FUNDAMENTALS OF

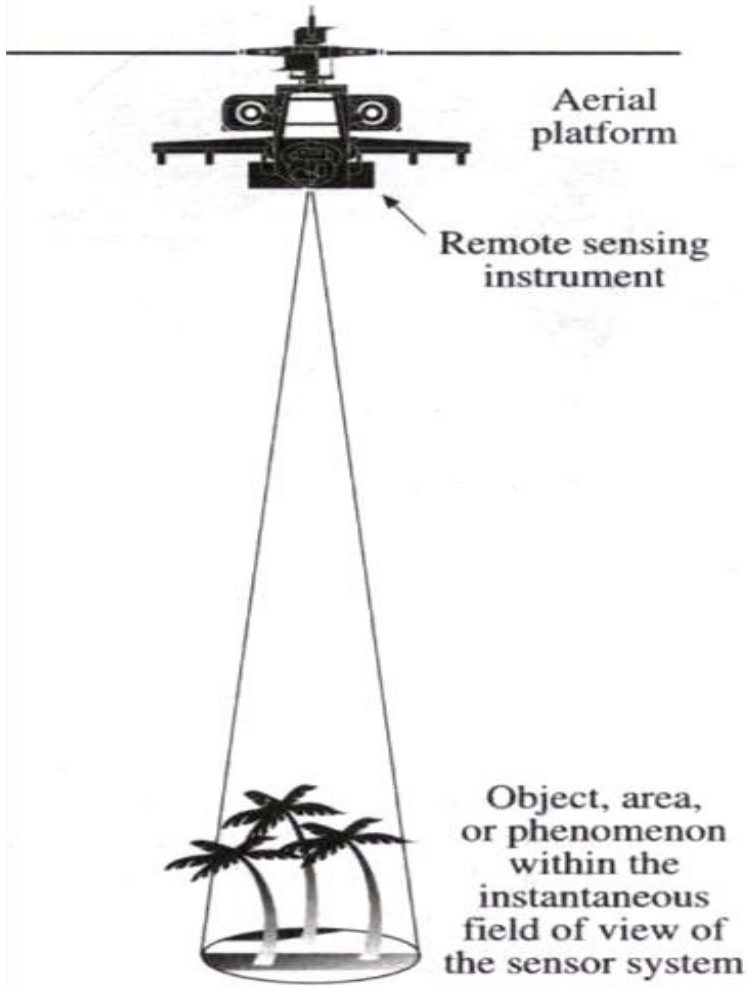
REMOTE SENSING

- Remote Sensing is the non physical contact recording of information from the
  - ultraviolet,
  - visible,
  - infrared and
  - microwave regions

  of the electromagnetic spectrum by means of instruments such as cameras, scanners, lasers etc., located on platforms such as aircraft or spacecraft, and the analysis of acquired information by means of visual and digital image processing.

R S data collection

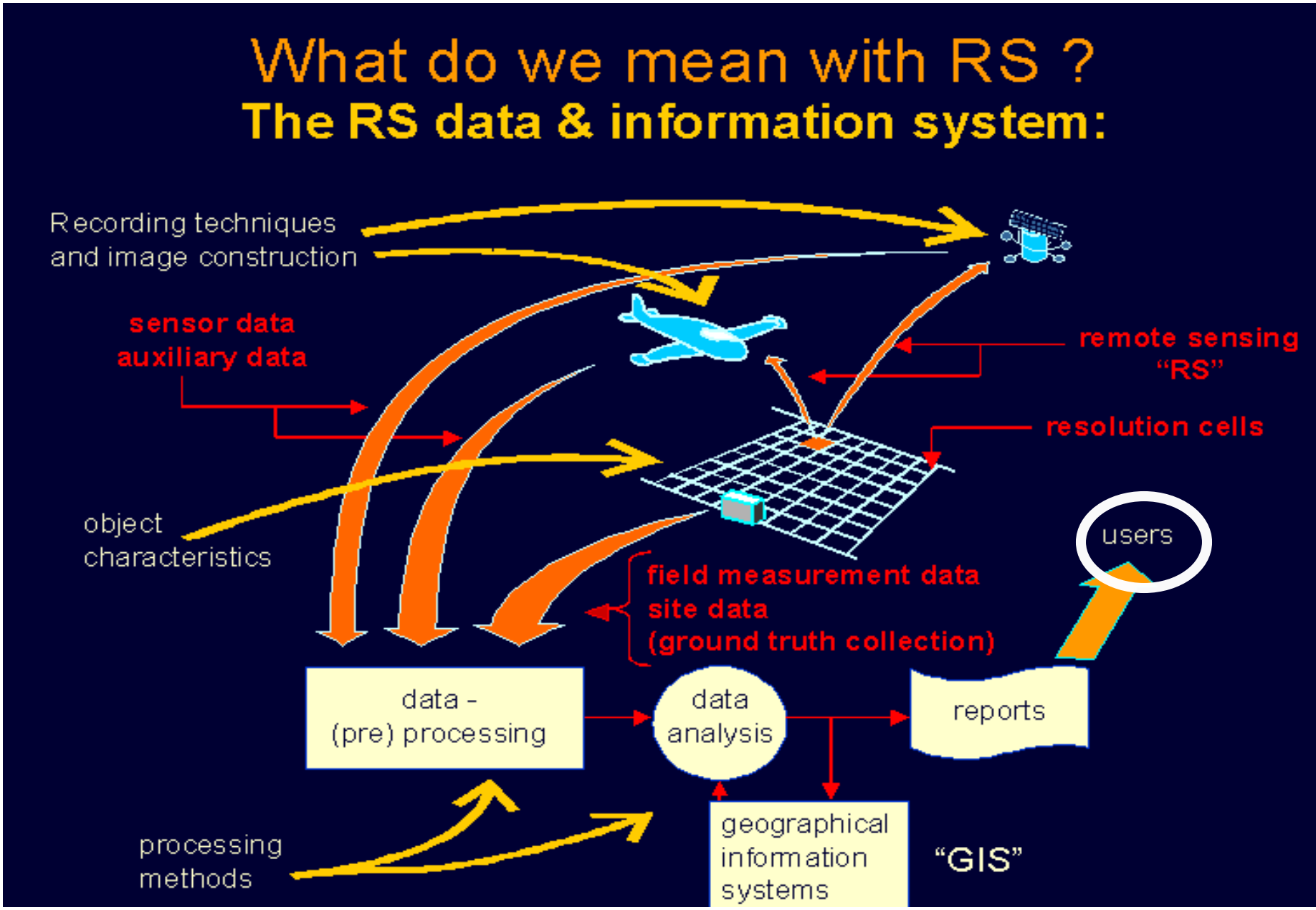
- Stage I : Collected information about an object or geographic space from a distant point using specialized instruments/sensors.
  - ❖ Remote data collection done using Aerial Cameras-development of field of Photogrammetry (very useful since World War II)
  - ❖ Def. acc to the manual of Photogrammetry: it is an art and science of obtaining reliable measurement by means of photography (American Society of Photogrammetry)
  - ❖ Thus, photographic **interpretation** is defined as “the act of examining photographic images for the purpose of identifying objects and judging their significance” (Coldwell, 1960)



A remote sensing instrument collects information about an object or phenomenon within the instantaneous field of view of the sensor system without being in direct physical contact.

What do we mean with RS ?

The RS data & information system:



Remote Sensing Mediums

- **Black and White or "Panchromatic"**
  - **Sensitive to visible light**

- **True Color**
  - Similar to color film

- **Infrared**
  - Sensitive to infrared frequencies that can't be seen by humans
  - Developed by military for identifying tanks painted with camouflage
  - Good for evaluating conditions of vegetation
  - Good for evaluating moisture in soil

- **False-color adjusted**
  - When frequencies of received data are shifted to allow or enhanced human viewing

- **Multi spectral**
  - When more than a single "band" of energy is captured
  - Color is multi-spectral (3 bands)
  - Some satellites can have 7 or even more "bands" of

What are the spatial units for which data are collected?

Pixel or Picture Element

Smallest unit of data collection
Features smaller than the pixel size can't be distinguished

Pixel Sizes

Landsat MSS	= 79 meters
Landsat TM	= 30 meters
SPOT	= 10 meters
IKONOS	= 1 meter
GeoEye-1	= 0.41 meters

R S- art/ science

- SCIENCE- Concerned with facts held together by principles- tested by scientific method
  - Mathematics and logic
  - Physical sciences
  - Biological sciences
  - Social sciences
  - RS is a tool/ technique similar to mathematics: simple math to measure to more complex mathematics to explain- sophisticated sensors to measure the EME exiting an object from a distance and then extracting valuable information from the data using mathematically and statistically based algorithms is a scientific activity.
- ART- The process of visual photo or image interpretation done with an understanding of lifetime processes which cannot be quantitatively measured

THUS IT FUNCTIONS IN HARMONY WITH OTHER SPATIAL DATA COLLECTION TECHNIQUES/TOOLS OF THE MAPPING SC., THAT IS CARTOGRAPHY AND GIS.

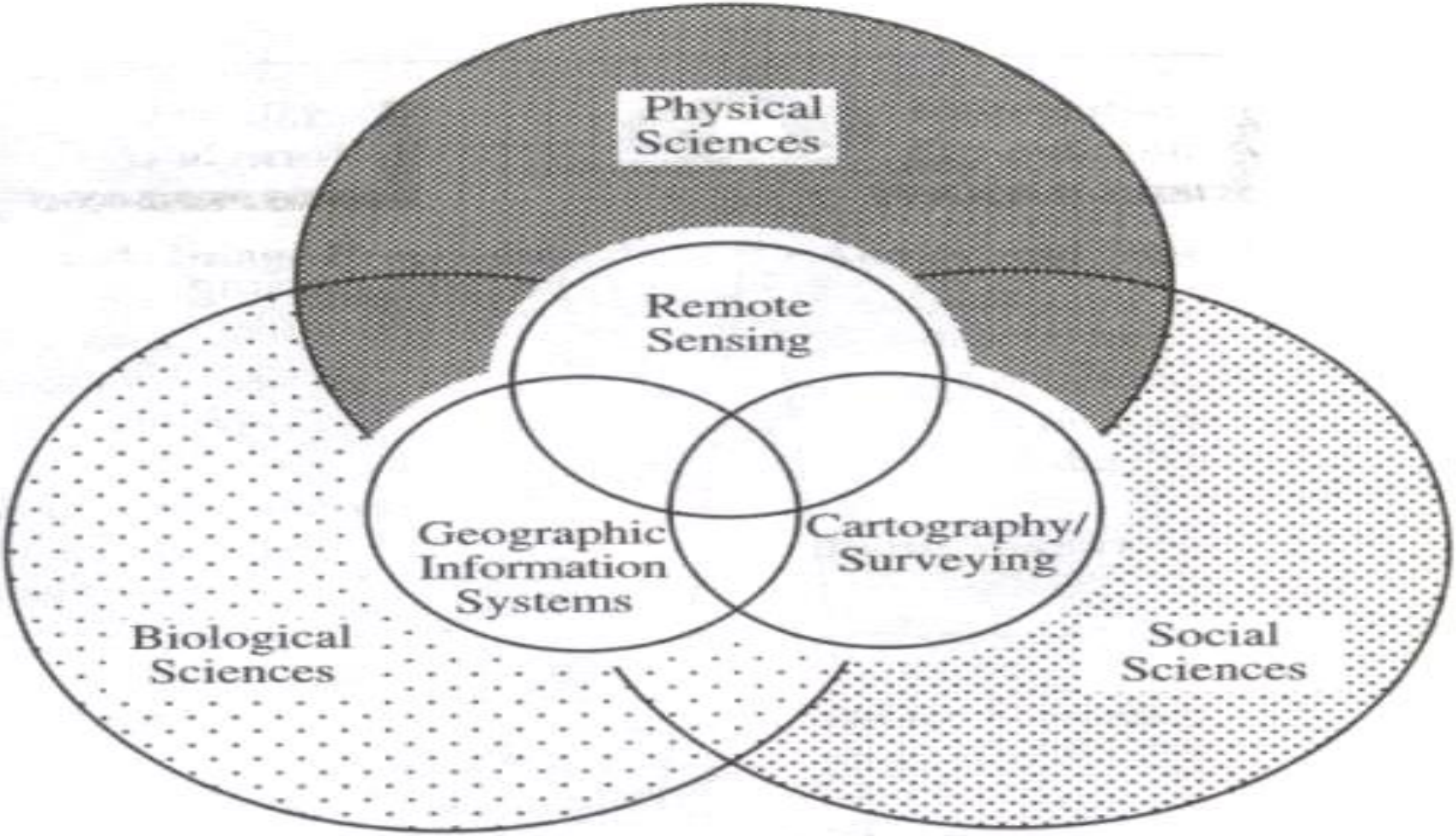


Figure 1-3 A three-way model of interaction between the mapping sciences of remote sensing, geographic information systems, and cartography/surveying as they are used in the physical, biological, and social sciences (after Dahlberg and Jensen, 1986; Fisher and Lindenberg, 1989).

- **RS covers**:

✓ Operational use of remotely sensed data

✓ Quantification is possible

✓ Provides a basis for scientific research and provide for practical solutions.

- **Advantages**

✓ Systematic data collection without obstruction

✓ covers large geographic area

✓ Useful non visible information can also be derived

- **Precautions**

✓ Technical knowledge and expertise in handling data.

✓ Deduction process should be logical.

✓ Atmospheric disturbances separated from actual ground condition.

PRINCIPLES AND CONCEPTS

- **STAGES IN R S**

❖ Source: Emission of electromagnetic radiation/ EMR (sun/self)

❖ Transmission of energy from the source to the surface of the earth. Also absorption and scattering

❖ Interaction of EMR with the earth's surface: reflection and emission

❖ Transmission of energy from surface to the remote sensor (platforms as carrier)

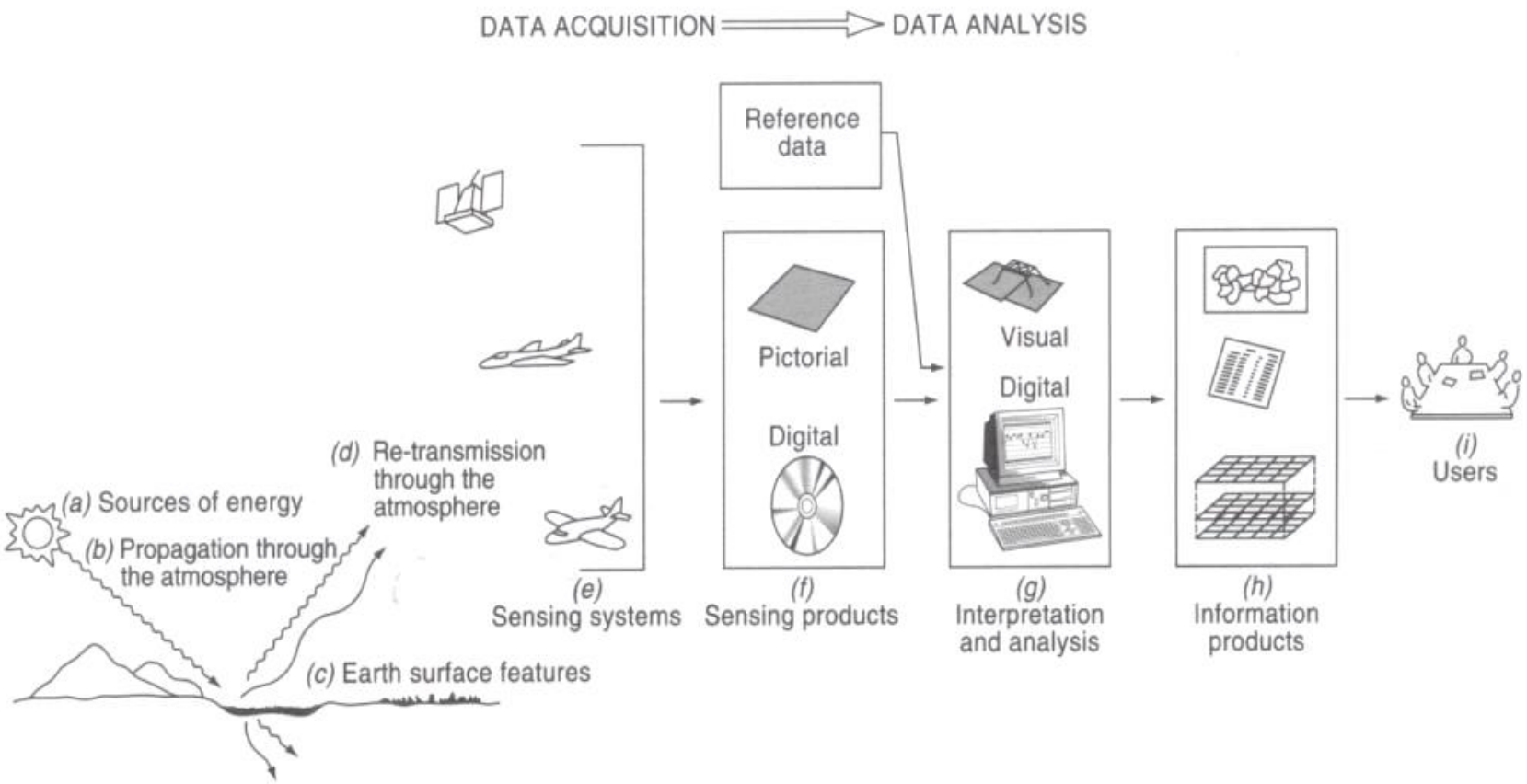
❖ Sensor data output (based on characteristics of the surface objects)- pictorial/digital format

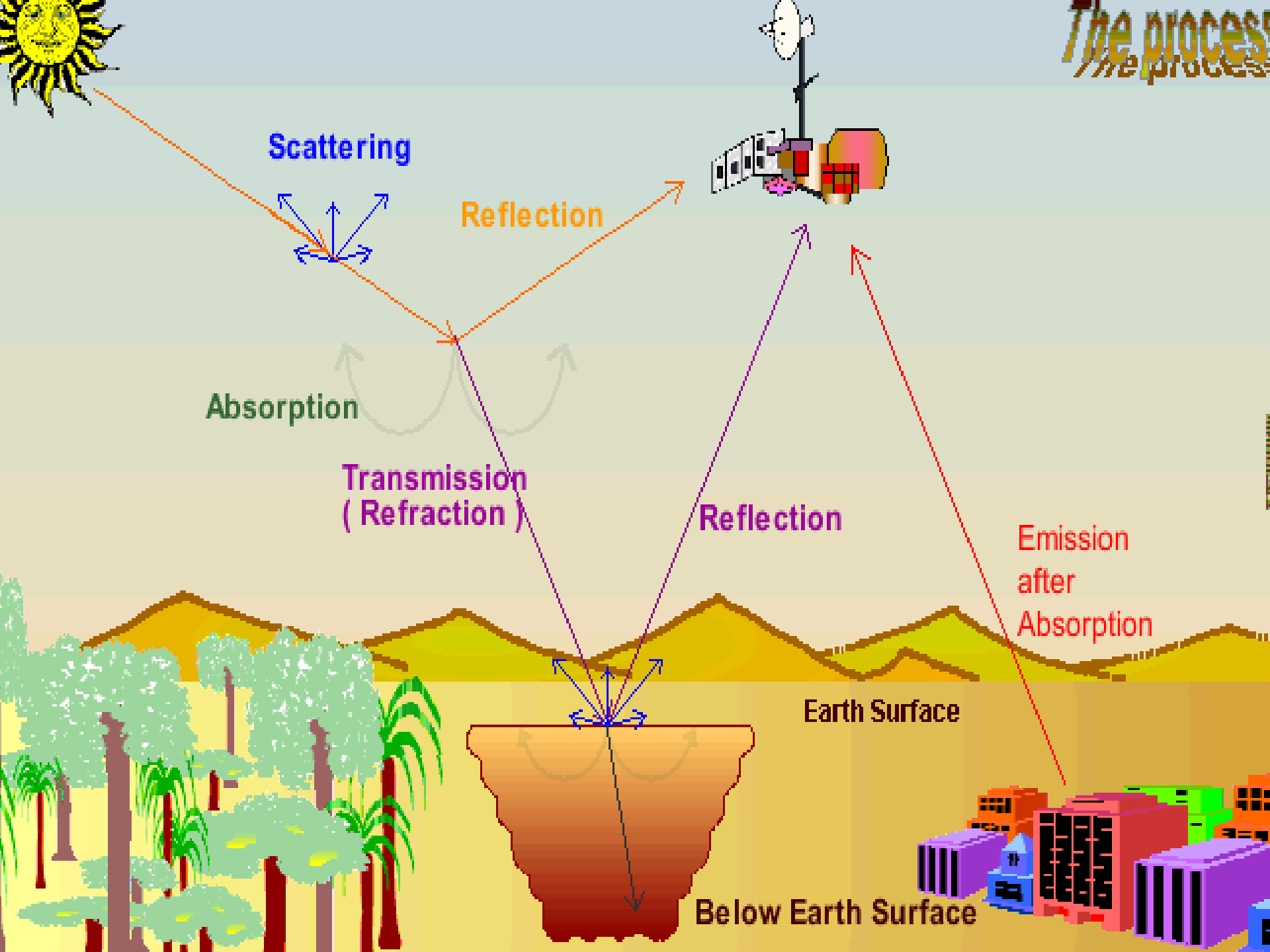
❖ Data transmission, processing and analysis

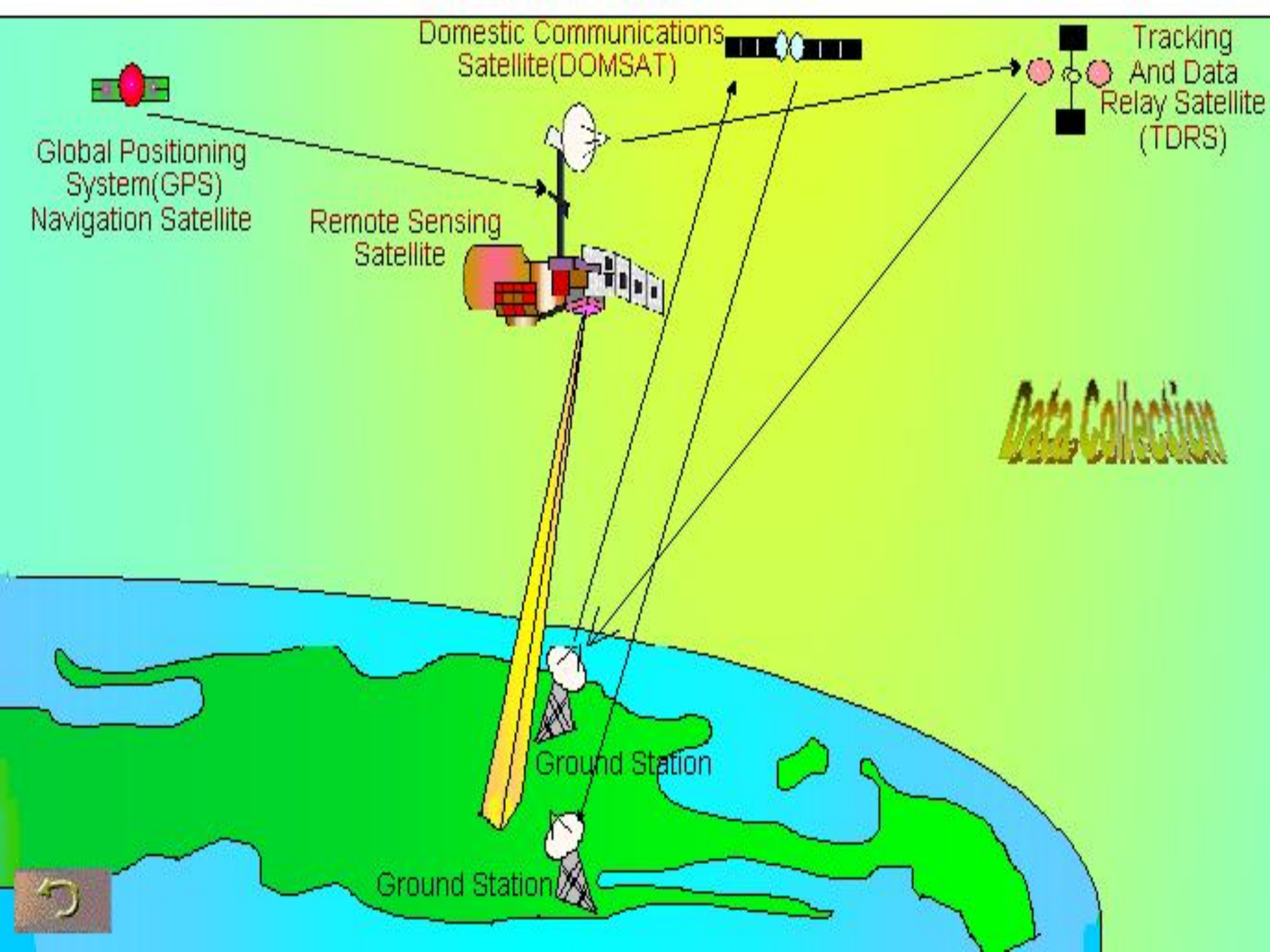
IDEAL VS REAL RS

IDEAL	REAL
• Uniform energy source wavelength over	Non uniform energy w.r.t. Constant wavelength & their properties time & space
• A non interfering atmosphere (energy not modified)	Interferes the energy (modifies the energy distribution)
• Energy- matter interaction fixed unique	Interaction process complex and varies with time, season, location, illumination factor etc.
• Sensor – simple, reliable & accurate same sensor can record all wavelengths	Each sensor type records a particular detail
• Data processing & supply is readily interpretable	Handling data is difficult and complex, require lot of reference material
• Multiple data users will help all specialists	Same data set may not be useful to all specialists

Remote Sensing Process




The process
Scattering
Reflection
Absorption
Transmission
(Refraction)
Reflection
Emission
after
Absorption
Earth Surface
Below Earth Surface


Domestic Communications Satellite(DOMSAT)
Tracking And Data Relay Satellite (TDRS)
Global Positioning System(GPS) Navigation Satellite
Remote Sensing Satellite
Data Collection
Ground Station
Ground Station

INTERACTION PROCESS

WHEN RADIATION INTERACTS IT RESULTS IN

- EI (Incident energy) = ER + EA +ET
- Transmission-

  Refraction – Bending of light as it passes though diff medium.

  scattering- Diffusion of radiation by particles in the atmosphere

    Raleigh scattering: particle size smaller than wavelength

    Mie scattering: particle size = wavelength

    Non selective: particle size more than wavelength

Absorption : atmosphere and earth surface

Reflection: radiation bounces off from surface
atmosphere and earth surface
specular reflection- IE =RE
diffused/ lambertian reflection- reflects
in all direction due to sur roughness

- EMR is a property of wavelength and frequency
- Wavelength is inversely proportional to frequency
- Portion of spectrum that transmits energy is called atmospheric window

  Combined effect of various constituent of atmosphere- can cause atm to close down completely in certain regions of the spectrum (no energy is transmitted)- bad for R S

- Reflected (reflected energy recorded)

  Ultra violet: 0.254-0.366 um

  Visible: 0.4-0.7 um B G R or RGB

  IR near: 0.7- 1.3 um
- Thermal (thermal emission recorded)

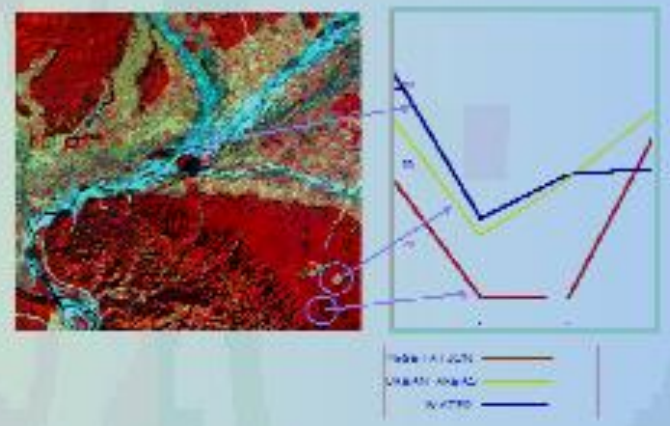
  3- 5um

  8- 14 um
- Microwave (energy from the sensor- reflected from the surface- back to the sensor)

  1mm- 1m

Spectral Signature

The reflectance/emittance of any object at different wavelength follows a pattern, which is characteristic of that object known as 'spectral signature'.
Proper interpretation of the spectral signal leads to the identification of the object.



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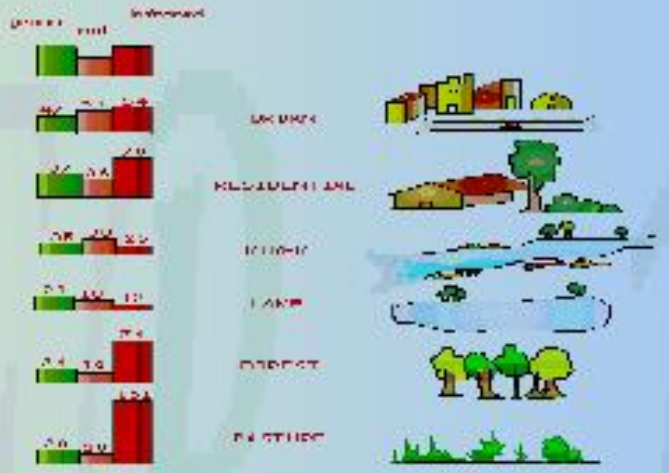
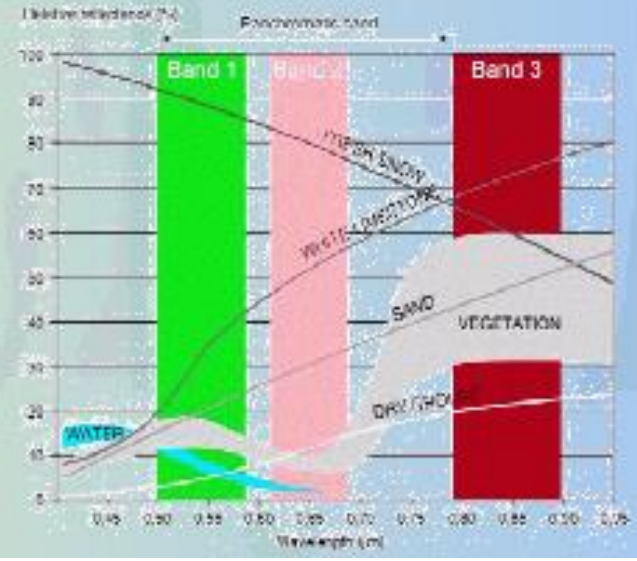
Everything in nature has a spectral signature. If we can detect that spectral signature we can separate features, and get an insight to the general size and shape of objects.

Spectral signatures (spectral response patterns) change over time and space.

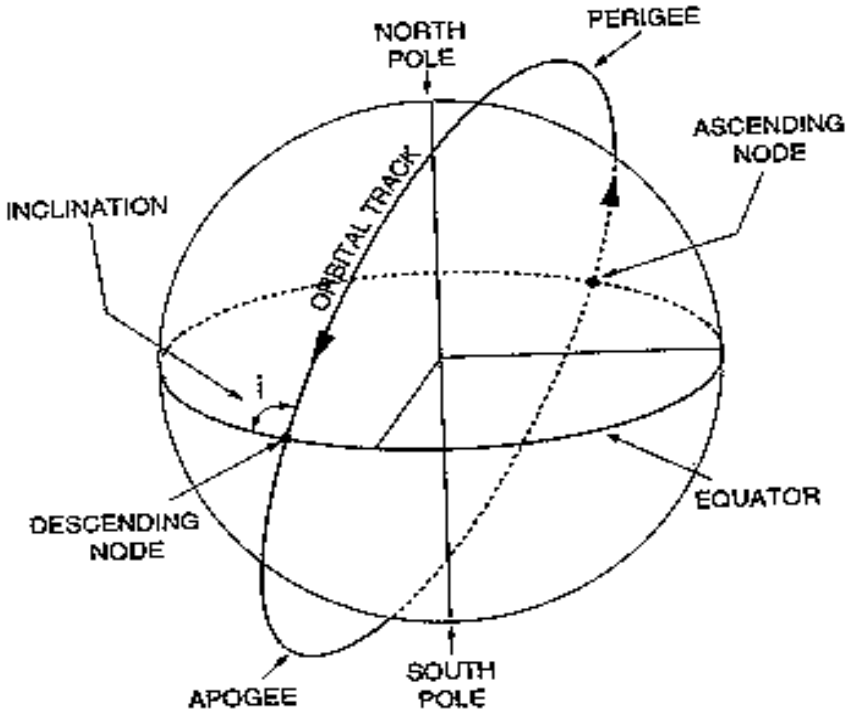
Zoom

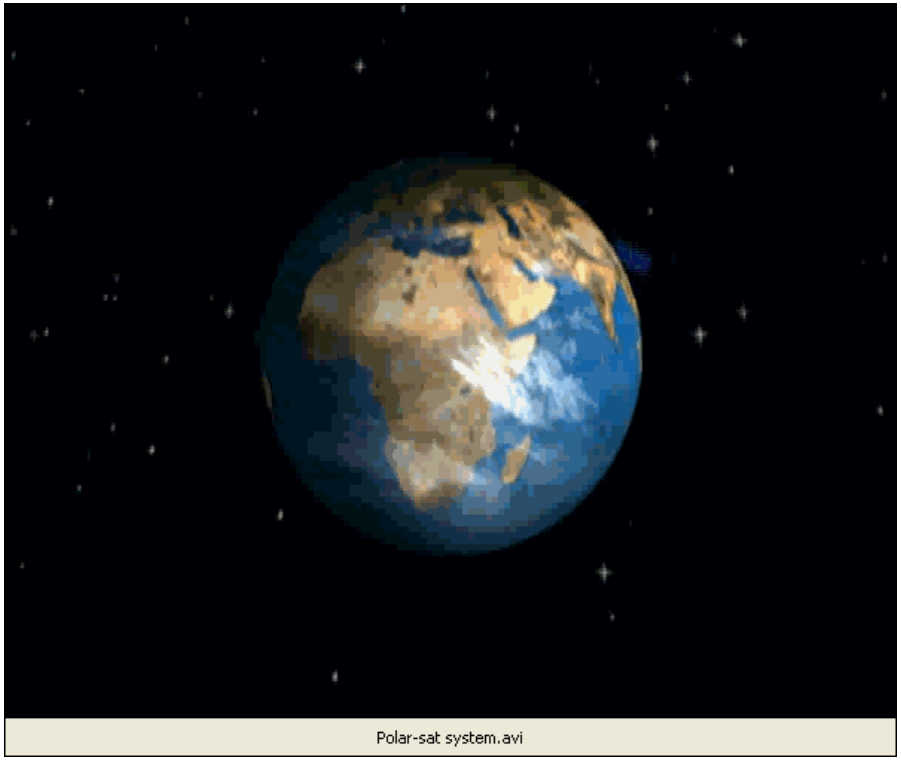


Zoom



1. Sun synchronous orbit or Polar Orbiting





2. Geostationary orbit

A satellites period increases with altitude, at an altitude of 36000 Km a satellite has the same period as that of the earth, hence it remains stationary with respect to the earth's surface – geostationary orbit. Geostationary orbits are ideal for meteorological or communication satellites.

Satellite Characteristics

1) Geostationary satellites

An equatorial west to east satellite orbiting the earth at an altitude of 36000 km., the altitude at which it makes one revolution in 24 hours, synchronous with the earth's rotation.

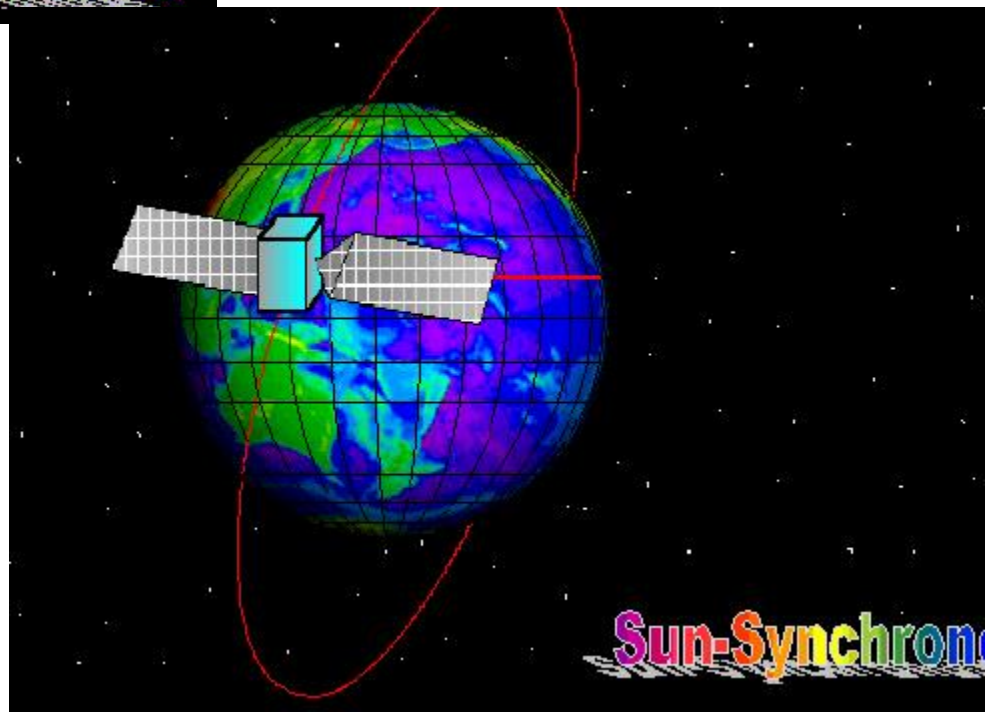
These are mainly used for communication and meteorological applications viz. GO METOSAT, INTELSAT, and INSAT satellites.

2)Polar orbiting or Sun-synchronous satellites

An earth satellite orbit in which the orbital plane is near polar and the altitude is such that the satellite passes over all places on earth having the same latitude twice in each orbit at the same local sun-time. LANDSAT series, SPOT series, IRS series, NOAA, SEASAT, TIROS, HCMM, SKYLAB, SPACE SHUTTLE **Figure**

- Very- high altitude satellites operate 36,000 km above the Earth.
- These are geostationary satellites.
- These satellites appears to be stationary over certain area.
- Meteorological and other resource data is obtained from these satellites.

- These satellites operate approximately 1000 km above the earth surface.
- These are unmanned satellites.
- Satellites are sun-synchronous, means polar orbit cover the entire earth at the same equator time.
- The system provide data for a number of years and when they eventually fail, remain within their orbit .



Resolution

Remote Sensing involves the discretization of a natural scene into an aray of picture elements(pixel).One can interpret a pixel as a sample of a new natural scene.Pixels only ocasionally contain one cover type but a very bright or dark object may dominate overall pixel brightness.

One can distinguish four important types of resolution:

Spatial Resolution

Radiometric Resolution

Spectral Resolution

Temporal Resolution

Spatial Resolution

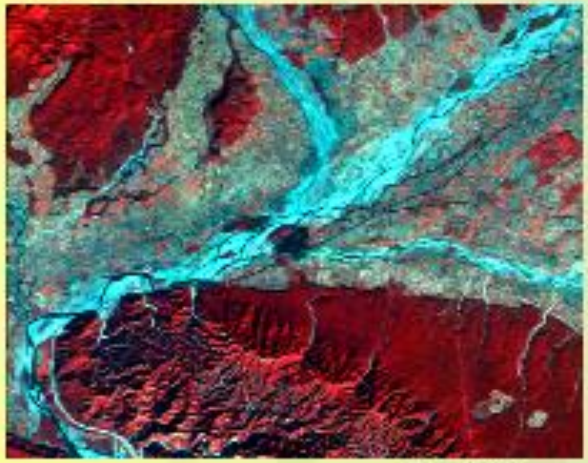
The Spatial Resolution can be defined as the instantaneous field of view(ifov) which can be defined as the field of a scanner with the scan motion stopped.When expressed in linear or area units such as meters or hectares, it has an altitude dependent measure of the ground resolution of the scanner.If one pixel is a ground cell sample of 20 by 20 meter then no objects smaller than 20 meter can be distinguished from their background.This does not mean they can not be detected.
e.g. Fires as small as 10 by 10 meters can be detected by the NOAA/AVHRR satellites which have a spatial resolution of 1.1 x 1.1 k.m.These fires are detected not resolved.

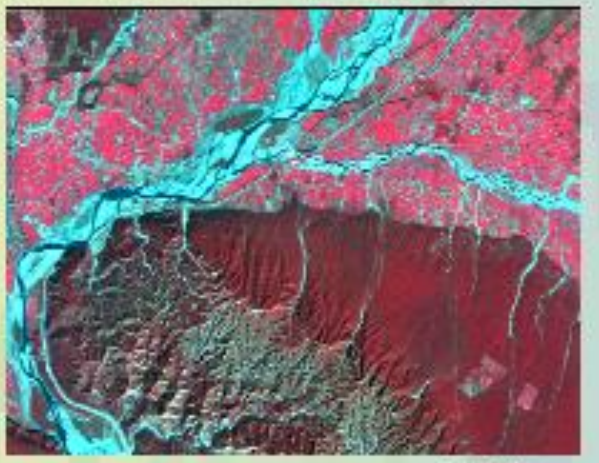
Examples *Table*

Spatial Resolution

Zoom

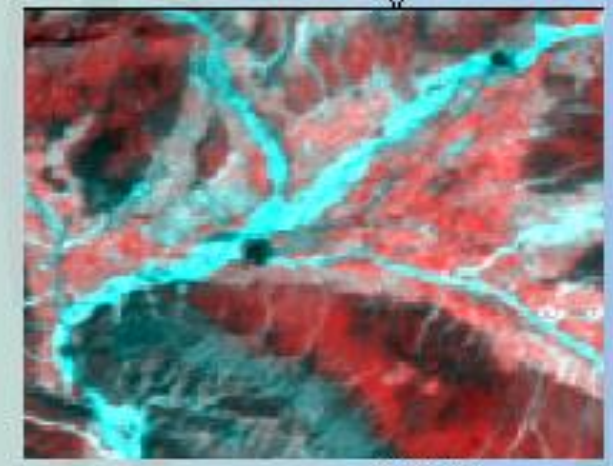
IRS LISS II 36.25m

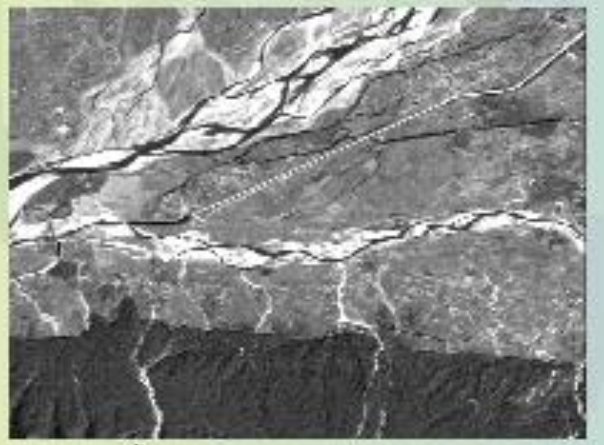




IRS LISS III 23.5m

IRS WiFS 188m





IRS PAN 5.8m

Zoom

Zoom

Zoom

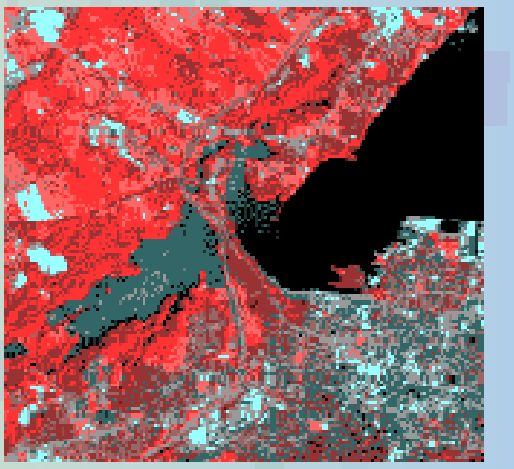
Radiometric Resolution

Radiometric Resolution refers to the number of digital levels(colours) used to express the data collected by the sensor . In general , the greater the number of levels the greater the detail in information. At one extreme one could consider a digital image composed of only two levels. As the number of levels increases so the amount of detail visible on the image increases.

Table

← 8-bit Radiometric Resolution
=256 colors

3-bit Radiometric Resolution
=8 colors →



Spectral Resolution

The Spectral Resolution of a remote sensing instrument (sensor) is determined by the bandwidths of the Electro-magnetic radiation of the channels used. High spectral resolution, thus, is achieved by narrow bandwidths collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth.

Multispectral scanners - remote sensing instruments which record several spectral bands (usually < 10) simultaneously

"spectral band" = "spectral channel"

Hyperspectral scanners - remote sensing instruments which record hundreds of spectral bands simultaneously

Examples **Spectral Resolution**

TM1: 0.45–0.52μm -Blue

TM2: 0.52-0.60μm -Green

TM3: 0.63-0.69μm-Red

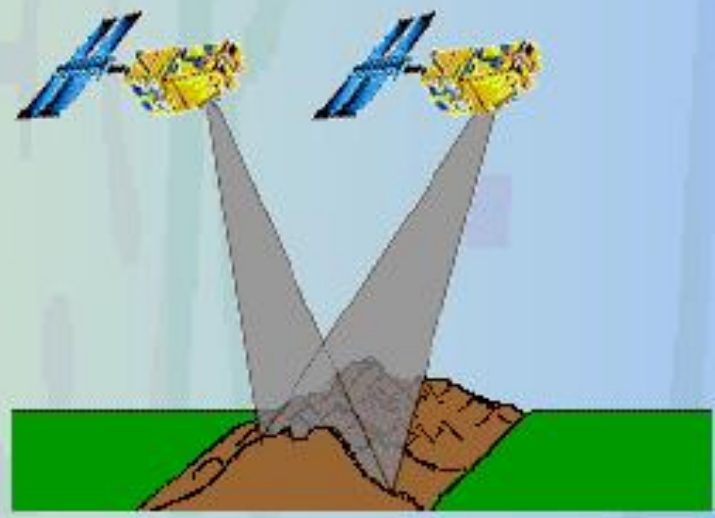
Temporal Resolution

Temporal Resolution is the time between successive image acquisitions.In practice the constrain or orbital parameters, weather and money determine the temporal resolution, while ideally the problem to be solved should determine the temporal resolution.

Change detection - the identification of differences in surface features observed in images acquired over the same area at 2 different times.

Multitemporal remote sensing - change detection involving up to 10 images acquired at different times.

Hypertemporal remote sensing - change detection involving hundreds of images acquired at different times.



Table