UNIT-2- **REMOTE SENSING SATELLITES AND SENSORS**

Platforms-Types-Applications – Sun synchronous and geo synchronous orbits-Active and Passive sensors-Resolution-Spatial, Spectral, Radiometric and Temporal, significance of Resolution-Satellites and Sensors- LANDSAT, SPOT, IRS, RESOURCESAT, CARTOSAT, LISS Images, Thematic Mapper-High Resolution commercial satellites-METEOSAT,NOAA-ERS, RADARSAT.

REMOTE SENSING PLATFORMS

Major Components of Remote Sensing Technology:

1. Energy Source
2. Passive System: sun, irradiance from earth's materials;
3. Active System: irradiance from artificially generated energy sources such as radar.
4. Platforms:(Vehicle to carry the sensor) (truck, aircraft, space shuttle, satellite, etc.)
5. Sensors:(Device to detect electro-magnetic radiation) (camera, scanner, etc.)
6. Detectors: (Handling signal data) (photographic, digital, etc.)
7. Processing:(Handling Signal data) (photographic, digital etc.)
8. Institutionalisation: (Organisation for execution at all stages of remote-sensing technology: international and national orrganisations, centres, universities, etc.).

Platforms provide a vantage point for the sensors used in remote sensing. Platforms may be as simple as a ladder through trolley, balloons, aircraft and to highly sophisticated satellite systems. In general, three types of platforms are of interest for remote sensing**: ground, airborne and space borne observation platforms**.

Ground observation platforms (Hand held, portable masts, a trolley mounted) are used for experimental purpose in designing sensors, characterizing spectral reflectance and emissivity of different objects. These platforms provide an altitude of up to 15m.

Air borne platforms

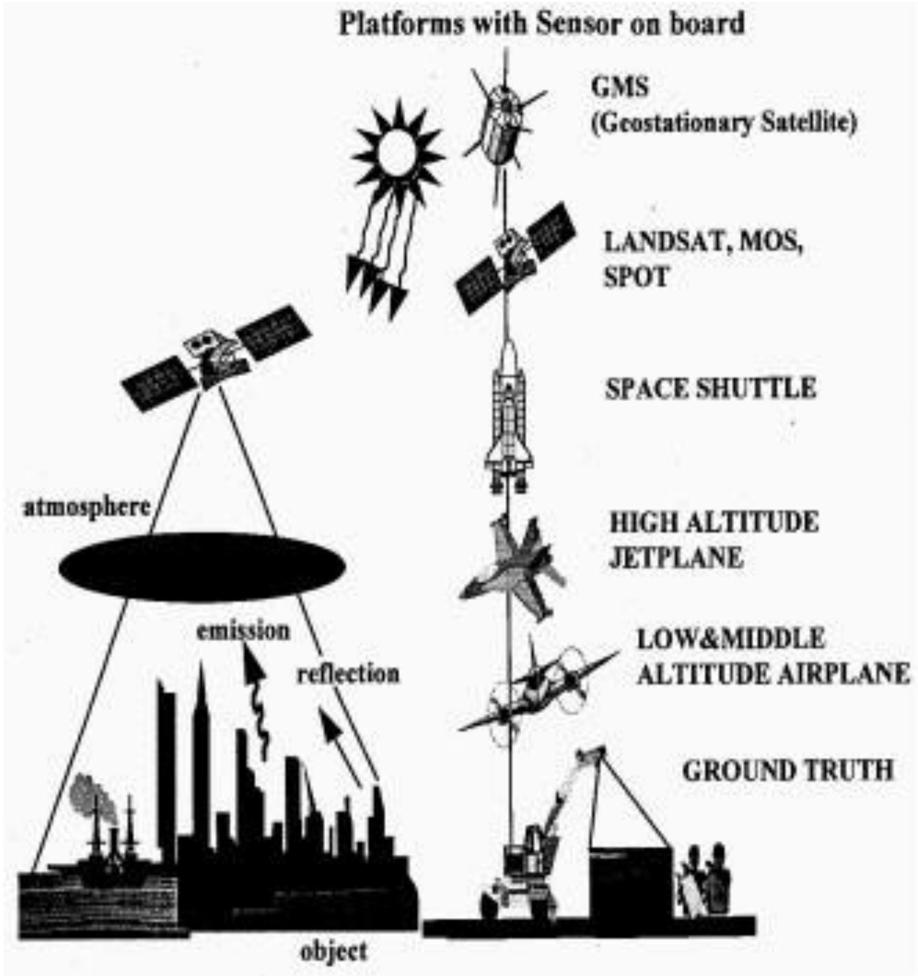
Balloons offer reasonably stable platforms up to very considerable altitudes, 30 km, when propulsion is there.

Aircraft flying at low and medium altitudes (1500-3000m) are appropriate for surveys of local or limited regional interest. High-altitudes photographs are obtained (by NASA) with aircrafts flying at 18 km above terrain.

Space borne platforms

High-altitude rockets like Space Shuttles are used for experimental purpose. Synoptic imagery of some 40,000 to 90,000 km^2 per frame can be obtained from such platforms. The approximate altitude of these platforms range from 200 km to 400 km. Space shuttle orbit at 185 km.

Satellite platforms offer a good coverage and all weather capability. The platform can be utilized for earth observation, weather monitoring and telecommunication and positioning system. The altitude above 300 km and can be upto 36000 km.



<u>Satellite platforms</u>: Orbits and Swaths

Remote sensing instruments can be placed on a variety of platforms to view and image targets. Although ground-based and aircraft platforms may be used, satellites provide a great deal of the remote sensing imagery commonly used today. Satellites have several unique characteristics which make them particularly useful for remote sensing of the Earth's surface.

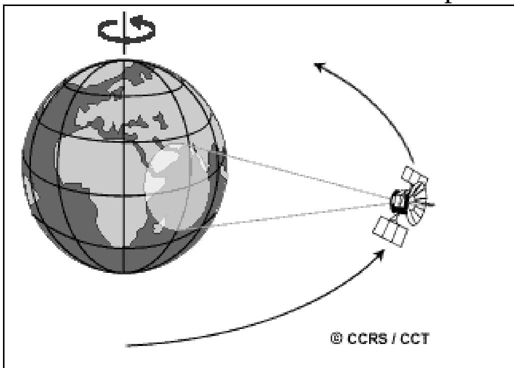
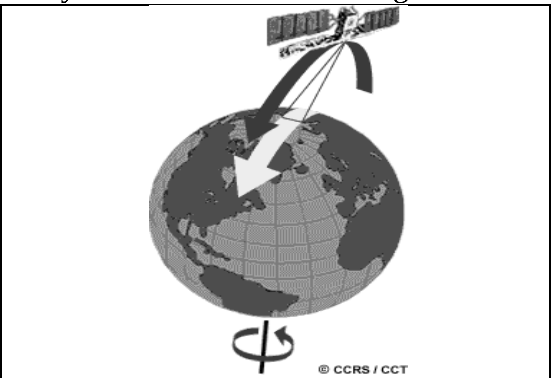
	

Figure 3-a	Figure 3-b

The path followed by a satellite in the space is referred to as its **orbit**. Satellite orbits are matched to the capability and objective of the sensor(s) they carry. Orbit selection can vary in terms of altitude (their height above the Earth's surface) and their orientation and rotation relative to the Earth.

Geostationary or Geosynchronous orbits: Satellites at very high altitudes, which view the same portion of the Earth's surface at all times (Figure 3-a)**.** These geostationary satellites, at altitudes of approximately 36,000 kilometres, revolve at speeds which match the rotation of the Earth so they seem stationary, relative to the Earth's surface. This allows the satellites to observe and collect information continuously over specific areas. Weather and communications satellites commonly have these types of orbits (eg. INSAT series of satellites).

Sun-synchronous orbits: Many remote sensing platforms are designed to follow an orbit (basically north-south) which, in conjunction with the Earth's rotation (west-east), allows them to cover most of the Earth's surface over a certain period of time. They cover each area of the world at a constant local time of day called **local sun time**. These are **near-polar orbits**, so named for the inclination of the orbit relative to a line running between the North and South poles. At any given latitude, the position of the sun in the sky as the satellite passes overhead will be the same within the same season. This ensures consistent illumination conditions when acquiring images in a specific season over successive years, or over a particular area over a series of days. This is an important factor for monitoring changes between images or for mosaicking adjacent images together, as they do not have to be corrected for different illumination conditions.

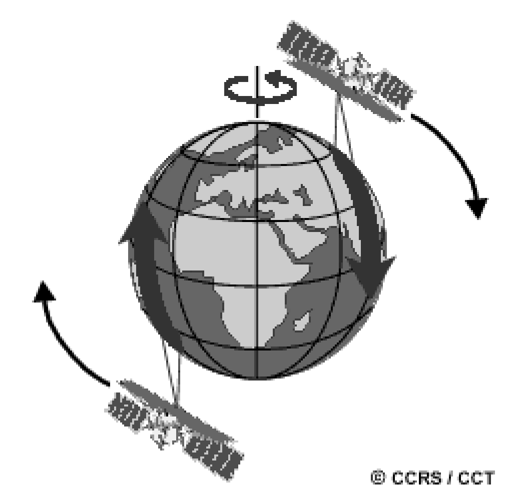


Figure 3-c

Most of the remote sensing satellite platforms today are in near-polar orbits, which means that the satellite travels northwards on one side of the Earth and then toward the southern pole on the second half of its orbit. These are called **ascending and descending passes**, respectively (Figure 3-c). If the orbit is also sun-synchronous, the ascending pass is most likely on the shadowed side of the Earth while the descending pass is on the sunlit side. Sensors recording reflected solar energy only image the surface on a descending pass, when solar illumination is available. Active sensors which provide their own illumination or passive sensors that record emitted (e.g. thermal) radiation can also image the surface on ascending passes.

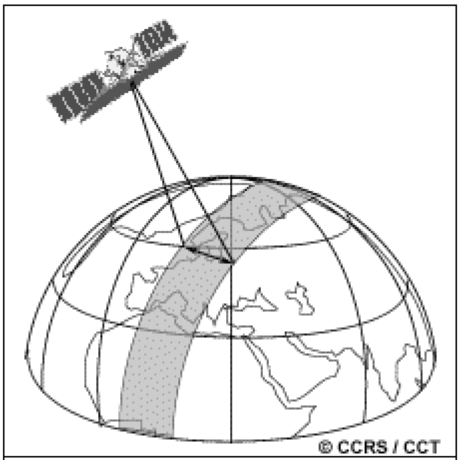


Figure 3-d

<u>**Swath**:</u> As a satellite revolves around the Earth, the sensor "sees" a certain portion of the Earth's surface. The area imaged on the surface, is referred to as the swath (Figure 3-d). The width of the swaths for spaceborne sensors generally varies between tens and hundreds of kilometres. The satellite's orbit and the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits.

Nadir: Earth's surface directly below the satellite is called the nadir point. The exact length of time of the orbital cycle will vary with each satellite. The interval of time required for the satellite to complete its orbit cycle is not the same as the "**revisit period**". The revisit period is an important consideration for a number of monitoring applications, especially when frequent imaging is required (for example, to monitor the spread of an oil spill, or the extent of flooding). In near-polar orbits, areas at high latitudes will be imaged more frequently than the equatorial zone due to the increasing **overlap in adjacent swaths** as the orbit paths come closer together near the poles.

4. <u>REMOTE SENSING SENSORS AND DATA PRODUCTS</u>

SENSORS	
<u>**ACTIVE SENSORS**</u> (Detect the reflected or emitted electromagnetic radiation from natural sources.)	<u>**PASSIVE SENSORS**</u> (Detect reflected responses from objects that are irradiated from artificially-generated energy sources such as radar.)
Passive Non-Scanning ▪ <u>Non-Imaging.</u> (They are a type of profile recorder, ex. Microwave Radiometer. Magnetic sensor.Gravimeter.Fourier Spectrometer. ▪ <u>Imaging.</u> (Example of this are the cameras which can be: Monochrome,	Active Non-Scanning ▪ <u>Non-Imaging.</u> (They are a type of profile recorder, ex. Microwave Radiometer.Microwave Altimeter.LaserWater Depth Meter.Laser Distance Meter. Scanning ▪ <u>Imaging.</u> (It is a radar ex. Object Planescanning: Real Aperture Radar.

Natural Colour, Infrared etc.) Scanning ▪ Imaging. Image Plane scanning.Ex. TV CameraSolid scanner. Object Plane scanning. Ex. Optical Mechanical ScannerMicrowave radiometer.	• Synthetic Aperture Radar. Image Plane Scanning: • Passive Phased Array Radar.

Sensor characteristics:

Spatial Resolution, Pixel Size, and Scale

Sensors onboard platforms far away from their targets, typically view a larger area, but cannot provide great detail. Compare what an astronaut onboard the space shuttle sees of the Earth to what you can see from an airplane. The astronaut might see your whole province or country in one glance, but couldn't distinguish individual houses. Flying over a city or town, we would be able to see individual buildings and cars, but you would be viewing a much smaller area than the astronaut. There is a similar difference between satellite images and airphotos.

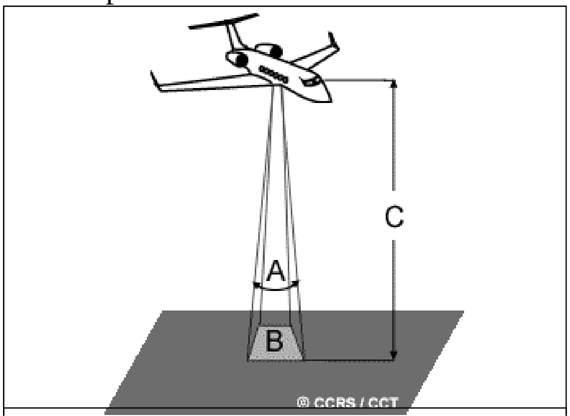


Figure 4-a

a.<u>Spatial resolution</u> refers to the size of the smallest possible feature that can be detected on an image. Spatial resolution of passive remote sensors depends primarily on their Instantaneous Field of View (IFOV)**.**

Instantaneous Field of View (IFOV): The IFOV is the angular cone of visibility of the sensor (A in figure 4-a) and determines the area on the Earth's surface which is "seen" from a given altitude at one particular moment in time (B in figure 4-a). The size of the area viewed is determined by multiplying the IFOV by the distance from the ground to the sensor (C in figure 4-a). This area on the ground is called the **resolution cell** and determines a sensor's spatial resolution.

Pixels most remote sensing images are composed of a matrix of picture elements called pixel, which are <u>the smallest units of an image</u>. It is important to distinguish between pixel size and spatial resolution - they are not interchangeable. If a sensor has a spatial resolution of 20 metres and an image from that sensor is displayed at full resolution, each pixel represents an area of 20m x 20m on the ground.

Images where only large features are visible are said to have **coarse or low resolution.** In **fine or high resolution** images, small objects can be detected. And finer the resolution, the less total ground area can be seen.

Scale: The ratio of distance on an image or map, to actual ground distance is referred to as scale. In a map with a scale of 1:100,000, an object of 1cm length on the map would actually be an object 100,000cm (1km) long on the ground. Maps or images with small "map-to-ground ratios" are referred to as small scale (e.g. 1:100,000), and those with larger ratios (e.g. 1:5,000) are called large scale.

b. <u>Spectral Resolution</u>

Spectral resolution describes the *ability of a sensor to define fine wavelength intervals* (Figure 4-b). The finer the spectral resolution, the narrower the wavelength range for a particular channel or band. Broad classes, such as water and vegetation, can usually be separated using very broad wavelength ranges - the visible and near infrared. Other more specific classes, such as *different rock types*, may not be easily distinguishable using either of these broad wavelength ranges and would require comparison at much finer wavelength ranges to separate them.

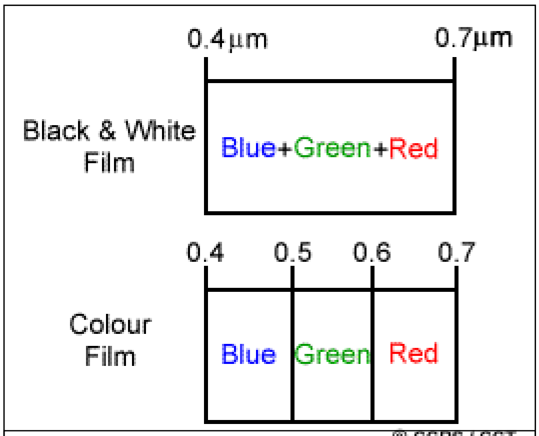


Figure 4-b

Multi-spectral sensors : Remote sensing systems record energy over several separate wavelength ranges at various spectral resolutions.

Hyperspectral sensors: They are advanced multi-spectral sensors which detect hundreds of very narrow spectral bands throughout the visible, near-infrared, and mid-infrared portions of the electromagnetic spectrum. Their very high spectral resolution facilitates fine discrimination between different targets.

c. <u>Radiometric Resolution</u>

The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. It describes the actual information content in an image. The finer the radiometric resolution of a sensor the more sensitive it is to detecting small differences in reflected or emitted energy.

d. <u>Temporal Resolution</u>

In addition to spatial, spectral, and radiometric resolution, the concept of temporal resolution is also important to consider in a remote sensing system. This is governed by revisit period, which refers to the length of time it takes for a satellite to complete one entire orbit cycle. The revisit period of a satellite sensor is usually several days. Therefore the absolute temporal resolution of a remote sensing system to image the exact same area at the same viewing angle a second time is equal to this period. Some satellite systems are able to point their sensors to image the same area very frequently using rotating camera / sensors. Thus, the actual temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capabilities, the swath overlap, and latitude.

METHODS OF SCANNING BY REMOTE SENSING SENSORS

There are two main modes or methods of scanning employed to acquire multispectral image data - **across-track scanning** and **along-track scanning**.

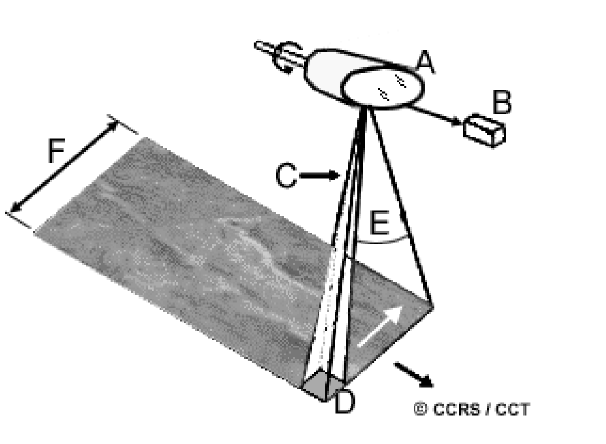
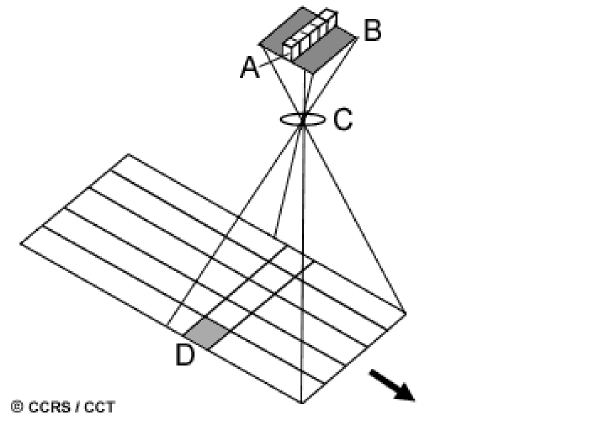
	

Figure 4-c: Across track scanning	Figure 4-d: Along track scanning

Across-track scanners scan the Earth in a series of lines across the track. The lines are oriented perpendicular to the direction of motion of the sensor platform (i.e. across the swath) and also referred to as whiskbroom scanning. Each line is scanned from one side of the sensor to the other, using a *rotating mirror* (A in Figure 4-c)**.** As the platform moves forward over the Earth, successive scans build up a two-dimensional image of the Earth´s surface. The incoming reflected or emitted radiation is separated into several spectral components that are detected independently.

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)**.** Airborne scanners typically sweep large angles (between 90º and 120º), while satellites, because of their higher altitude need only to sweep fairly small angles (10-20º) to cover a broad region.

Along-track scanners (Figure 4-d) use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction. However, instead of a scanning mirror, they use a linear array of detectors (A) located at the focal plane of the image (B) formed by lens systems (C), which are "pushed" along in the flight track direction (i.e. along track). 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. 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.

Advantages of Along-track scanners over Across-track mirror scanners.

- 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).
- 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.

Limitation: Cross-calibrating thousands of detectors to achieve uniform sensitivity across the array is necessary and complicated.

<u>SALIENT FEATURE OF SOME IMPORTANT SATELLITE PLATFORMS</u>

Features	**Landsat1,2,3**	**Landsat 4,5**	**SPOT**	**IRS-IA**	**IRS-IC**	**IRS - P6**
Nature	Sun Syn	Sun Syn	Sun Syn	Sun Syn	Sun Syn	Sun-syn
Altitude (km)	919	705	832	904	817	817
Orbital period (minutes)	103.3	99	101	103.2	101.35	10.35
Inclination (degrees	99	98.2	98.7	99	98.69	98.69
Temporal resolution (days)	18	16	26	22	24	24
Revolutions	251	233	369	307	341	341
Equatorial crossing (AM)	09.30	09.30	10.30	10.00	10.30	10.30
Sensors	RBV, MSS	MSS, TM	HRV	LISS-I, LISS-II	LISS-III; PAN; WIFS	LISS-III; LISS IV; AWIFS
Country	USA	USA	France	India	India	India

<u>Sensors on board of different satellites</u>

LISS - Linear Imaging Self Scanning SensorAWiFS – Advanced Wide Field Sensor
PAN – Panchromatic camera / TM – Thematic Mapper
RBV – Return beam Vidicon / MSS – Multi Spectral Scanner
HRV – High Resolution Visible

Features	LISS III	LISS IV	AWIFS	PAN	MSS	HRV-IR
Spatial resolution (m)	23.5	5.8	56-70	1	80	10
Swath (km)	141	23.9-70	740	56	185	
Bands	B2, B3, B4,B5	B2, B3, B4	B2, B3, B4,B5	single	B2, B3, B4,B5	B2, B3,B4, B5
where B2-Visible Green	B3-Visible Red		B4-Near IR -I		B5- Near IR -II	

Landsat

- Landsat – 1 / ERTS-1 was launched on July 23, 1972.
- First announced satellite specifically designed to acquire data about earth resources on a systematic, repetitive, medium, resolution, multispectral basis
- To test the feasibility of collecting earth resources data from unmanned satellites
- Landsat – 1 to Landsat – 7 (1999)

IRS

- Indian Remote Sensing Satellite (IRS) system was established with the launch of IRS-1A in March 1988.
- At present we have IRS-1B, -1C, -1D and IRS-P2, -P3, -P4, -P5, -P6, -P7satellites inseries.
- IRS – P4 (Oceansat - I) – 1999
- IRS – P5 (Cartosat - I) – 2005
- IRS – P6 (Resourcesat - I) – 2003
- IRS – P7 (Oceansat - II) - 2009

REMOTE SENSING DATA PRODUCTS

The National Remote Sensing Centre (NRSC), Hyderabad is the focal point for distribution of remote sensing satellite data products in India and its neighboring countries. NRSC has an earth station at Shadnagar, about 55Km from Hyderabad, to receive data from almost all contemporary remote sensing satellites such as IRS-P5, IRS-P6, IRS-P4, IRS-1D, IRS-1C, IRS-P3,ERS-1/2, NOAA series, AQUA and TERRA satellites.

NDC (NRSC Data Centre) is a one-stop-shop for a range of data products with a wide choice of resolutions, processing levels, product media, output scales, area coverage, revisit, season and spectral bands. Data products can be supplied on a wide variety of media and formats

The classification of products is generally based on the following:

1. Level of processing
2. Output media/scale
3. Area of coverage

1. LEVEL OF PROCESSING

Data products can be categorized as:

- Standard products
- Value Added products
- Derived products

Path/Row based products

These products are generated based on specific path/row, sensor, sub-scene, date of pass, band number/band combination (for photographic products).

Shift Along Track (SAT) products

If a user's area of interest falls in between two successive scenes of the same path, then the data can be supplied by sliding the scene in the along track direction. These are called Shift Along Track products. These products are available from IRS-1C time frame. The percentage of shift has to be between 10% and 90% in multiples of 10%.

Quadrant products

These products are applicable only to LISS-III. The LISS-III full scene is divided into four nominal and eight derived quadrants. Quadrant numbers 1 to 4 are nominal quadrants. The remaining eight quadrants are obtained by sliding quadrants 1,2,3 and 4 by 25% along and across the scene, within the path. While placing a request for these products, users need to specify the quadrant number and shift if any, in addition to the details specified for path/row based products.

Georeferenced products

These are true north oriented products. These products are supplied on digital media only. The location accuracy of these products is same as that of standard products. The inputs to be supplied are same as that of path/row based products with appropriate product code.

Basic Stereo products

A stereo pair comprises of two images of the same area, acquired on different dates / same day and from different angles. The Cartosat-1 mission provides along track stereo images.

One of the parameters from which the quality of a stereo pair can be judged is the base/height (B/H) ratio. B/H ratio is the ratio of distance between two satellite passes or the viewing angular separation of the cameras and satellite altitude. The data are only radiometrically corrected and are supplied on digital media.

Area of Interest (AOI) based products

Area of Interest (AOI) based products cover user-specified geographic area. The scenes covering the AOI can be selected from basic stereo data or from single camera data (Aft camera data is default). The scenes covering the user's area of interest are packaged together as tiled products and provided without mosaicing. The different tiles are not radiometrically matched. The minimum order quantity is 25 x 25 sq km for IRS-P5 and 23 x 23 Sq km for IRS-P6 LISS-1V MX. The maximum order quantity is 10,000 sq km. All AOI based products are provided as digital products (CD/DVD) only.

In the case of Cartosat-1, these products are supplied with different processing levels.

i.Radiometrically corrected

ii.Orthokit

The Orthokit products are supplied with radiometric corrections and the required projections. A file consisting of the Rational Polynomial Coefficients (RPCs) is also provided for further processing at user's end. Users can produce their own ortho-rectified / Geo-rectified products by using commercially available, off-the-shelf (COTS) software.

Value Added Products

Value added products are generated by further processing the standard corrected data.Examples are

- Geocoded products
- Merged products
- Ortho products

Geocoded Products

Geocoding corrects the imagery to a source independent format, whereby multi-date and multi-satellite data can be handled with ease. Geocoded products are generated after applying radiometric and geometric corrections, orienting the image to true north and generating the products with an output resolution, appropriate to the map scale (in the case of photographic products). Both floating and Survey of India (SOI) map sheet based products are supplied.

Merged Products

Merged products are generated by merging multi-spectral data with high resolution Panchromatic / Mono band data. The two data sets are first registered and then merged. The registration is based on an automatic technique for selection of control points based on feature contrast and finding match points through digital correlation. The merging of registered data is performed using a number of techniques.

For example, the high resolution CARTOSAT-1 image is wavelet decomposed for two levels using the cubic spline wavelets to obtain a low resolution image corresponding to the LISS-IV resolution and 6 detail components corresponding to high frequency information. The LISS-IV image is combined with these detail components and the wavelet recomposed to obtain the merged image. While this is the default merging technique used, several other techniques are used whenever required.

Ortho products

Ortho images are geometrically corrected products with corrections for displacement caused by tilt and relief. In other words, it is a picture prepared in such a manner that the perspective aspect of the picture has been removed.

Hence ortho image is an image that shows ground objects in their true map or so called orthographic projection. An orthographic projection is the one in which the projecting rays are perpendicular to the plane of projections. Any part of the object that is parallel to the plane of projection will appear in its proper shape and correct scale. These properties of the ortho image enable it to be used as a map for the measurement of distances, angles, areas etc., with scale being constant everywhere. They can also be used as map layers in geographic information systems or other computer based data manipulation, overlaying, management and analysis or display operations. However, ortho image differs from a map in the manner of depiction of detail. On a map, only selected detail is shown by conventional symbols, whereas on an ortho image all details appear just as in the original satellite image. On the other hand satellite image without terrain correction differs from the ortho image, in scale variation due to height and tilt distortions.

The basic inputs required for ortho image generation are

(i) Digital Elevation Model (DEM),

(ii) Ground Control Points (GCP)

(iii) Satellite ephemeris (orbit, attitude information) and

(iv) Radiometrically corrected image data.

Derived Products

These are products generated by further processing / analyzing the data like vegetation indices and sea surface temperature profiles. These products are readily usableby the user.

2. <u>OUTPUT MEDIA/SCALE</u>

Satellite data products are available on photographic and digital media. Photographic products can be supplied as films or prints.

Generally, single band data is provided in B/W such as PAN data or one band data from multi-spectral sensors such as LISS-III, LISS-II, TM etc. Similarly, photographic, color productscalled as False Color Composites (FCC) can be provided for multi-spectral data.The output scale for prints can vary from 1:1 M to 1:5000.

Digital Data Product formats

Digital Data are supplied in the following formats

- LGSOWG Superstructure Format (all satellites/sensors except NOAA,AQUAand TERRA)
- Fast Format (all satellites/sensors except NOAA, AQUA and TERRA)
- GeoTIFF- Gray Scale (from IRS-1C onwards except NOAA, AQUA and TERRA)
- GeoTIFF - RGB single band FCC or NCC(from IRS-1C onwards except NOAA,AQUA and TERRA)
- HDF (AQUA and TERRA and OCEANSAT-2)
- The digital data format document is provided along with the digital data.

3. AREA OF COVERAGE

Different sensors have different swaths. Generally, standard products are provided as full scenes. However, to obtain better output scales or to optimize data requirements, part of the Full scenes such as Quadrants or Geocoded products or Shift Along Track products can also be obtained from NRSC.

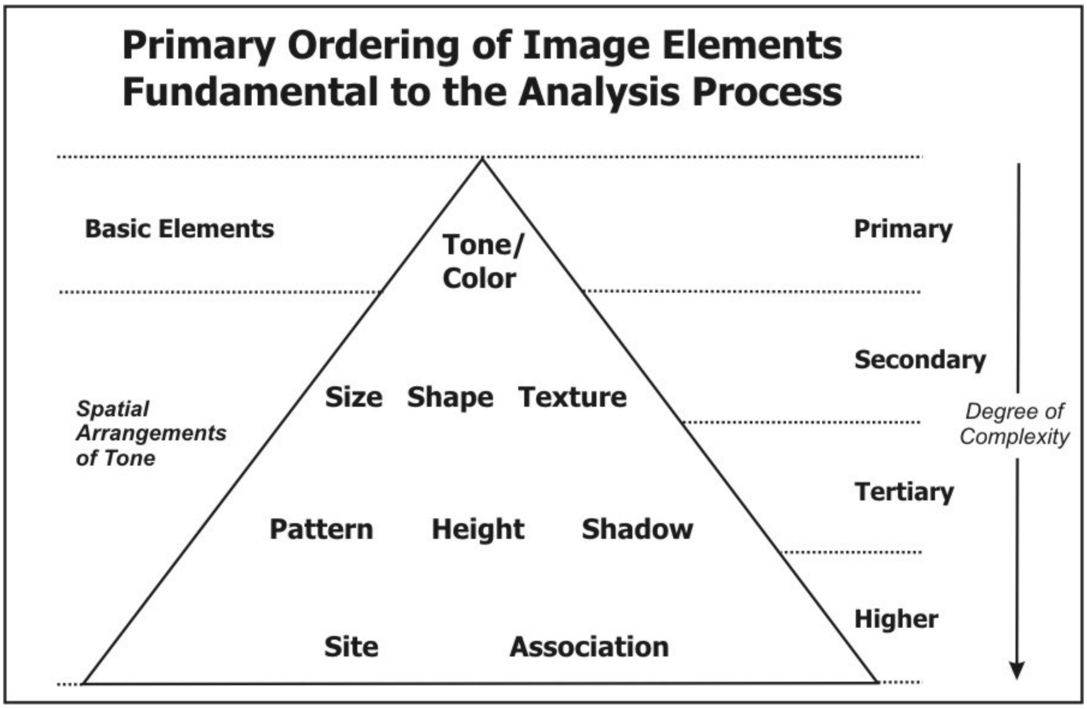
5. VISUAL INTERPRETATION OF AERIAL PHOTO AND SATELLITE IMAGERIES

Image interpretation or analysis is defined as the "act of examining images for the purpose of identifying objects and judging their significance". Interpreters study remotely sensed data and attempt through logical process in detecting, identifying, classifying, measuring and evaluating the significances of physical and cultural objects, their patterns and special relationship. Image interpretation is a complex process of physical and psychological activities occurring in a sequence of time.

Elements of Visual Interpretation

Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the ***visual elements*** *viz.*, **tone, shape, size, pattern, texture, shadow, and association**. Visual interpretation using these elements is often a part of our daily lives, whether we are conscious of it or not. Examining satellite images on the weather report, is a familiar examples of visual image interpretation. Identifying targets in remotely sensed images based on these visual elements allows us to further interpret and analyze. The nature of each of these interpretation elements is described below, along with an image example ofeach.

Tone refers to the relative brightness or colour of objects in an image. Generally, tone is the



fundamental element for distinguishing between different targets or features. Variations in tone also allows the elements of shape, texture, and pattern of objects to be distinguished.

Shape refers to the general form, structure, or outline of individual objects. Shape can be a very distinctive clue for interpretation. Straight edge shapes typically represent urban or agricultural (field) targets, while natural features, such as forest edges, are generally more irregular in shape, except where man has created a road or clear cuts. Farm or crop land irrigated by rotating sprinkler systems would appear as circular shapes.

Size of objects in an image is a function of scale. It is important to assess the size of a target relative to other objects in a scene, as well as the absolute size, to aid in the interpretation of that target. A quick approximation of target size can direct interpretation to an appropriate result more quickly.

Pattern refers to the spatial arrangement of visibly discernible objects. Typically an orderly repetition of similar tones and textures will produce a distinctive and ultimately recognizable pattern. Orchards with evenly spaced trees, and urban streets with regularly spaced houses are good examples of pattern.

Texture refers to the arrangement and frequency of tonal variation in particular areas of an image. Rough textures would consist of a mottled tone where the grey levels change abruptly in a small area, whereas smooth textures would have very little tonal variation. Smooth textures are most often the result of uniform, even surfaces, such as fields, asphalt, or grasslands. A target with a rough surface and irregular structure, such as a forest canopy, results in a rough textured appearance. Texture is one of the most important elements for distinguishing features in radar imagery.

Shadow is also helpful in interpretation as it may provide an idea of the profile and relative height of a target or targets which may make identification easier. However, shadows can also reduce or eliminate interpretation in their area of influence, since targets within shadows are much less (or not at all) discernible from their surroundings. Shadow is also useful for enhancing or identifying topography and landforms, particularly in radar imagery.

Association takes into account the relationship between other recognizable objects or features in proximity to the target of interest. The identification of features that one would expect to associate with other features may provide information to facilitate identification. For example playgrounds are often associated with educational institutions.