Remote Sensing Platforms

Remote Sensing Platforms - Introduction
• Allow observer and/or sensor to be above the target/phenomena of interest

• Two primary categories
  – Aircraft
  – Spacecraft

• Each type offers different characteristics, advantages & disadvantages in terms of range, cost, stability, frequency, and scale

Types of Platforms
• Stationary
  – Hand-held / cranes
  – Captive/tethered balloons
  – Manned and unmanned
  – Useful for acquiring low altitude imagery with frequent coverage for dynamic phenomena
  – Relatively inexpensive, stable

• Lighter-than-air
  – Free floating balloons
    • Restricted by atmospheric conditions
    • Used to acquire meteorological/atmospheric data
  – Blimps/dirigibles
    • Major role - news media/advertisers

• Helicopters
  – Can pin-point locations
  – Lack stability and vibrate

Unmanned Vehicles

Types of Platforms
• Aircraft
  – Platform type most often used to acquire aerial imagery

  – Requirements:
    • Requisite speed
    • High rate of climb
    • Stability in flight
    • Unobstructed view for navigation and identification of landmarks
    • Range commensurate with size of project
    • Ceiling higher than highest altitude specified
    • Capable of remaining in air long enough to take advantage of suitable photographic time
    • Can accommodate equipment
Low Altitude Aircraft
- Generally operate below 30,000 ft
- Most widely used are single engine or light twin engine
- Imagery can be obtained by shooting out the window or placing camera mount on window or base of aircraft
- Suitable for obtaining image data for small areas (large scale)

High Altitude Aircraft
- Operate above 30,000 ft
- Includes jet aircraft with good rate of climb, maximum speed, and high operating ceiling
- Stable
- Acquire imagery for large areas (smaller scale)
  - e.g., NHAP, NAPP, AVIRIS

U-2/ER-2
- Lockheed U-2 high altitude reconnaissance aircraft. Many U-2s are still in service as earth resource observation aircraft.

Advantages/Disadvantages of Aircraft
- Advantages
  - Acquire imagery under suitable weather conditions
  - Control platform variables such as altitude
  - Time of coverage can be controlled -- flexibility
  - Easy to mobilize
- Disadvantages
  - Expensive – primarily cost of aircraft
  - Less stable than spacecraft
    - Drift off course
    - Random attitude changes (turbulent motions)
    - Motion blurring

Types of Platforms – Spacecraft
- Numerous programs
- Manned and unmanned systems

Range
- Range for spacecraft is determined by orbit, which is fixed in altitude and inclination
  - Sun synchronous – near polar; cross equator at approximately same local time each day
  - Geostationary – fixed orbit over equator; primarily meteorological systems
Aerial Photographic Systems

Aerial Support Hardware

- Used to improve quality of imagery by
  - Reducing effect of platform motion
  - Keeping attitude constant
- Image motion compensator
  - Moves film in same direction as aircraft at speed proportional to aircraft velocity
- Gyro Stabilization
  - Stabilizes camera within plane to keep it pointing at nadir
  - Adjusts orientation of camera if attitude of plane shifts

Panchromatic vs. Infrared Signatures

Color Theory

- Primary colors
  - Red
  - Blue
  - Green
- Color characteristics
  - Hue – dominant \( \lambda \) (color)
  - Saturation – purity of color
  - Intensity (value) – light/dark

Spectral Sensitivity – Color IR Film

- Color-Infrared Film
  - Contains 3 emulsion layers sensitive to green, red, or NIR light (0.5 – 0.9 \( \mu \)m)
  - Filter used to block blue light
Aerial Cameras - Digital

- During exposure, lens focuses light on bank of detectors
- Exposure causes an electrical charge that is related to amount of incident energy
- Electrical signal (analog) is converted to a digital brightness value

- Uses area array of solid-state charge-coupled-device (CCD) detectors in place of film

Aerial Cameras – Digital (cont)

- Single chip camera
  - Uses single full-frame CCD
  - Filter is placed over each pixel to capture red/green/blue or NIR/red/green wavelengths

- Three or Four camera system
  - Use 3 or 4 separate full-frame camera/CCDs
  - Each sensitive to different wavelength

Airborne Data Acquisition and Registration (ADAR)
Satellite-based Systems:
LANDSAT & SPOT

Landsat – Satellite
• Weight ~ 2200 kg (5000 lbs)
• Length ~ 4.5 m (14 ft)
• Width ~ 3 m (9 ft)

Landsat – Orbit
• Sun synchronous, near polar
• ~ 705 km altitude
• 9:42 am equator crossing
Landsat Worldwide Reference System
- Location over earth catalogued by WRS path/row
- Each scene covers 185 km (wide) by 170 km (long)

Landsat - Thematic Mapper (TM)
- Introduced on Landsat 4 (1982)
- Improvement over MSS on Landsat 1-3
  - Spectral – extended spectral region – visible, NIR, mid-IR and thermal
  - Spatial – 30m vs. 80m (120m for thermal)
  - Radiometric – 8-bit vs. 6-bit
  - Temporal – 16 day (Landsat 1-3, 18 day)
  - *note* MSS continued on Landsat 4 & 5

MSS vs. TM Imagery
SPOT Satellite System

- Satellite Pour l’Observation de la Terre (SPOT)
- French Space Agency & other European countries

SPOT – Launch Vehicle

- Ariane rocket – European design & manufacture
- Launch site – French Guiana

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SPOT HRV Design & Operation

- HRV (High Resolution Visible)
- Linear array 'pushbroom' system
  - Mirror focuses reflected energy on bank of detectors arranged side-by-side and perpendicular to satellite orbit track
  - A line of data is obtained by sampling detectors along the array

SPOT Sensors

- SPOT 1 – 3
  - two HRV sensors
- SPOT 4 & 5
  - two HRV sensors
  - Vegetation sensor

- HRV sensor (High Resolution Visible)
  - panchromatic
  - multi-spectral

- VEGETATION sensor
  - multi-spectral
SPOT HRV - Panchromatic

- Panchromatic (PAN)
- Spatial resolution: 10 m
- Spectral resolution: 0.51 – 0.73 μm

SPOT HRV – Multispectral

- Multispectral (XS)
- Spatial resolution: 20 m
- Spectral resolution:
  - 0.50-0.59 μm
  - 0.61-0.68 μm
  - 0.79-0.89 μm
  - 1.58-1.75 μm
  (SWIR band added to SPOT 4)

SPOT - Pointability

- Increased imaging frequency

SPOT – Pointability (cont)

- Stereoscopic imaging

Other Satellite Systems
**NASA EOS – Earth Observing System**

- Integrated experiment to study earth as a system
- Planned as imaging and non-imaging instruments on series of satellites to study different science objectives
- EOS AM-1, renamed Terra launched in 1999
- EOS PM-1, renamed Aqua launched in 2002
- Sensors include MODIS, ASTER, MISR, CERES, MOPITT

**Remote Sensing Data available in San Diego 2007 Wildfires**

- Areal Photos (NEOS – a light weighted aircraft),
  - UAV (NASA's Ikhana unmanned aircraft )
    - MODIS (NASA)
  - FORMOSAT-2 (Taiwan's NSPO)
    - EO-1 (NASA)
    - IKONOS (commercial)
    - SPOT (commercial)
    - QuickBird (commercial)
    - GOES-W (NASA)

**NASA Uninhabited Aerial Vehicles (UAVs) -- Ikhana**


- MODIS (Terra and Aqua) 250m, 500m (daily)
- EO-1 (30m) – 16 days (not daily)
- Ikhana (UAV) (small coverage)
- NASA GOES-W (b/w, very low resolution)

**FORMOSAT-2 Imagery**

(high resolution, daily, large coverage, nature-color composites)

November 8-19, 2007, FORMOSAT-2
Near Real Time Support

FORMOSAT

NTNU FS IADC

NSPO Tasking

NSPO Downlink & Preprocess

Image Interpreter

NTNU FS IADC Image Processing

High Resolution Systems

- Commercial
  - Space Imaging – IKONOS
  - EarthWatch – QuickBird
  - OrbImage – OrbView3
    - Linear array pushbroom
    - 0.6 - 4 m spatial resolution
    - ~ 10 x 10 km coverage per image
    - Visible, NIR, and Pan bands
    - High revisit (pointable)
    - Stereo coverage

Extent of Coverage

- Ground area covered by a single image

Image Products

- Film Transparencies
- Digital Products
  - Tape or CD
    - Some minimum level of processing performed
- Enhanced data products
  - Data stretches, edge enhancements, transforms, derived data

On-screen Display

- red band
- green band
- blue band
- spectrally mixed
On-screen Display (cont.)

**True Color**

**False Color IR**

**False Color**

*LandSat 7 Image of Palm Spring, CA 30 x 30 m (bands 4,3,2 = RGB)*

*Jensen, 2000*

*IKONOS Panchromatic Stereopair of Columbia, SC Airport*

November 15, 2000

*IKONOS Imagery of Columbia, SC Obtained on October 28, 2000*

Panchromatic 1 x 1 m Pan-sharpened multispectral 4 x 4 m