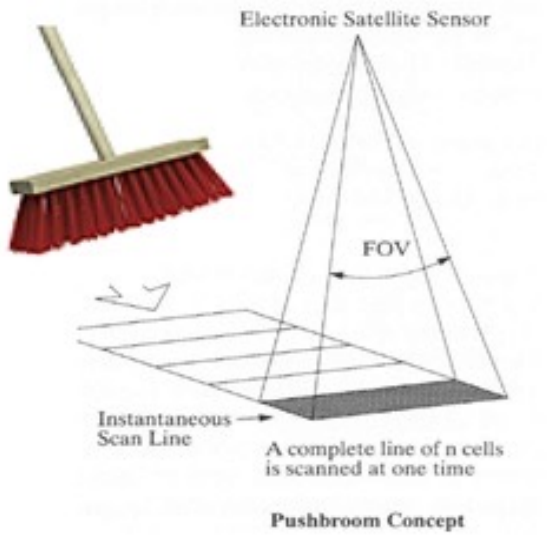
Dwell time is the time required for the detector IFOV to sweep across a ground cell. The longer dwell time allows more energy to impinge on the detector, which creates a stronger signal.

Along-track or Pushbroom scanning

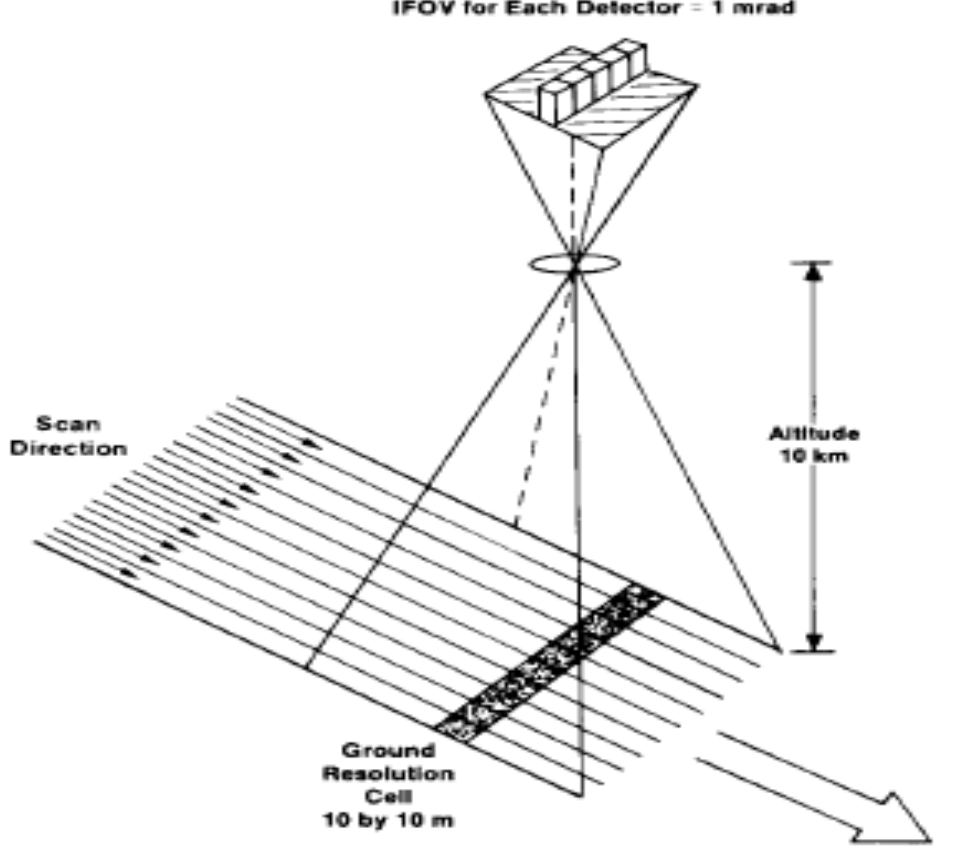
These sensors do not use opto-mechanical device and have no moving parts. The energy coming from ground directly falls on the array of charge-coupled devices {CCD), which calibrate the received energy and change it to digital counts.

This method allows sensing of energy for larger time and hence results in better signal.

- **GIFOV :- Ground projected instenteneous FOV**
- **GSI :- Ground projected sample interval**
- **FOV :- Field of view**
- **IFOV :- Instenteneous field of view**
- **GFOV :- Ground projected field of view**

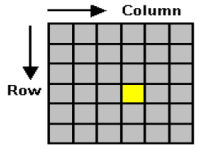


Pushbroom Concept



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

B. Along-track scanner.



Pushbroom

Sabin, 1997

Wiskbroom

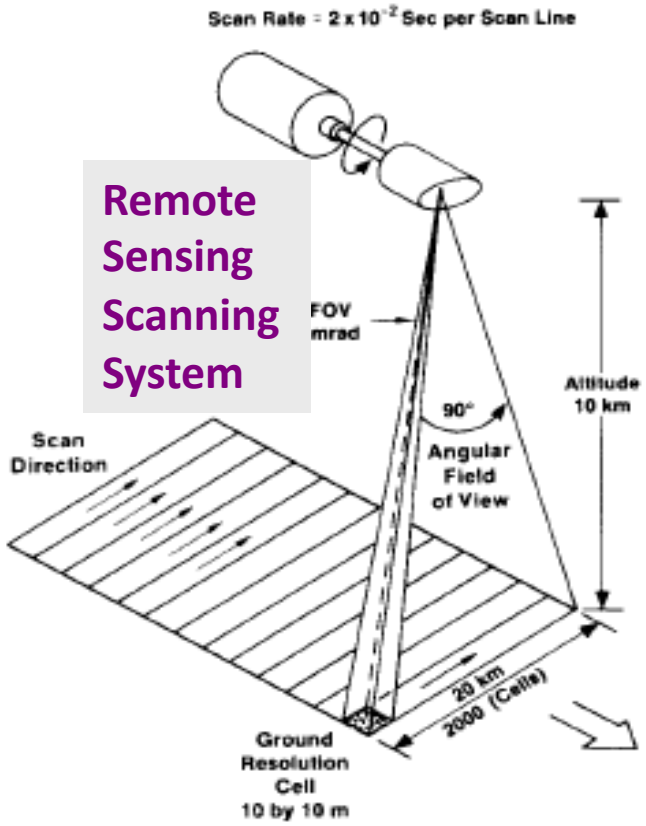
ALONG TRACK SCANNER

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.

Remote Sensing Scanning System

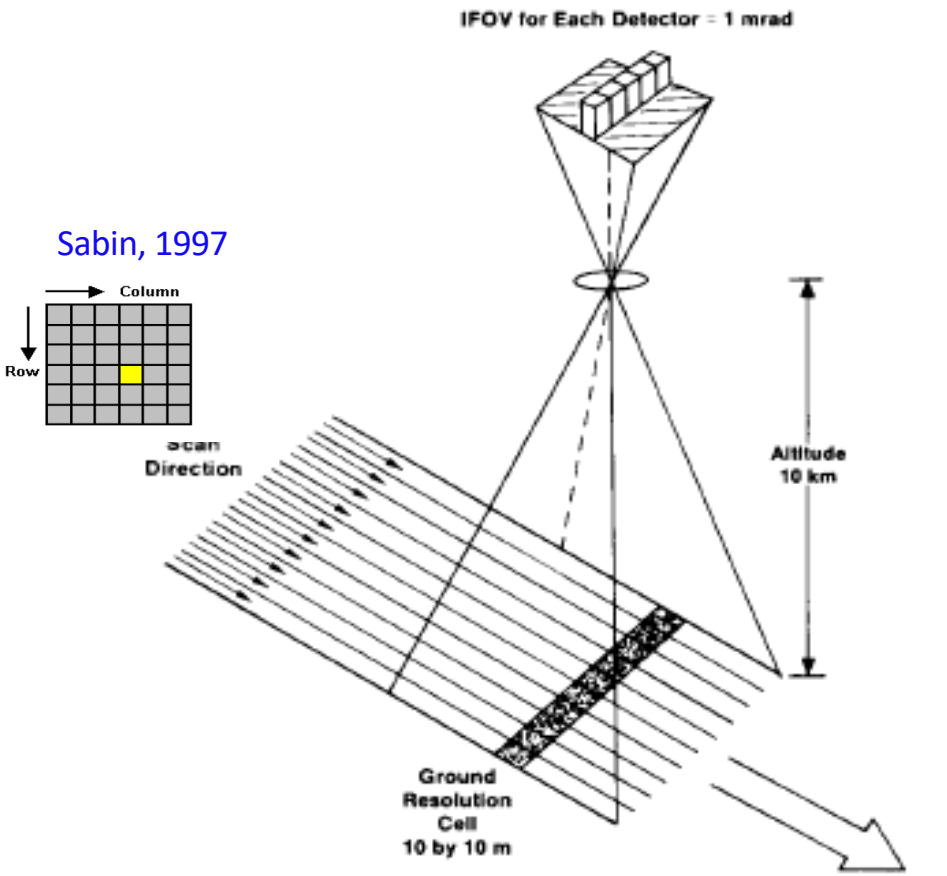
Sabin, 1997



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

A. Cross-track scanner.

Wiskbroom



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

B. Along-track scanner.

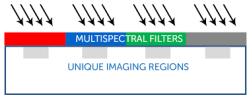
Pushbroom

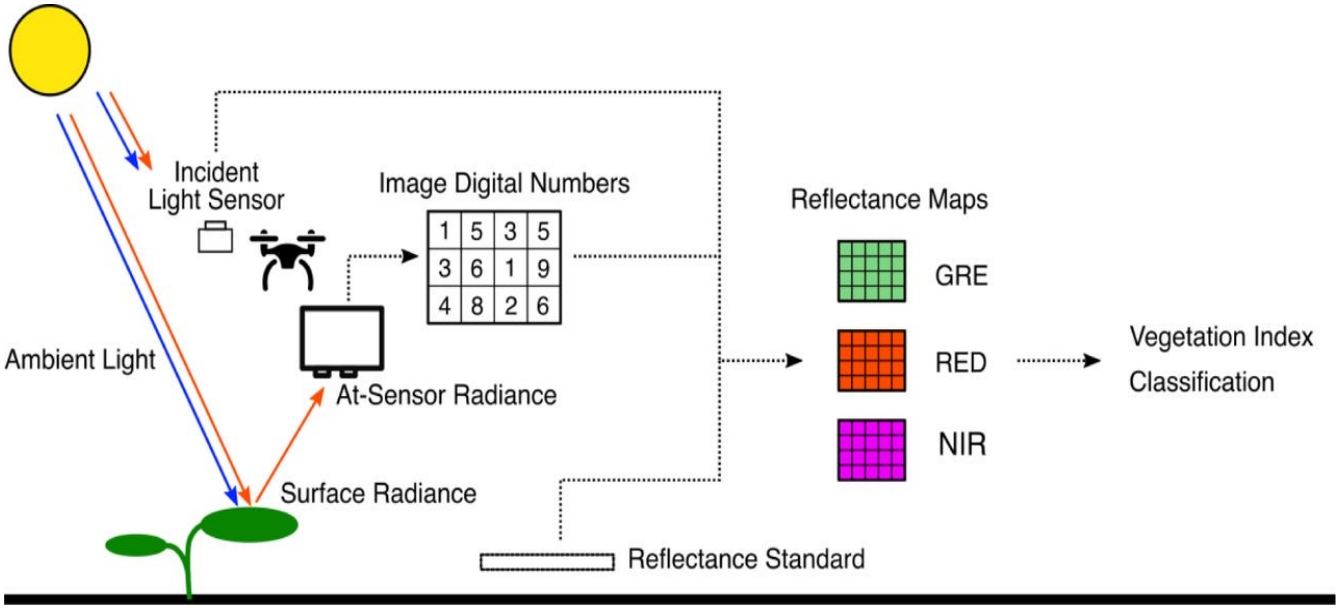
Field of View (FOV), Instantaneous Field of View (IFOV)

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.

A multispectral imager is one that captures image data within specific wavelength ranges across the electromagnetic spectrum.

... Multispectral imaging measures light in a small number (typically 3 to 15) of spectral bands.





Multispectral remote sensing is generally based on acquisition of image data of Earth's surface simultaneously in multiple wavelengths.

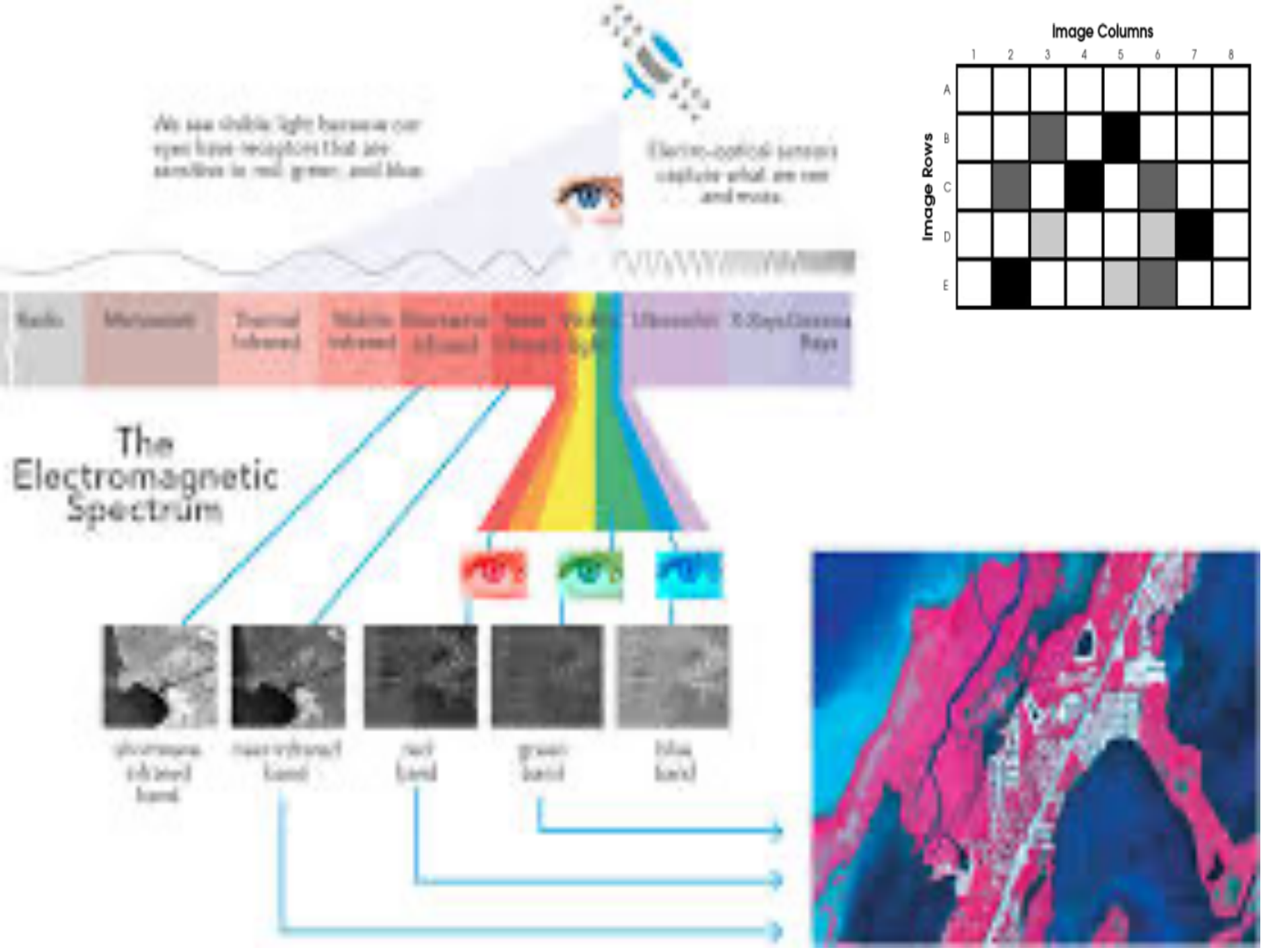
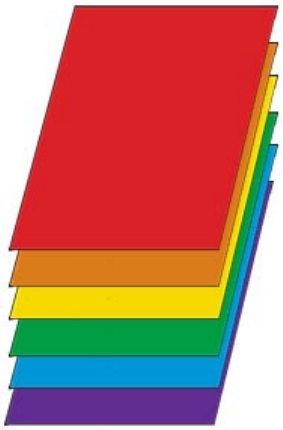
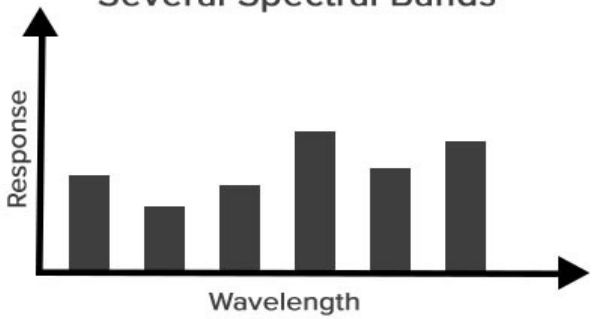


Image Columns
1 2 3 4 5 6 7 8
Image Rows
A
B
C
D
E
The Electromagnetic Spectrum

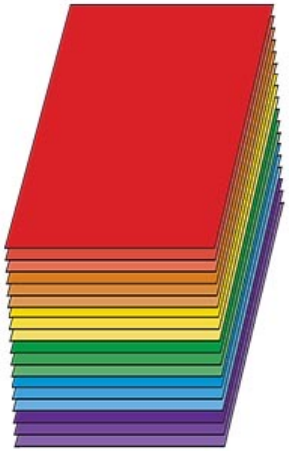
Multispectral Imaging (MSI)



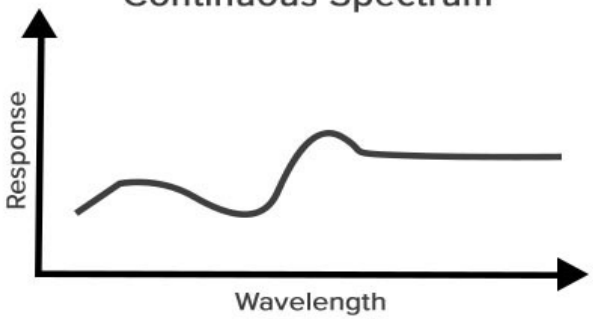
Several Spectral Bands



Hyperspectral Imaging (HSI)



Continuous Spectrum



QUESTION BANK

1. Explain working principle of multispectral imager
2. Difference between along whiskbroom and pushbroom multispectral resolution