Satellites & Orbits

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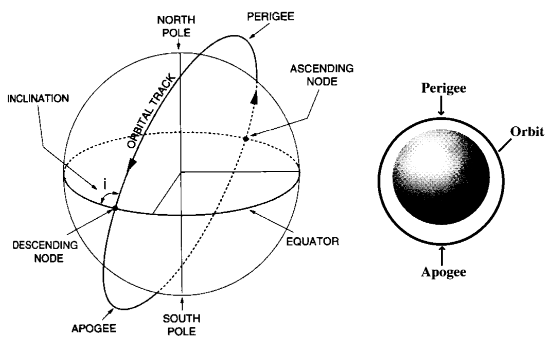
Satellite Orbits

- Orbit will be elliptical or near circular
- Time taken by a satellite to complete one revolution in its orbit around the earth is called the Orbital period.
- Apogee and Perigee
- Angle of inclination of orbital plane with respect to equator is measured clockwise (typically 99^{o} for RS Satellite)
- Nadir is the point of interception on the surface of the earth of the radial line between the center of the earth and the satellite
  - This is the point of shortest distance from the satellite
  - The circle on the surface of the earth described by the nadir point as the satellite revolves is called the ground track
- Any point just opposite to the nadir, above the satellite is called zenith.

Polar Orbit



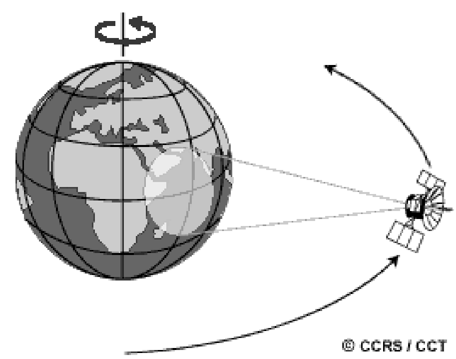
Satellite Orbits

- Altitude of a satellite is its height w.r.t. surface immediately below it
- Antipodes are diametrically opposite points on the surface of the earth.
  - Communication between any two antipodes can be established with the help of 3 geostationary satellites in the form of an equilateral triangle.

Satellite Orbits

- Geostationary & Polar Orbiting Satellites
- Geostationary or Geosynchronous Satellites are used for communication & meteorological purposes
  - Satellite is stationary with respect to a point on equator
  - Satellite must be geosynchronous i.e., orbital period should be 24 hrs.
  - Placed in high altitude of 36,000 km
  - It must be on equatorial plane
    - Heavily inclined orbit – 180^{o}
  - Sense of direction must be the same as sense of rotation of earth on its axis i.e., West to East
  - Can yield a large area coverage of 45% to 50% of the total globe (Foot Print)

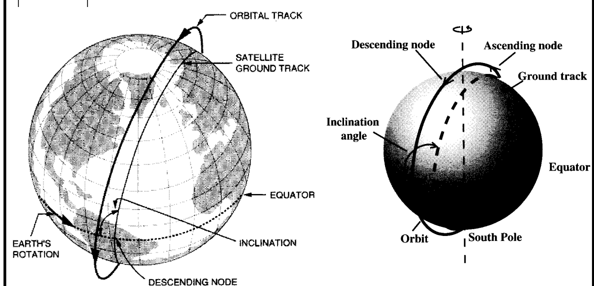
Geo-stationary Orbit



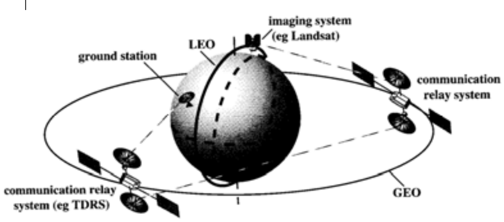
Polar Orbits

- Polar orbit is to take the advantage of earth's rotation on its axis so that the newer segments (or sections) of earth will be under view of the satellite, provided the orbital period is smaller than the rotational period of earth (24 hrs)
  - Typically RS satellite period will be 103 mts.

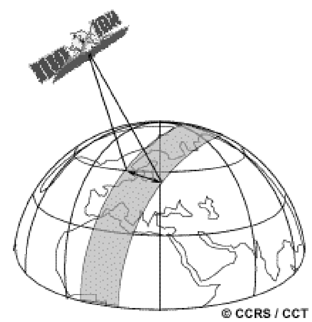
Polar Orbiting Satellites



Geostationary & Polar Orbiting Satellites



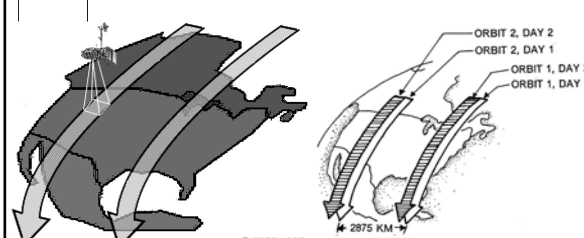
Swath



RS Satellite

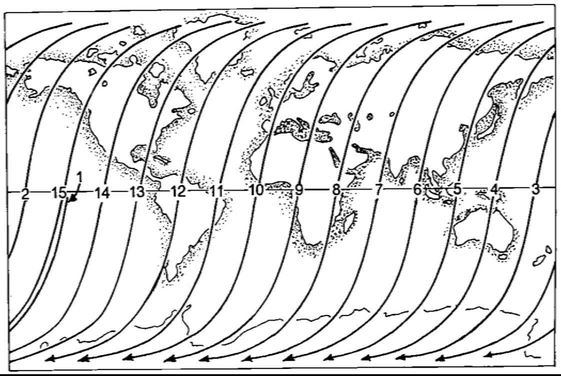
- RS Satellite is placed in Near polar, Near circular, inclined, medium period and sun synchronous orbit
  - Near Polar – for global coverage
  - Near circular – for uniform swath
  - Inclined – for differences in gravitational pull
  - medium period – for global coverage
  - Sun synchronous – for constant angle between the aspects of incident sun and viewing by the satellite

Near Polar Orbit

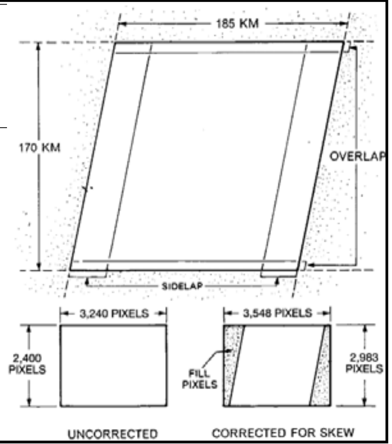


Landsat 1

Coverage Cycle of Landsat 1, 2 & 3 (14 Orbits per day)
Incremental shift – 18 days revisiting



Sidelap and Overlap



Landsat – TM Sensor Characteristics

Band	Resolution	Spectral definition	Some applications[a]
1	30 m	Blue-green, 0.45–0.52 µm	Penetration of clear water; bathymetry; mapping of coastal waters; chlorophyll absorption; distinction between coniferous and deciduous vegetation
2	30 m	Green, 0.52–0.60 µm	Records green radiation reflected from healthy vegetation; assesses plant vigor; reflectance from turbid water
3	30 m	Red, 0.63–0.69 µm	Chlorophyll absorption important for plant-type discrimination
4	30 m	Near infrared, 0.76–0.90 µm	Indicator of plant cell structure; biomass; plant vigor; complete absorption by water facilitates delineation of shorelines
5	30 m	Mid-infrared, 1.55–1.75 µm	Indicative of vegetation moisture content; soil moisture mapping; differentiating snow from clouds; penetration of thin clouds
6	120 m	Far infrared, 10.4–12.5 µm	Vegetation stress analysis; soil moisture discrimination; thermal mapping; relative brightness temperature; soil moisture; plant heat stress
7	30 m	Mid-infrared, 2.08–2.35 µm	Discrimination of rock types; alteration zones for hydrothermal mapping; hydroxyl ion absorption

[a]Sample applications listed here; these are not the only applications.

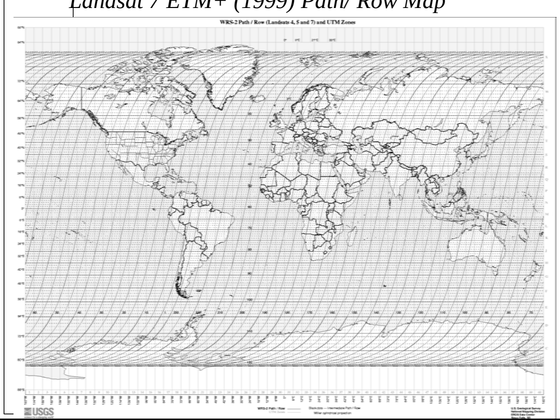
Revisit - 16 days; Swath – 185 km

Landsat 7 (1999) – ETM+ Sensor Characteristics

Band	Spectral range	Ground resolution
1	0.450–0.515 µm	30 m
2	0.525–0.605 µm	30 m
3	0.630–0.690 µm	30 m
4	0.75–0.90 µm	30 m
5	1.55–1.75 µm	30 m
6	10.4–12.5 µm	60 m
7	2.09–2.35 µm	30 m
Pan	0.52–0.90 µm	15 m

Revisit - 16 days; Swath – 185 km

Landsat 7 ETM+ (1999) Path/ Row Map



IRS Program

IRS 1A - 1988; IRS 1B – 1991

IRS 1C - 1995; IRS 1D - 1997

Pan – 0.5-0.75 µm; 5.8 m;

Swath: 70 km – 90 km; Revisit: 5 days

WiFS; OBTR (24 mts or 62 GB)

Spectral Characteristics of LISS I & LISS II (IRS 1A & 1B)

		Resolution	
Band	Spectral limits	LISS-I	LISS-II
1	Blue-green 0.45–0.52 µm	72.5 m	36.25 m
2	Green 0.52–0.59 µm	72.5 m	36.25 m
3	Red 0.62–0.68 µm	72.5 m	36.25 m
4	Near infrared 0.77–0.86 µm	72.5 m	36.25 m

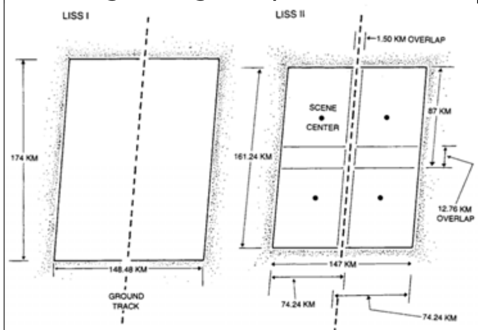
Spectral Characteristics of LISS III (IRS 1C & 1D)

Band	Spectral limits	Resolution
1[a]	Blue —	
2	Green 0.52–0.59 µm	23 m
3	Red 0.62–0.68 µm	23 m
4	Near infrared 0.77–0.86 µm	23 m
5	Mid-infrared 1.55–1.70 µm	70 m

[a]Band 1 is not included in this instrument, although the numbering system from earlier satellites is maintained to provide continuity.

Revisit - 22 days; Swath – 148.48 km for LISS I and 74.24 km LISS II

Coverage Diagram for LISS I & II



Four sub scenes gathered by LISS II will combine to cover the area covered by coarser resolution LISS I at the same time

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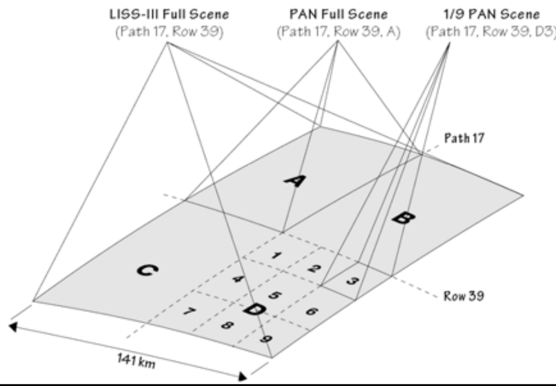
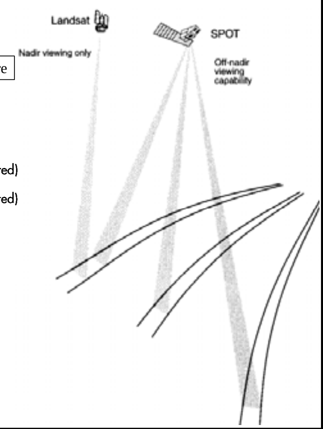
IRS LISS–III and PAN scenes



IRS 1C/1D/P6 Ground Station Network

SPOT

Satellite Probatoire d'Observation de la Terre



Multispectral mode (XS)

Band 1	0.50–0.59 µm (green)
Band 2	0.61–0.68 µm (red)
Band 3	0.79–0.89 µm (near infrared)

Band 4 (SPOT 4 only)1.58–1.75 µm (near infrared)

Panchromatic mode (P)

0.51–0.73 µm (SPOT 1, 2 and 3)
0.61–0.68 µm (SPOT 4)

Broad Area Coverage

NOAA – AVHRR

IFOV – 1.1 km (Nadir); Swath: 2,399 km
Meteorology, Climatology

- *Band 1:* 0.58–0.68 µm (red; matches TM Band 3)
- *Band 2:* 0.725–1.10 µm (near infrared; matches TM Band 4)
- *Band 3:* 3.55–3.93 µm (mid-infrared)
- *Band 4:* 10.3–11.3 µm (thermal infrared)
- *Band 5:* 11.5–12.5 µm (thermal infrared)

SeaWiFS

IFOV – 1.1 km (Nadir); Swath: 2,800 km
Noon equatorial crossing
Meteorology, Climatology & Oceanography

- *Band 1:* 0.402–0.422 µm (blue; yellow pigment/phytoplankton)
- *Band 2:* 0.433–0.453 µm (blue; chlorophyll)
- *Band 3:* 0.480–0.500 µm (blue-green; chlorophyll)
- *Band 4:* 0.500–0.520 µm (green; chlorophyll)
- *Band 5:* 0.545–0.565 µm (red; yellow pigment/phytoplankton)
- *Band 6:* 0.660–0.680 µm (red; chlorophyll)
- *Band 7:* 0.745–0.785 µm (near infrared; land–water contact, atmospheric correction, vegetation)
- *Band 8:* 0.845–0.885 µm (near infrared; land–water contact, atmospheric correction, vegetation

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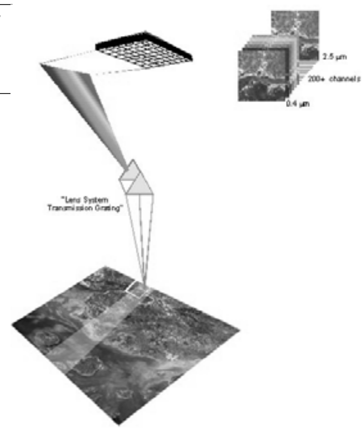
Hyperspectral Imaging

- Hyperspectral imaging has wide ranging applications in mining, geology, forestry, agriculture, and environmental management. Detailed classification of land assets through the Hyperion will enable more accurate remote mineral exploration, better predictions of crop yield, and assessments, and better containment mapping.
- NASA EO-1 Hyperion
  - Hyperion capabilities provide resolution of surface properties into hundreds of spectral bands versus less than ten multispectral bands flown on traditional RS Satellites
  - Through the large number of spectral bands, complex land eco-systems shall be imaged and accurately classified
  - The Hyperion provides a high resolution hyperspectral imager capable of resolving 220 spectral bands (from 0.4 to 2.5 µm) with a 30 meter spatial resolution and 10 nm spectral resolution. The instrument images a 7.5 km by 100 km land area per image and provides detailed spectral mapping across all 220 channels with high radiometric accuracy.

Hyperspectral Imaging



Fine Spatial Resolution Systems

IKONOS *(Image in Greek)*

April 1999; IFOV – 1 m; 0.45-0.90 µm
Swath – 11 km (Nadir); Revisit: 1.5 – 3 days

- *Band 1:* 0.45–0.52 µm (blue)
- *Band 2:* 0.52–0.60 µm (green)
- *Band 3:* 0.63–0.69 µm (red)
- *Band 4:* 0.76–0.90 µm (near infrared)

QuickBird

October 2001
IFOV – 61 cm (Pan) & 2.44 m (MSS)
Swath – 16.5 km (Nadir); Revisit: < 3 days

- *Band 1:* 0.45–0.52. µm (blue)
- *Band 2:* 0.52–0.60 µm (green)
- *Band 3:* 0.63–0.69 µm (red)
- *Band 4:* 0.76–0.890 µm (near infrared)
- *Band 5:* 0.76–0.890 µm (panchromatic)

IKONOS

Tsunami Images

Nagappattinam, India
Post-tsunami
Lat: 10.7906° N Lon: 79.8428° E

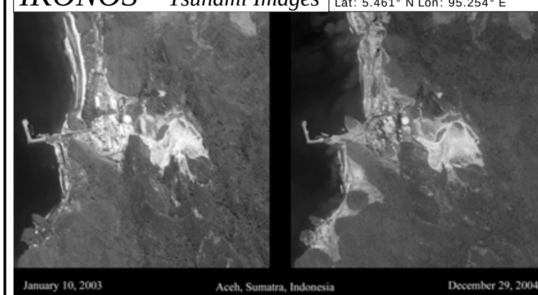
This one-meter resolution image was taken by Space Imaging's IKONOS satellite on Dec. 29, 2004 — just three days after the devastating tsunami hit. The image shows destruction and damage along the coastline of this port city of Nagappattinam, India, located 260 km (162 mi) south of Chennai (Madras).
Small homes along the shoreline have been destroyed, boats and small ships have been washed ashore, a seawall has been breached and plumes of grey smoke rise into the sky from fires.

1M IKONOS Image
Acquired: 29 December 2004

Credit "Space Imaging"
www.spaceimaging.com

IKONOS - Tsunami Images

Aceh Province, Sumatra, Indonesia
Lat: 5.461° N Lon: 95.254° E



The image shows an industrial facility, pier and shoreline along the coast south of Banda Aceh, Aceh Province, Sumatra, Indonesia.

The image shows tidal wave damage to a coastal industrial and shipping facility, washed away trees and other vegetation and damage to the road leading north from the tank farm. Lush vegetation and pristine beaches once surrounded this area.

Credit "Space Imaging/ CRISP-Singapore"
www.spaceimaging.com

Assignment #1

1. Give details of any ten operational remote sensing satellites including the following details
   a. Launch date and mission objectives
   b. Spatial, Spectral, Radiometric and Temporal resolutions of various sensors on board
   c. Any other special features of the satellite
   List of satellites should be so chosen that, there will be examples of satellites which have high resolution of one of the four characteristics listed above
   (For example: NOAA AVHRR has very high radiometric resolution; QuickBird has very high spatial resolution etc)
2. What are the advantages of using satellite imagery ? Can you identify some disadvantages ?
3. In some instances, it may be necessary to form a mosaic of several satellite scenes by matching several images together at the edges. List some of the problems that you expect to encounter as you prepare the mosaic.

Last date : 5th Sept 2016
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