REMOTE SENSING

Outline…

- Definition
- History
- Principles & Components
- Weather satellite imaging of the Earth
- The Electromagnetic Spectrum
- Types
- Remote Sensors
- Remote Sensing in India
- Remote sensing application

Definition…

- “remote - not in contact with the target”
- “The small or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device that is not in physical or intimate contact with the object.”
- "Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.".

Historic Overview

- **1859** - **Gaspard Tournachon** took an oblique photograph of a small village near Paris from a balloon. And the era of earth observation and remote sensing started…..

- During World War I , aero planes were used on a large scale for photoreconnaissance.

- Aircraft proved to be more reliable and more stable platforms for earth observation than balloons.

- Application fields of airborne photos included at that time geology, forestry, agriculture and cartography.

- Developments lead to much improved cameras, films and interpretation equipment.

- During World War II, the development of other imaging systems such as near-infrared photography; thermal sensing and radar took place.

- **1941** -The first successful airborne imaging radar proved valuable for nighttime bombing.

- Such system was called by the military '**plan position indicator**' and was developed in Great Britain

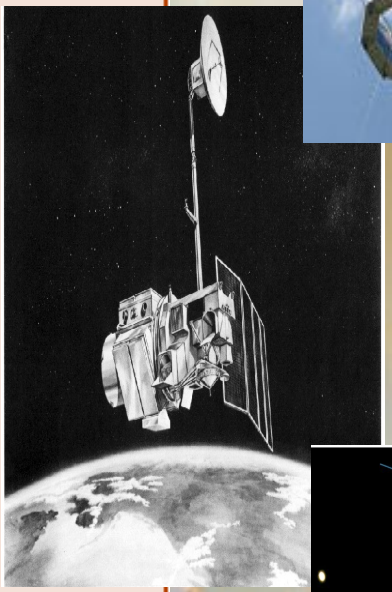
The Need For A Name…

- the term "**remote sensing**" was coined by **Evelyn L. Pruitt**, a geographer formerly with the Office of Naval Research, to replace the more limiting terms *"aerial"* and *"photograph".*

- The new term, promoted throughout a series of symposia at the Willow Run Laboratories of the University of Michigan, gained immediate and widespread acceptance.

Milestones in the History of Remote Sensin

1800	Discovery of Infrared by Sir W. Herschel
1839	Beginning of Practice of Photography
1847	Infrared Spectrum Shown by J.B.L. Foucault
1859	Photography from Balloons
1873	Theory of Electromagnetic Spectrum by J.C. Maxwell
1909	Photography from Airplanes
1916	World War I: Aerial Reconnaissance
1935	Development of Radar in Germany
1940	WW II: Applications of Non-Visible Part of EMS
1950	Military Research and Development
1959	First Space Photograph of the Earth (Explorer-6)
1960	First TIROS Meteorological Satellite Launched
1970	Skylab Remote Sensing Observations from Space
1972	Launch Landsat-1 (ERTS-1) : MSS Sensor
1972	Rapid Advances in Digital Image Processing
1982	Launch of Landsat -4 : New Generation of Landsat Sensors: TM
1986	French Commercial Earth Observation Satellite SPOT
1986	Development Hyperspectral Sensors
1990	Development High Resolution Space borne Systems
	First Commercial Developments in Remote Sensing
1998	Towards Cheap One-Goal Satellite Missions
1999	Launch EOS : NASA Earth Observing Mission
1999	Launch of IKONOS, very high spatial resolution sensor system



- a combination of various disciplines
  - optics
  - spectroscopy
  - photography
  - computer
  - electronics and telecommunication
  - satellite launching
- All these technologies are integrated to act as one complete system in itself, known as

Remote Sensing System

What is the principle???

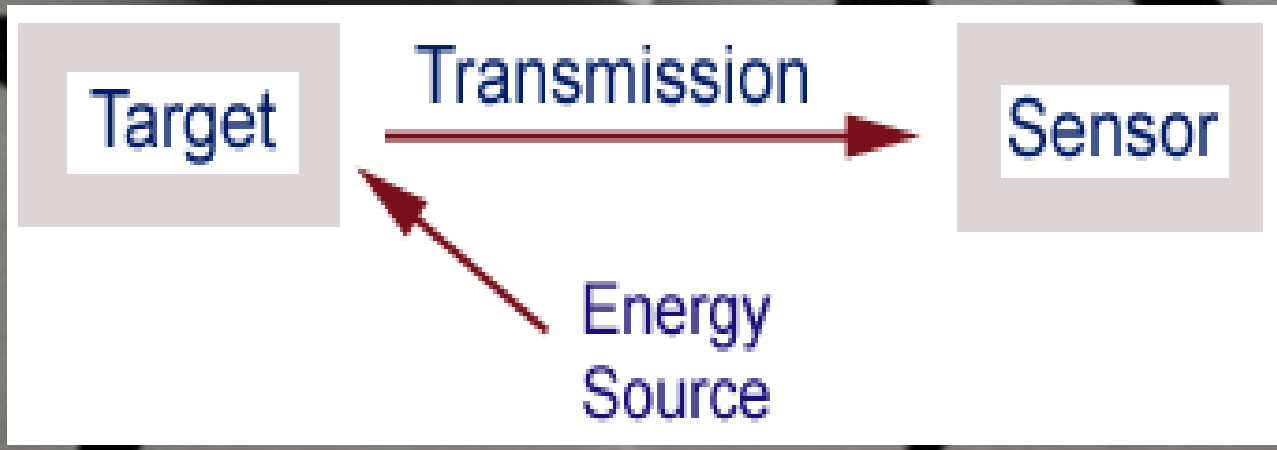
Components of a Remote Sensing System

Target

Energy source

Transmission path

Sensor



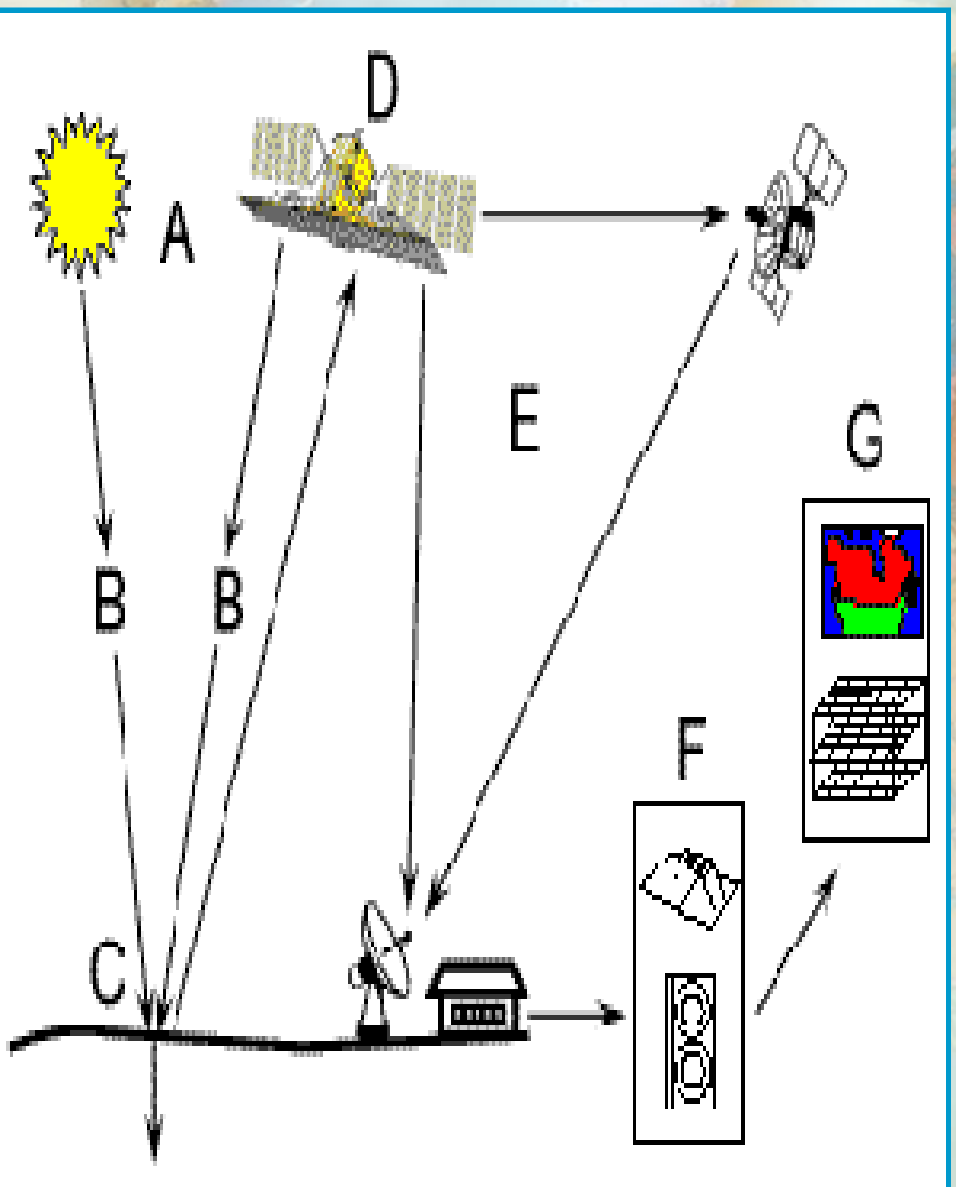
- Target– the object or material that is being studied. The components in the system work together to measure and record information about the target without actually coming into physical contact with it.

- Energy source - Illuminates or provides electromagnetic energy to the target. The energy interacts with the target, depending on the properties of the target and the radiation, and will act as a medium for transmitting information from the target to the sensor.

- Sensor - a remote device that will collect and record the electromagnetic radiation. Sensors can be used to measure energy that is given off (or emitted) by the target, reflected off of the target, or transmitted through the target.

- The resulting set of data is transmitted to a receiving station where the data are processed into a usable format, which is most often as an image. The image is then interpreted in order to extract information about the target.
- This interpretation can be done visually or electronically with the aid of computers and image processing software.

Process from Beginning to End…



(A) Energy Source or Illumination

(B) Radiation and the Atmosphere

(C) Interaction with the Target

(D) Recording of Energy by the Sensor

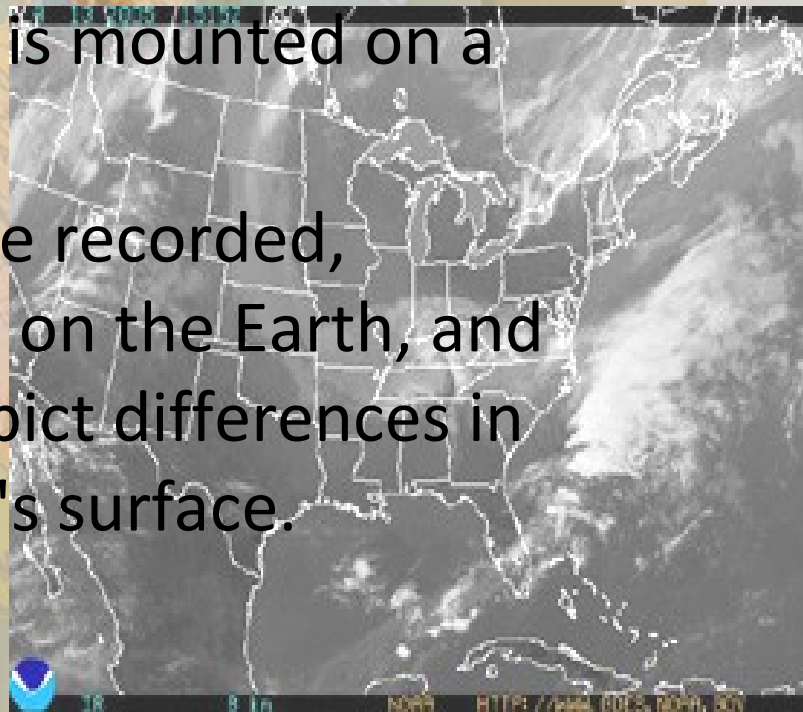
(E) Transmission, Reception, and Processing

(F) Interpretation and Analysis

(G) Application

Weather satellite imaging of the Earth

- Target- the Earth's surface
- gives off energy in the form of infrared radiation (or heat energy).
- energy travels through the atmosphere and space and reaches the sensor, which is mounted on a satellite platform.
- Varying levels of this energy are recorded, transmitted to ground stations on the Earth, and converted into images that depict differences in temperature across the planet's surface.



familiar forms of remote sensing

- medical imaging technologies
  - Magnetic Resonance Imaging (MRI)
  - sonograms
  - X-Ray imaging.

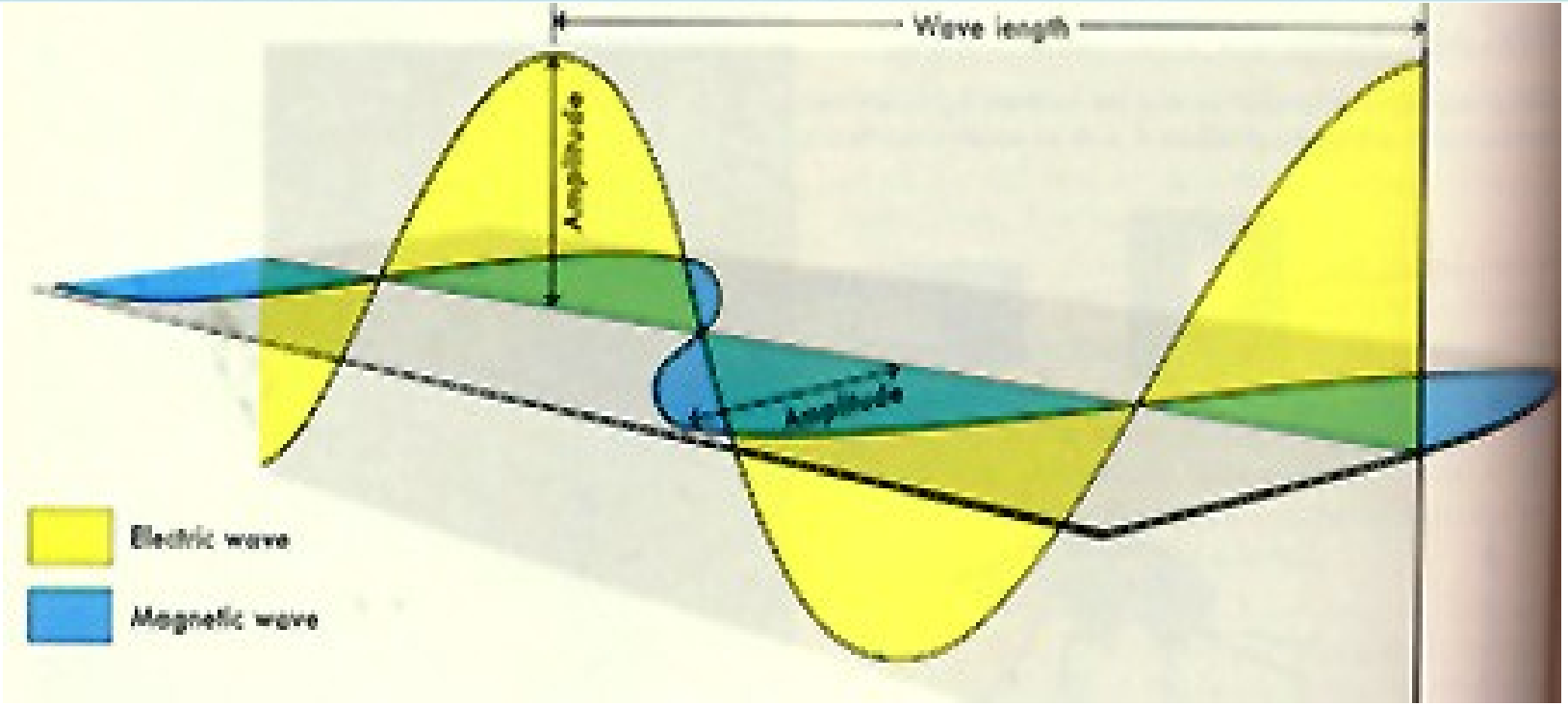
- technologies use forms of energy to produce images of the inside of the human body.

- Remote sensing is not limited to investigations within our own planet.
- Most forms of astronomy are examples of remote sensing, since the targets under investigation are such vast distances from Earth
- Astronomers collect and analyze the energy given off by these objects in space by using telescopes and other sensing devices.
- This information is recorded and used to draw conclusions about space and our universe

Other Examples :-

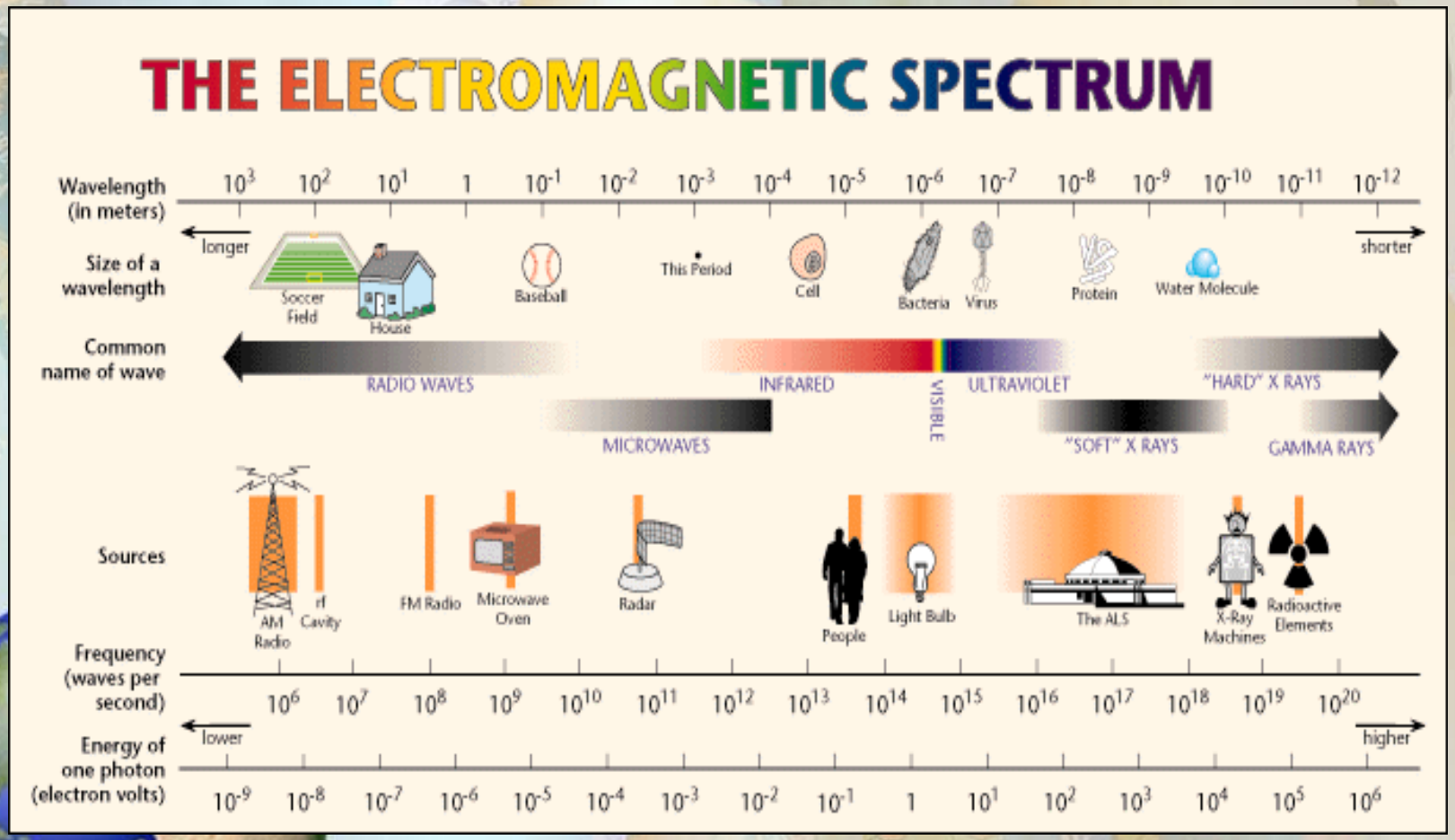
- ocean and atmospheric observing
- Magnetic resonance Imaging (MRI)
- Positron Emission Tomography (PET)
- Space probes

(A) Energy Source or illumination

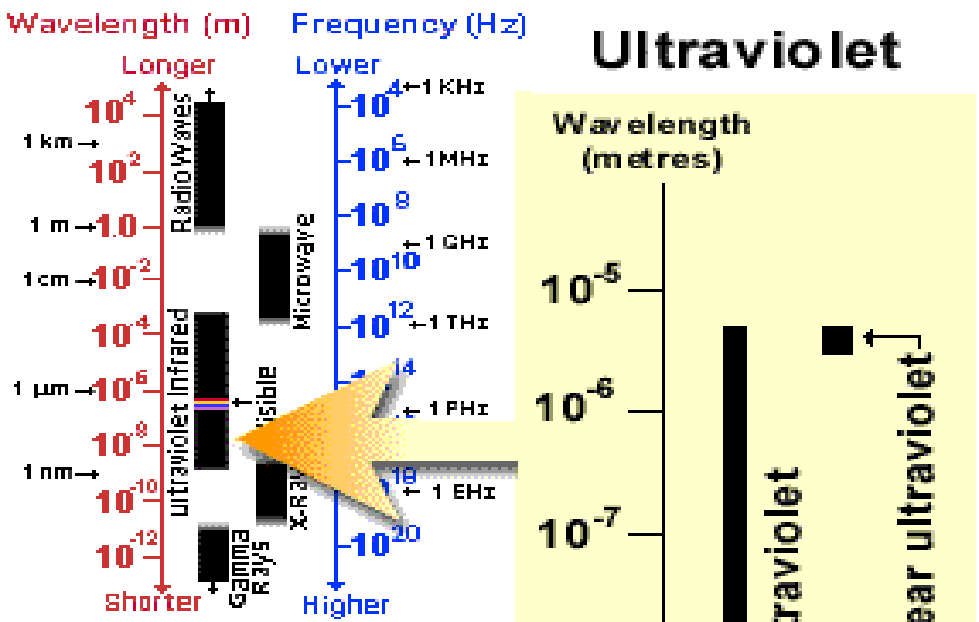


- **Electromagnetic radiation** consists of an electrical field (E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field.
- characteristics of electromagnetic radiation in terms of their wavelength and frequency are imp to understanding the information to be extracted from remote sensing data.

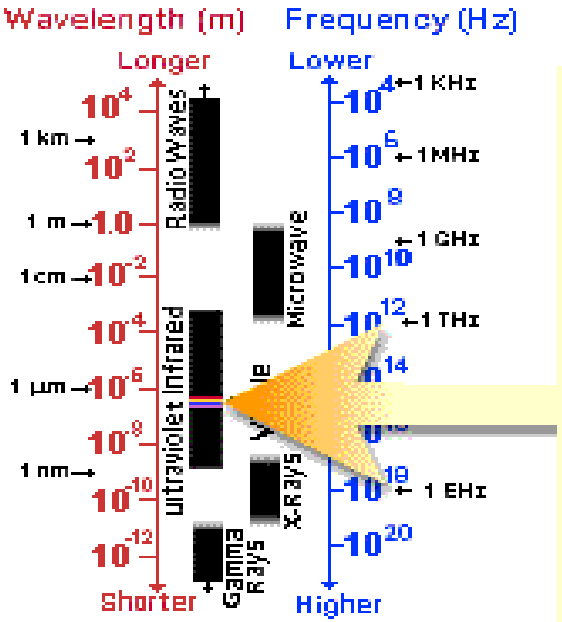
The Electromagnetic Spectrum



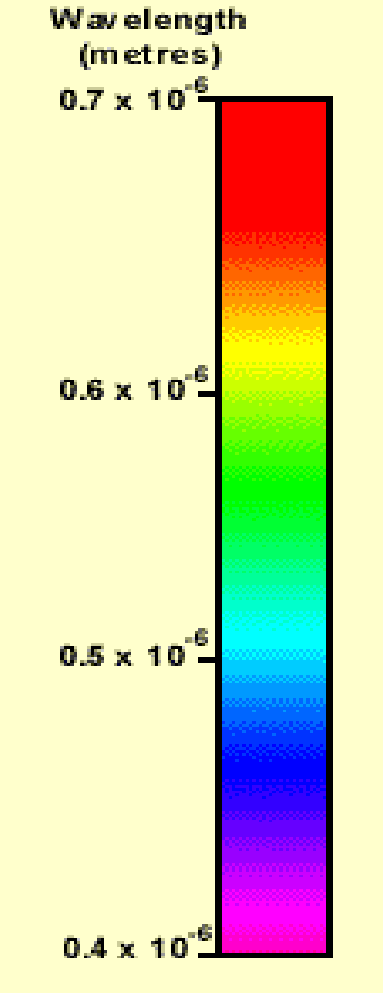
$c = v\lambda$ **$c = 3 \times 10^{8}$ m/sec**

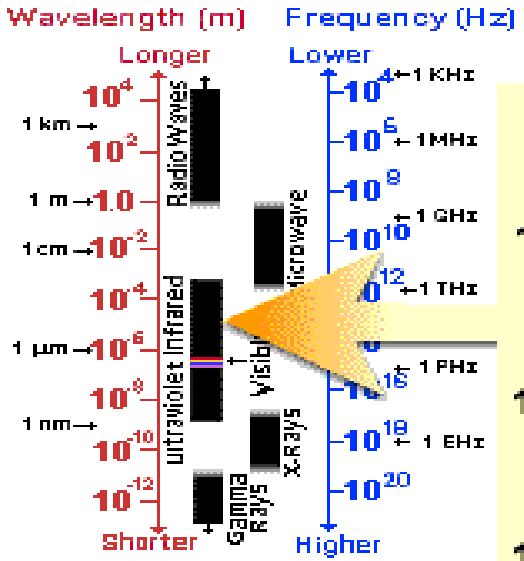


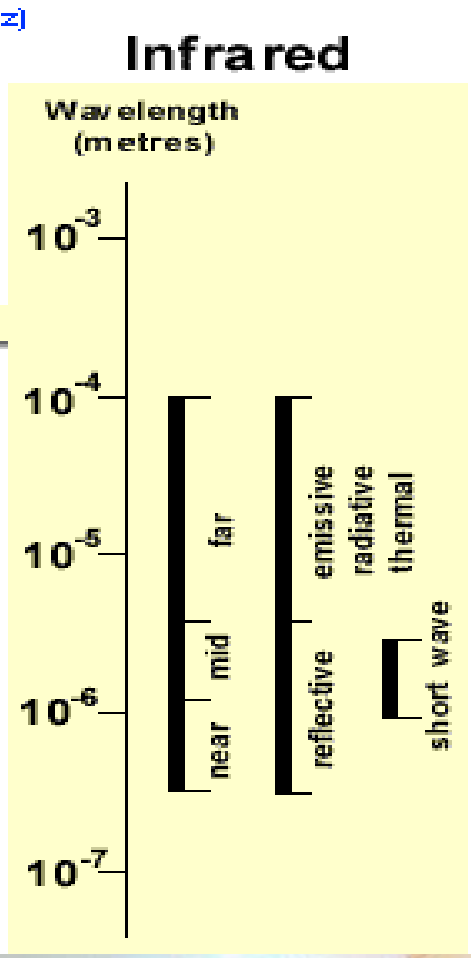
Ultraviolet

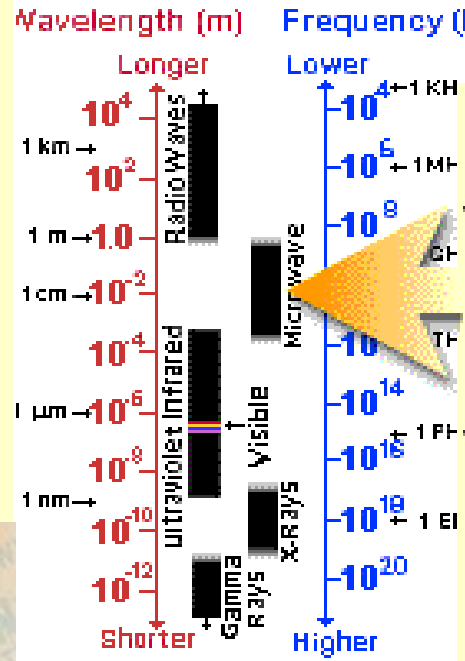


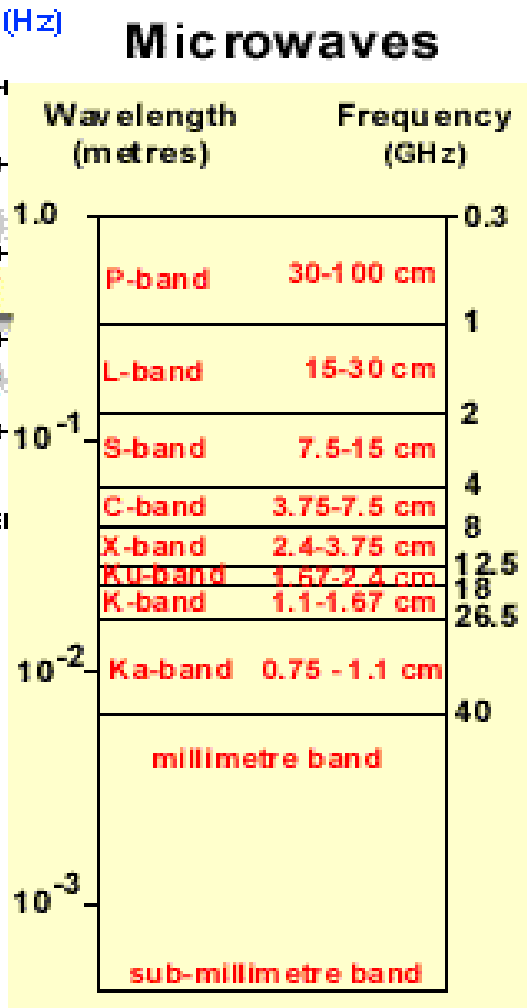
Visible




Wavelength (m)
Frequency (Hz)
Longer
Lower
Shorter
Higher
Radio Waves
Microwave
Infrared
Visible
ultraviolet
X-Rays
Gamma Rays
1 km
1 m
1cm
1 µm
1 nm
1 KHz
1 MHz
1 GHz
1 THz
1 PHz
1 EHz


Infrared
Wavelength
(metres)
far
mid
near
emissive
radiative
thermal
reflective
short wave


Wavelength (m)
Frequency (Hz)
Longer
Lower
Shorter
Higher
Radio Waves
Microwave
Infrared
Visible
ultraviolet
X-Rays
Gamma Rays
1 km
1 m
1cm
1 µm
1 nm

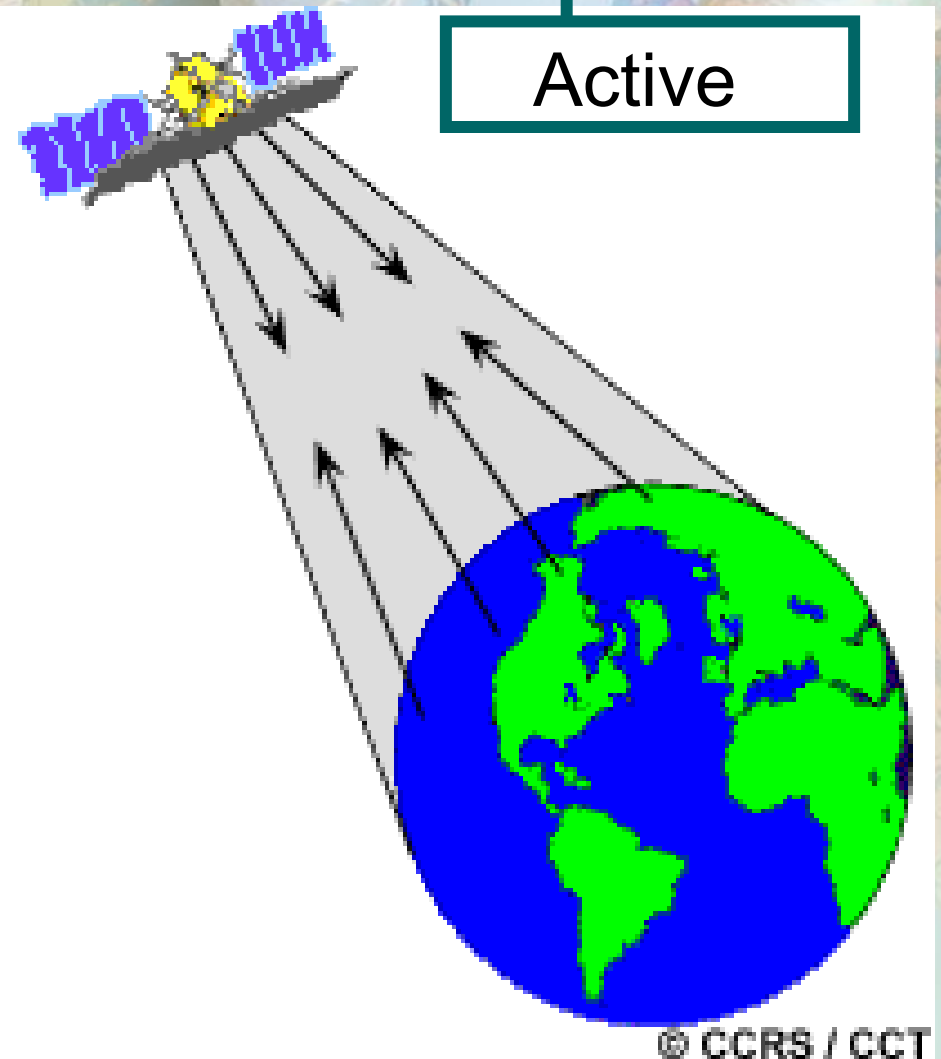

Microwaves
Wavelength
(metres)
Frequency
(GHz)
1.0
0.3
P-band
30-100 cm
1
L-band
15-30 cm
2
S-band
7.5-15 cm
4
C-band
3.75-7.5 cm
8
X-band
2.4-3.75 cm
12.5
Ku-band
1.67-2.4 cm
18
K-band
1.1-1.67 cm
26.5
Ka-band
0.75 - 1.1 cm
40
millimetre band
sub-millimetre band

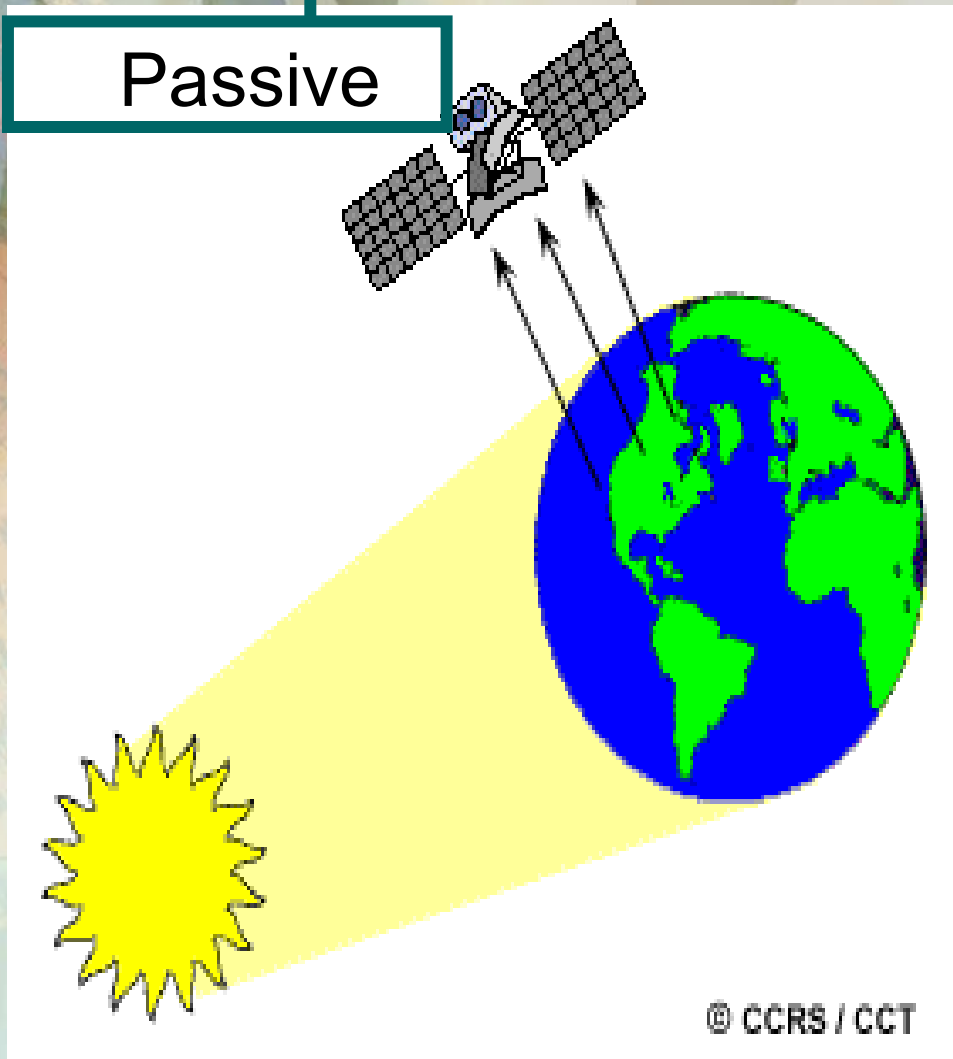
Types of Remote Sensing

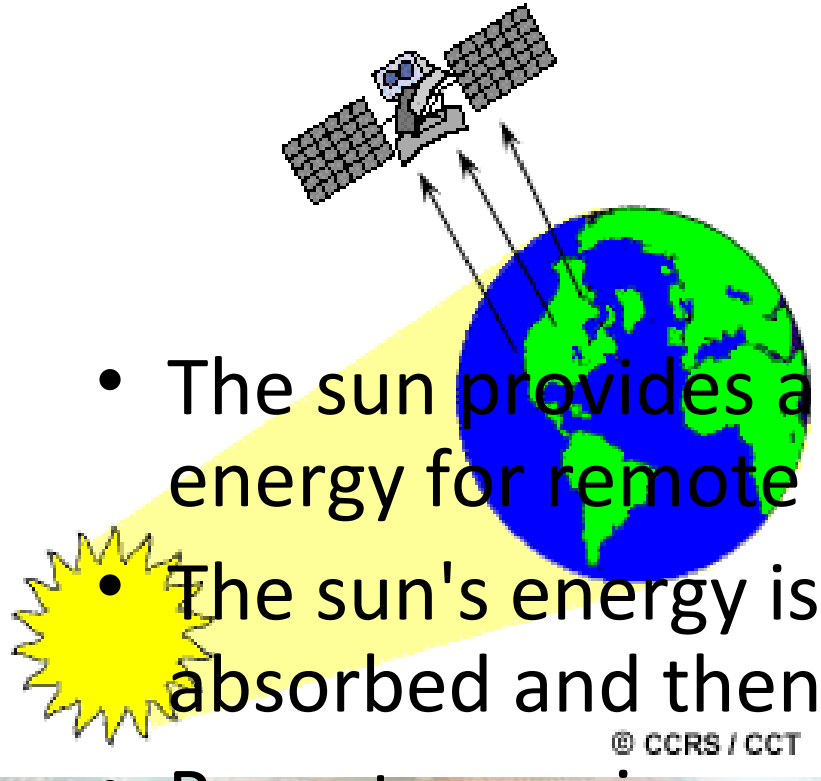
Based on Source of energy

Active

Passive





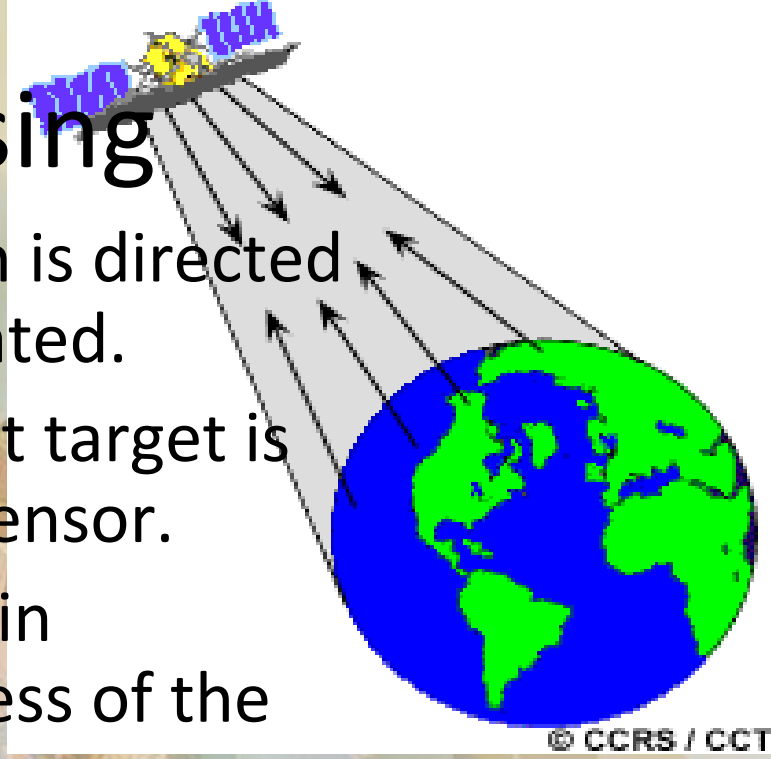


Passive Sensing

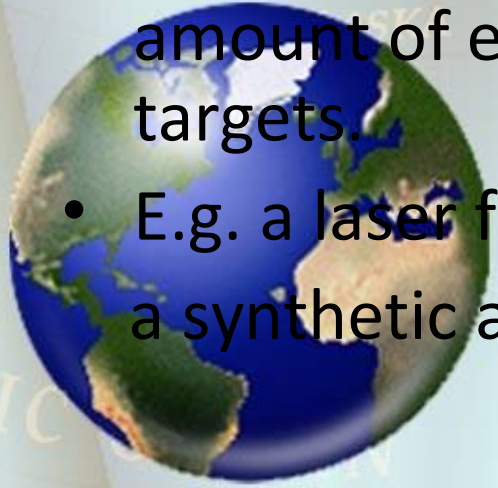
- The sun provides a very convenient source of energy for remote sensing.
- The sun's energy is either reflected, or absorbed and then reemitted.
- Remote sensing systems which measure energy that is naturally available are called **passive sensors**.
- Passive sensors can only be used to detect energy when the naturally occurring energy is available.

- Passive sensors can only be used to detect energy when the naturally occurring energy is available.
- For all reflected energy, this can only take place during the time when the sun is illuminating the Earth.
- 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.

Active Sensing



- 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 :- the ability to obtain measurements anytime, regardless of the time of day or season.
- require the generation of a fairly large amount of energy to adequately illuminate targets.
- E.g. a laser fluorosensor and a synthetic aperture radar (SAR)



Types of Remote Sensing

- Based on Range of Electromagnetic Spectrum
  - Optical Remote Sensing
  - Thermal Remote Sensing
  - Microwave Remote Sensing

Optical Remote Sensing

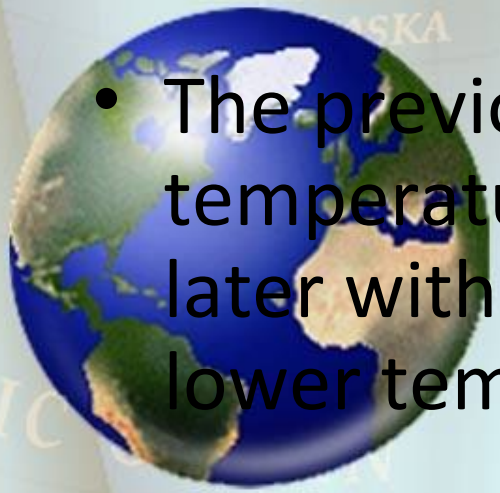
- wavelength range: **300 nm to 3000 nm.**
- The optical remote sensing devices operate in the visible, near infrared, middle infrared and short wave infrared portion of the electromagnetic spectrum.

- Most of the remote sensors record the EMR in this range

Thermal Remote Sensing

- the wavelength range :
  3000 nm to 5000 nm
  8000 nm to 14000 nm

- Record the energy emitted from the earth

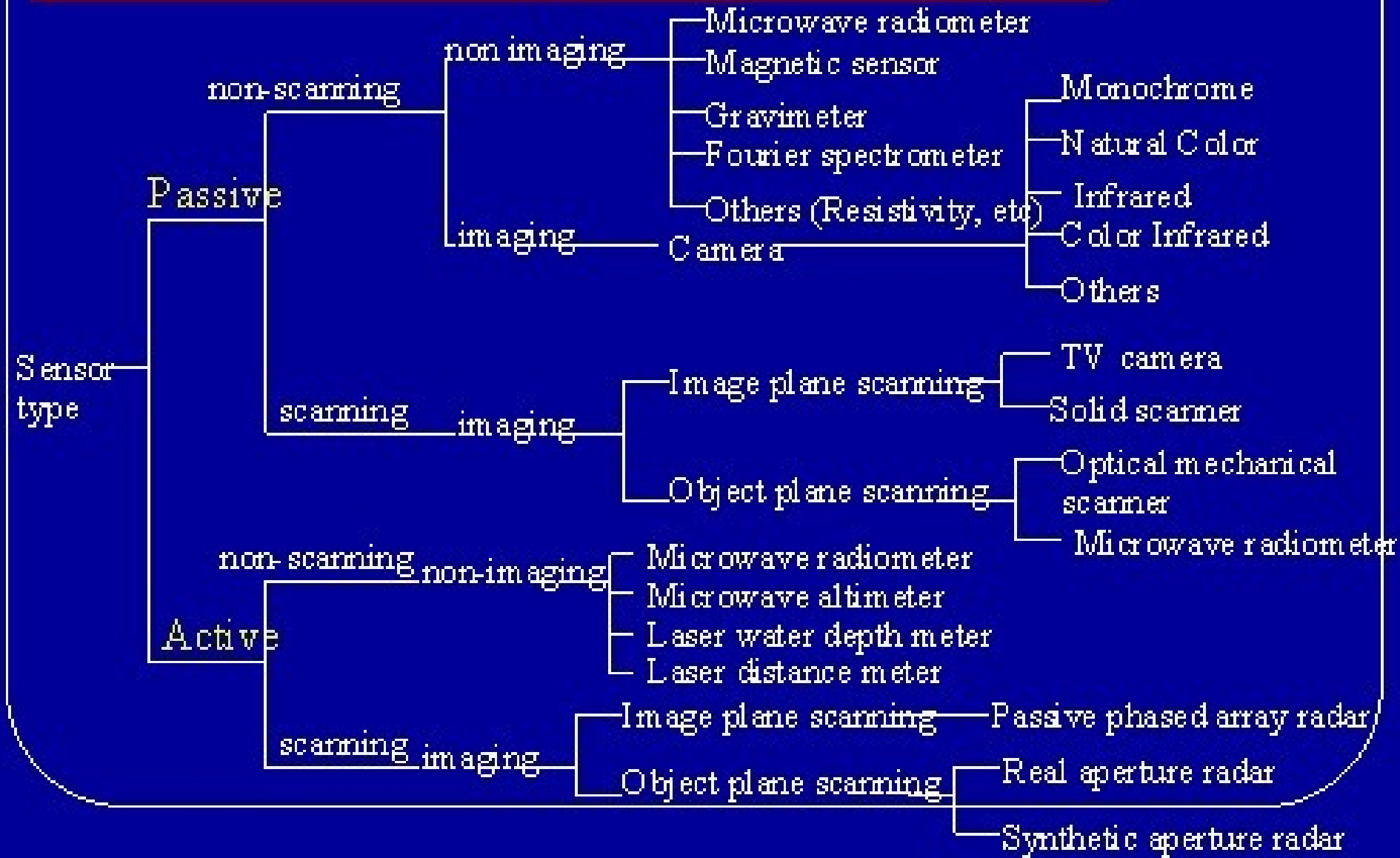


- The previous range is related to high temperature phenomenon like forest fire, and later with the general earth features having lower temperatures.

Microwave Remote Sensing

- wavelength range : 1 mm to 1 m
- Most of the microwave sensors are active sensors, having there own sources of energy, e. g, RADARSAT.
- **Longer wavelength microwave radiation can penetrate through cloud cover, haze, dust**
- as the longer wavelengths are not susceptible to atmospheric scattering which affects shorter optical wavelengths.
- This property allows detection of microwave energy under almost all weather and environmental conditions so that data can be collected at any time.

There are many remote sensors



Remote Sensing in India

National Remote Sensing Centre

Indian Space Research Organisation

Dept. Of Space ,Govt. Of India

- NRSC is one of the centres of Indian Space Research Organization under the Department of Space, Govt. of India, engaged in operational remote sensing activities.

- NRSC has its own ground station at Shadnagar, 60 Km south of Hyderabad to acquire remote sensing satellite data from the Indian Remote Sensing satellites, the latest being Cartosat-1 (IRS-P5), and other foreign satellites like LandSat, NOAA, ERS, TERRA and AQUA..

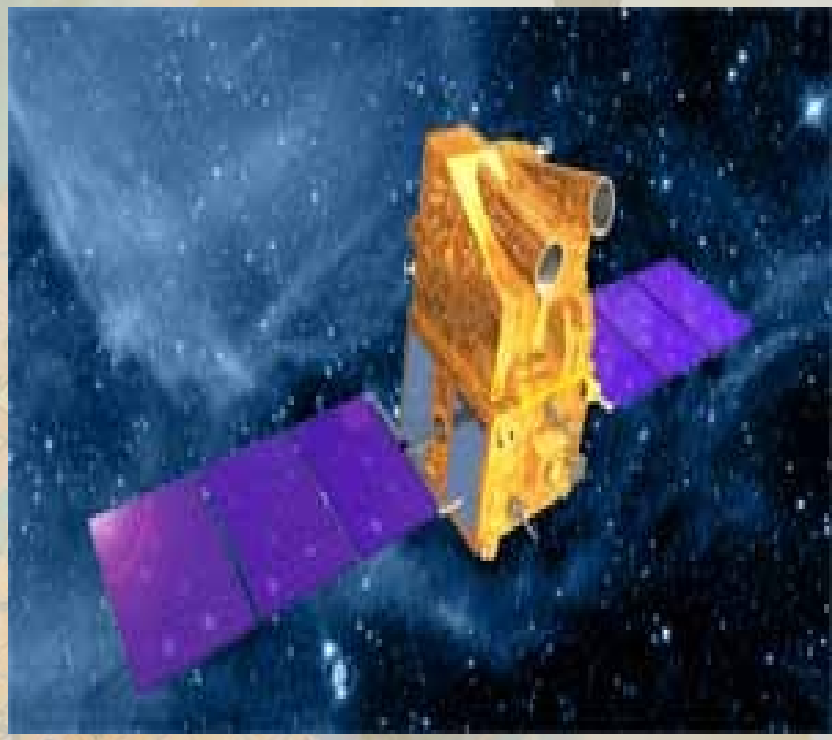
- IIRS under NRSC, Department of Space, Govt. of India is a premier training and educational institute set up for developing trained professional in the field of Remote Sensing, Geoinformatics and GPS Technology for Natural Resources and Disaster Management.

Indian remote sensing satellites

IRS-1A	17.03.1988	First operational remote sensing satellite. Launched by a Russian Vostok.
IRS-1B	29.08.1991	Same as IRS-1A. Launched by a Russian Launch vehicle, Vostok. Still in service.
IRS-1E	20.09.1993	Carried remote sensing payloads. Could not be placed in orbit.
IRS-P2	15.10.1994	Carried remote sensing payload. Launched by second developmental flight of PSLV.
IRS-1C	28.12.1995	Carries advanced remote sensing cameras. Launched by Russian Molniya launch vehicle. Still in service.
IRS-P3	21.03.1996	Carries remote sensing payload and an X-ray astronomy payload. Launched by third developmental flight of PSLV. Still in service.
IRS-1D	29.09.1997	Same as IRS-1C. Launched by India's PSLV service. In service.
IRS-P4 Oceansat	26.05.1999	Carries an Ocean Colour Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR), Launched by India's PSLV-C2,
Technology Experiment Satellite (TES)	22.10.2001	Technology Experiment Satellite Launched by PSLV-C3 .
IRS-P6 Resourcesat-1	17.10.2003	Launched by PSLV - C5, carries three camera, names, LISS-4, LISS-3 and AwiFS
CARTOSAT -1	05.05.2005	Launched by PSLV-C6, carries two panchromatic cameras - PAN (fore) and PAN (aft) - with 2.5 meter resolution. The cam mounted with a tilt of +26 deg and -5 deg along the track to provide stereo images.
CARTOSAT - 2	10.01.2007	Launched by PSLV-C7, it is an advanced remote sensing satellite carrying a panchromatic camera capable of providing scene specific spot imageries.
SRE - 1	10.01.2007	Launched by PSLV-C7, Space capsule Recovery Experiment (SRE-1), intended to demonstrate the technology of an orbiting platform for performing experiments in microgravity conditions. SRE-1 was recovered successfully after 12 days over Bay of Bengal.
CARTOSAT-2A	28.04.2008	Identical to CARTOSAT - 2, launched by PSLV-C9
IMS-1	28.04.2008	Launched by PSLV-C9 along with CARTOSAT-2A and other Eight Nanosatellites

CARTOSAT-1

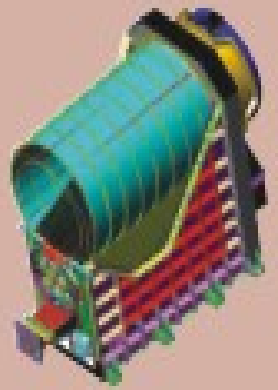
- PSLV-C9 successfully launches CARTOSAT-2A, IMS-1 and 8 foreign nano satellites from Sriharikota (April 28, 2008)
- cartographic applications
- eleventh satellite to be built in the Indian Remote Sensing (IRS) satellite series.



•launched into a 618 km high polar Sun Synchronous Orbit (SSO) by PSLV-C6.

CARTOSAT-1 Specifications

Orbit	:	618 km high, circular Polar Sun Synchronous
Orbit inclination	:	98.87 deg
Orbit period	:	97 min
Number of orbits per day	:	14
Local time of equator crossing	:	10.30 AM
Repetivity	:	126 days
Revisit	:	5 days
Lift-off mass	:	1560 kg
Attitude and orbit control	:	3-axis body stabilised using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Electrical power	:	15 sq m Solar Array generating 1100 W, Two 24 Ah Ni-Cd batteries
Mission life	:	5 years
Payloads	:	Two PAN Cameras (PAN fore mounted with a tilt of +26 deg and PAN aft mounted with a tilt of – 5 deg from the yaw axis to generate stereoscopic imagery)
Instantaneous Geometric Field of View (IGFOV)	:	< 2.5 m
Swath	:	30 km
Spectral Band	:	0.50-0.85 Micron
Data rate	:	105 Mbps for each camera
Solid State Recorder	:	120 GB capacity for image data storage



CARTOSAT-1 PAN camera

Remote sensing application

- a software application that processes remote sensing data
- enable generating geographic information from satellite and airborne sensor data
- read specialized file formats that contain sensor image data, georeferencing information, and sensor metadata.
- Some of the more popular remote sensing file formats include: GeoTIFF, NITF, HDF, and NetCDF.

Examples

- Chips
- ERDAS IMAGINE
- ENVI
- Google Earth
- Eonfusion
- GRASS GIS
- OpenEV
- Opticks
- RemoteView
- SeaDAS - NASA's free application for Ocean Color imagery, including SeaWiFS and MODIS imagery
- SOCET GXP
- NEST ESA's SAR Toolbox

Google Earth view of Goa University

References…

- www.nrsa.gov.in
- www.iirs-nrsa.gov.in

Thank You…