**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° 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**

- 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°
    - 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)
**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.

**Geostationary & Polar Orbiting Satellites**

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

Landsat – TM Sensor Characteristics

<table>
<thead>
<tr>
<th>Band</th>
<th>Resolution</th>
<th>Special reflection</th>
<th>Sensor application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 m</td>
<td>Blue-green, 0.45–0.52 μm</td>
<td>Reflectance of clear water, bathymetry; mapping of coastal areas, chlorophyll absorption; distinction between wetlands and dry vegetation.</td>
</tr>
<tr>
<td>2</td>
<td>30 m</td>
<td>Green, 0.52–0.60 μm</td>
<td>Reflectance green radiation reflected from healthy vegetation, assesses plant vigor, reflectance from surficial water.</td>
</tr>
<tr>
<td>3</td>
<td>30 m</td>
<td>Red, 0.63–0.69 μm</td>
<td>Chlorophyll absorption important for plant-type discrimination.</td>
</tr>
<tr>
<td>4</td>
<td>30 m</td>
<td>Near infrared, 0.76–1.2 μm</td>
<td>Indicator of plant cell structure, biomass, plant vigor, complete absorption by water facilitates delineation of shorelines.</td>
</tr>
<tr>
<td>5</td>
<td>30 m</td>
<td>Mid-infrared, 1.55–1.75 μm</td>
<td>Indicators of vegetation moisture content, soil moisture mapping; distinguishing noise from clouds, penetration of thin clouds.</td>
</tr>
<tr>
<td>6</td>
<td>120 m</td>
<td>Far infrared, 10.4–12.5 μm</td>
<td>Vegetation stress analysis, soil moisture discrimination, thermal mapping, relative brightness temperature, soil moisture, plant base stress.</td>
</tr>
<tr>
<td>7</td>
<td>30 m</td>
<td>Mid-infrared, 2.08–2.35 μm</td>
<td>Discrimination of rock types, alteration zone for rocks in the thermal mapping, hydrothermal flow analysis.</td>
</tr>
</tbody>
</table>

Revisit - 16 days; Swath – 185 km

Landsat 7 (1999) – ETM+ Sensor Characteristics

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral range</th>
<th>Ground resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.450–0.515 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>2</td>
<td>0.525–0.605 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>3</td>
<td>0.630–0.690 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>4</td>
<td>0.75–0.90 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>5</td>
<td>1.55–1.75 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>6</td>
<td>10.4–12.5 μm</td>
<td>60 m</td>
</tr>
<tr>
<td>7</td>
<td>2.09–2.35 μm</td>
<td>30 m</td>
</tr>
<tr>
<td>Pan</td>
<td>0.52–0.90 μm</td>
<td>15 m</td>
</tr>
</tbody>
</table>

Revisit - 16 days; Swath – 185 km

IRS Program

- IRS 1A - 1988, IRS 1B - 1991
- IRS 1C - 1995, IRS 1D - 1997

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

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral limits</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LISS-I</td>
<td>LISS-II</td>
</tr>
<tr>
<td>1</td>
<td>Blue-green 0.45–0.52 μm</td>
<td>12.5 m</td>
</tr>
<tr>
<td>2</td>
<td>Green 0.52–0.69 μm</td>
<td>12.5 m</td>
</tr>
<tr>
<td>3</td>
<td>Red 0.63–0.69 μm</td>
<td>12.5 m</td>
</tr>
<tr>
<td>4</td>
<td>Near infrared 0.77–0.86 μm</td>
<td>12.5 m</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Band</th>
<th>Spectral limits</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blue</td>
<td>23 m</td>
</tr>
<tr>
<td>2</td>
<td>Green 0.52–0.58 μm</td>
<td>23 m</td>
</tr>
<tr>
<td>3</td>
<td>Red 0.62–0.65 μm</td>
<td>23 m</td>
</tr>
<tr>
<td>4</td>
<td>Near infrared 0.77–0.86 μm</td>
<td>23 m</td>
</tr>
<tr>
<td>5</td>
<td>Mid-infrared 1.55–1.70 μm</td>
<td>70 m</td>
</tr>
</tbody>
</table>

Band 3 is not included in this instrument, although the numbering from earlier satellites is maintained to recapitulate continuity.

IRS Sensors Details: Swath - 70 km for LISS I and 75 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**

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**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)
  - 0.51–0.68 µm (SPOT 4)

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**Broad Area Coverage**

- **NOAA – AVHRR**
  - IFOV: 1.1 km (Nadir); Swath: 2,399 km
  - 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: 10.3–11.1 µm (thermal infrared)
  - Band 5: 11.5–12.5 µm (thermal infrared)

- **SeaWiFS**
  - IFOV: 1.1 km (Nadir); Swath: 2,309 km
  - Near equatorial crossing
  - Meteorology, Climatology & Oceanography
  - Band 1: 0.40–0.42 µm (blue; chlorophyll)
  - Band 2: 0.433–0.453 µm (blue; chlorophyll)
  - Band 3: 0.488–0.510 µm (blue-green; chlorophyll)
  - Band 4: 0.500–0.520 µm (green; chlorophyll)
  - Band 5: 0.545–0.565 µm (red; chlorophyll)
  - Band 6: 0.685–0.698 µm (red; chlorophyll)
  - Band 7: 0.765–0.775 µm (near infrared; land-water contrast, atmospheric correction, vegetation)
  - Band 8: 0.845–0.885 µm (near infrared; land-water contrast, 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 ecosystems 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.
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
E-mail submission: nagesh@civil.iisc.ernet.in