Remote Sensing Platforms

Remote Sensing Platforms - Introduction

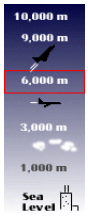
- Allow observer and/or sensor to be above the target/phenomena of interest
- Two primary categories
  - Aircraft
  - Spacecraft
- Each type offers different characteristics, advantages & disadvantages in terms of range, cost, stability, frequency, and scale

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



Types of Platforms



- 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

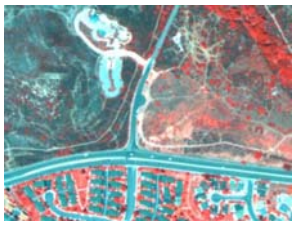



Types of Platforms

- 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.

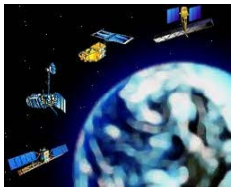
Jensen, 2000

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

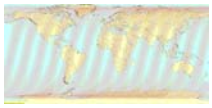
Types of Platforms – Spacecraft

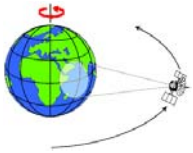
- Numerous programs
- Manned and unmanned systems



Range

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

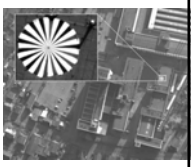




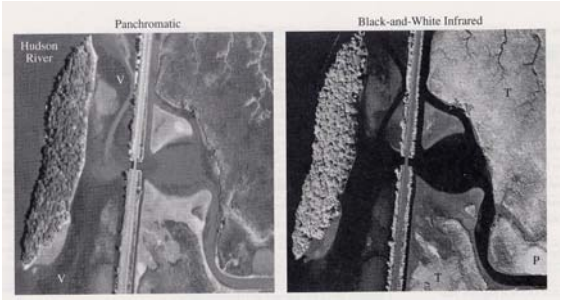
Aerial Photographic Systems

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

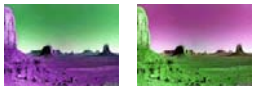


Color Theory

- Primary colors
  - Red
  - Blue
  - Green

- Color characteristics
  - Hue – dominant λ (color)
  - Saturation – purity of color
  - Intensity (value) – light/dark

Hue

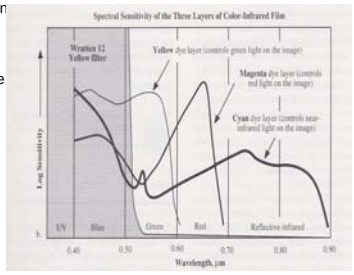


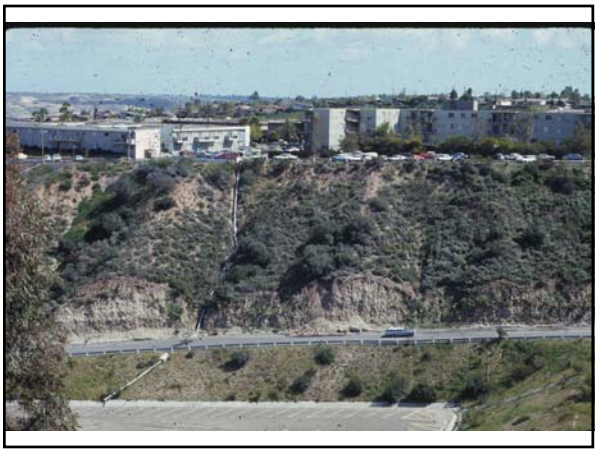
Saturation

Intensity

Spectral Sensitivity – Color IR Film

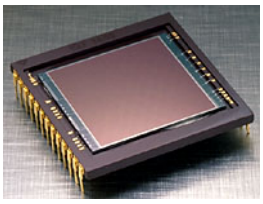
- Color-Infrared Film
  - Contains 3 emulsion layers sensitive to green red, or NIR light (0.5 – 0.9 μm)
  - Filter used to block blue light

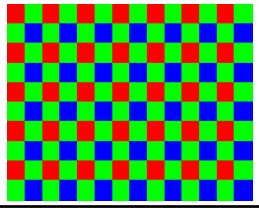




Aerial Cameras - Digital

- 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

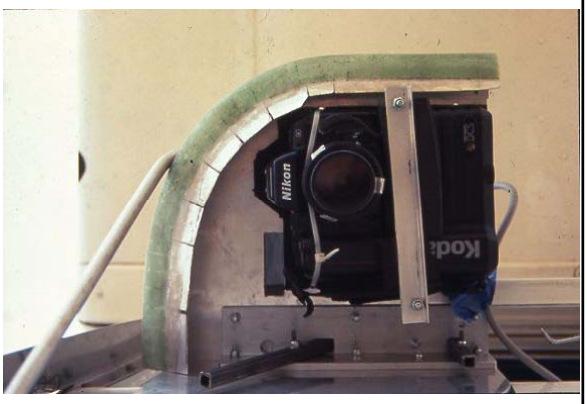


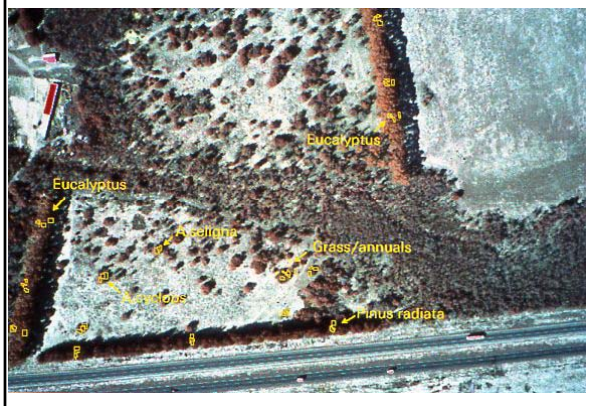


Aerial Cameras – Digital (cont)

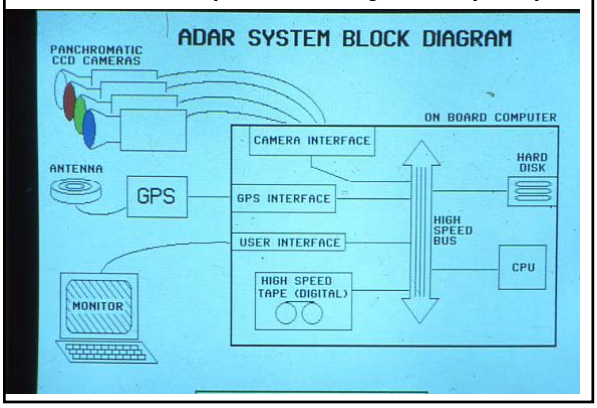
- Single chip camera
  - Uses single full-frame CCD
  - Filter is placed over each pixe capture red/green/blue or NIR/red/green wavelengths

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

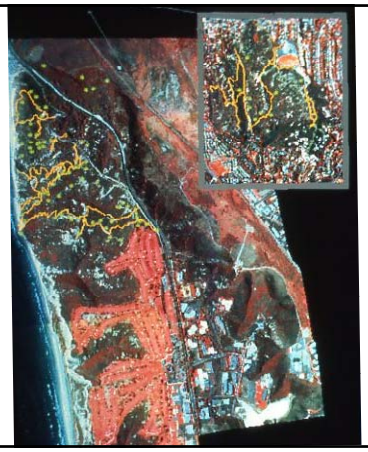




Airborne Data Acquisition and Registration (ADAR)

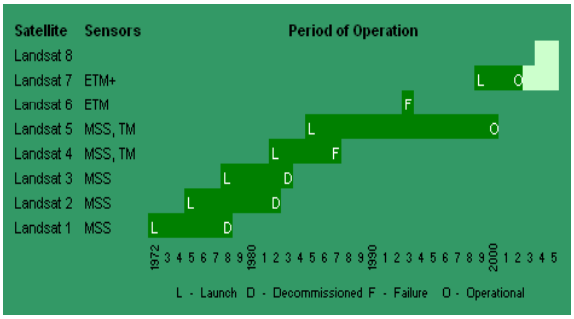


ADAR 5500 System



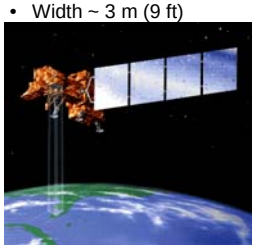
Satellite-based Systems:
LANDSAT & SPOT

Landsat System - History



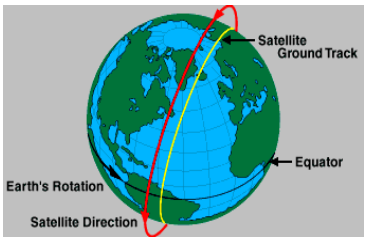
Landsat – Satellite

- Weight ~ 2200 kg (5000 lbs)
- Length ~ 4.5 m (14 ft)
- Width ~ 3 m (9 ft)



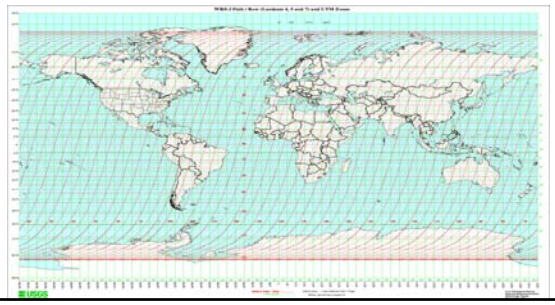
Landsat – Orbit

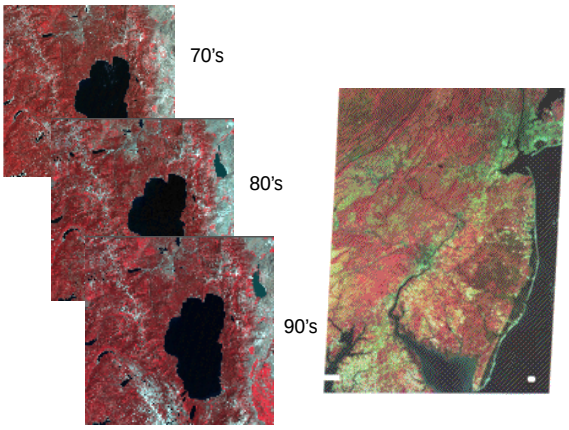
- Sun synchronous, near polar
- ~ 705 km altitude
- 9:42 am equator crossing



Landsat Worldwide Reference System

- Location over earth catalogued by WRS path/row
- Each scene covers 185 km (wide) by 170 km (long)

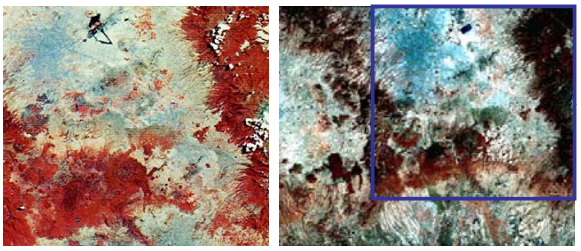




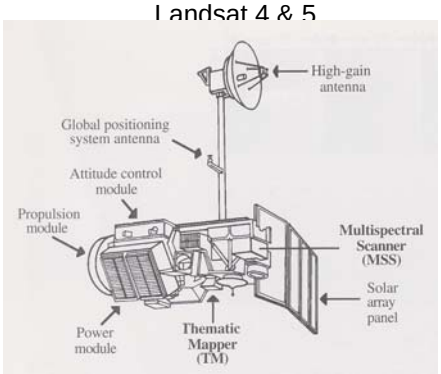
Landsat - Thematic Mapper (TM)

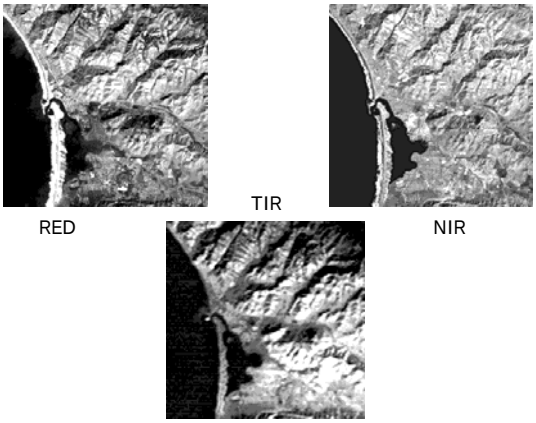
- Introduced on Landsat 4 (1982)
- Improvement over MSS on Landsat 1-3
  - Spectral – extended spectral region – visible, NIR, mid-IR and thermal
  - Spatial – 30m vs. 80m (120m for thermal)
  - Radiometric – 8-bit vs. 6-bit
  - Temporal – 16 day (Landsat 1-3, 18 day)
  - *note* MSS continued on Landsat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

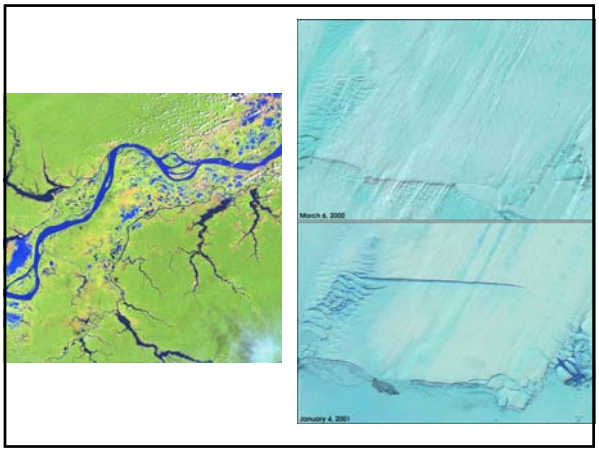
MSS vs. TM Imagery



Landsat 4 & 5

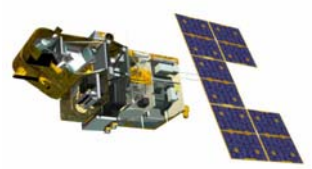






SPOT Satellite System

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



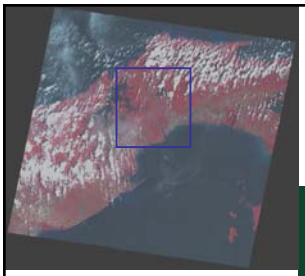
SPOT – Launch Vehicle

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

Satellite	Sensors	Period of Operation
SPOT 5		L
SPOT 4	MONO, Xi	L O
SPOT 3	PAN, XS	L F
SPOT 2	PAN, XS	L O
SPOT 1	PAN, XS	L N

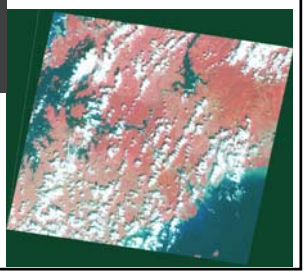
1986 7 8 9 1990 1 2 3 4 5 6 7 8 9 2000 1 2 3 4 5

L - Launch F - Failure O - Operational N - Not used



Landsat-TM

SPOT-XS



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

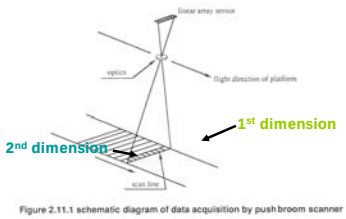
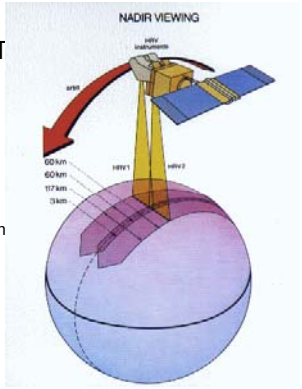


Figure 2.11.1 schematic diagram of data acquisition by push broom scanner

SPOT

- 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



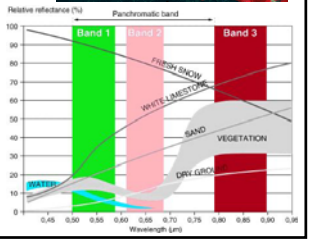
SPOT HRV - Panchromatic

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

SPOT HRV – Multispectral

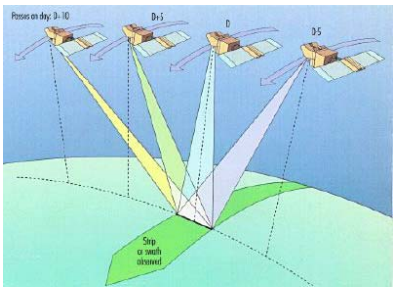
- Multispectral (XS)
- Spatial resolution: 20 m
- Spectral resolution
  - 0.50-0.59 μm
  - 0.61-0.68 μm
  - 0.79-0.89 μm
  - 1.58-1.75 μm

  (SWIR band added to SPOT 4)



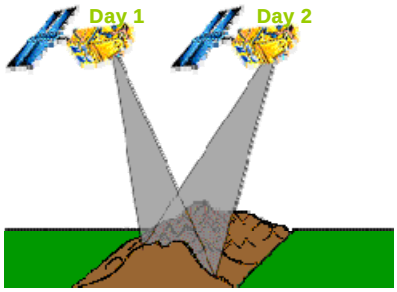
SPOT - Pointability

- Increased imaging frequency

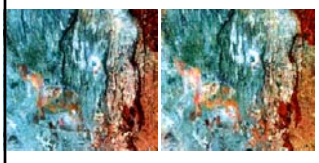


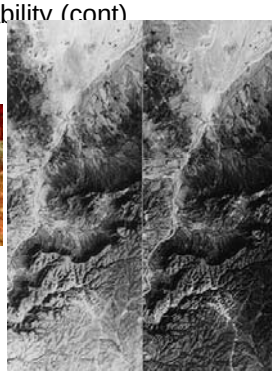
SPOT – Pointability (cont)

- Stereoscopic imaging



SPOT Pointability (cont)





Other Satellite Systems

NASA EOS – **Earth Observing System**

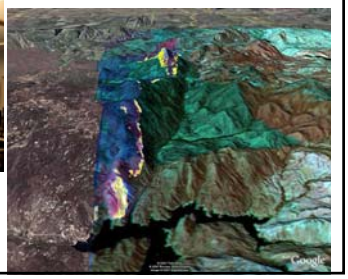
- Integrated experiment to study earth as a system
- Planned as imaging and non-imaging instruments on series of satellites to study different science objectives
- EOS AM-1, renamed **Terra** launched in 1999
- EOS PM-1, renamed **Aqua** launched in 2002
- Sensors include **MODIS**, ASTER, MISR, CERES,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

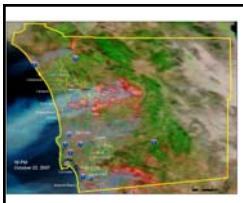
Remote Sensing Data available in San Diego 2007 Wildfires

- 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)

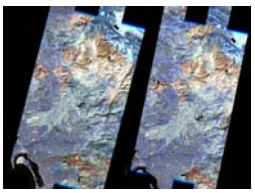
NASA Uninhabited Aerial Vehicles (UAVs) -- Ikhana

http://www.nasa.gov/centers/dryden/news/Features/2007/wildfire_socal_10_07.html

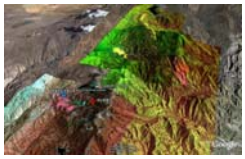




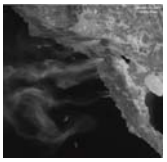
MODIS (Terra and Aqua) 250m, 500m (daily)



EO-1 (30m) – 16 days (not daily)



Ikhana (UAV) (small coverage)

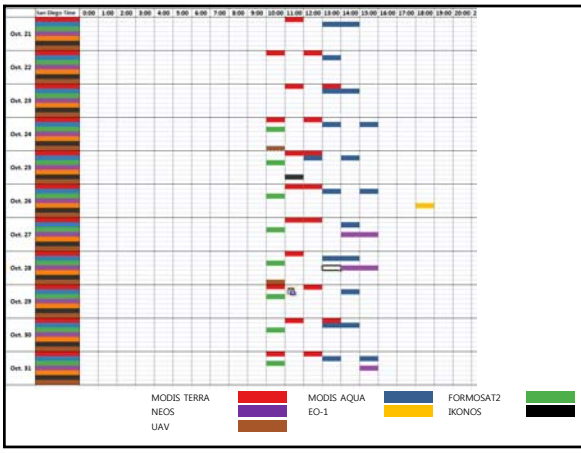


NASA GOES-W
(b/w, very low resolution)

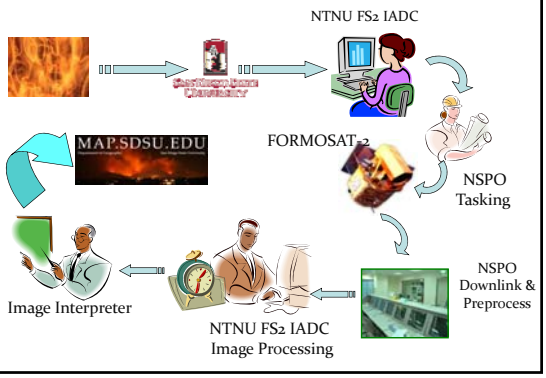
FORMOSAT-2 Imagery

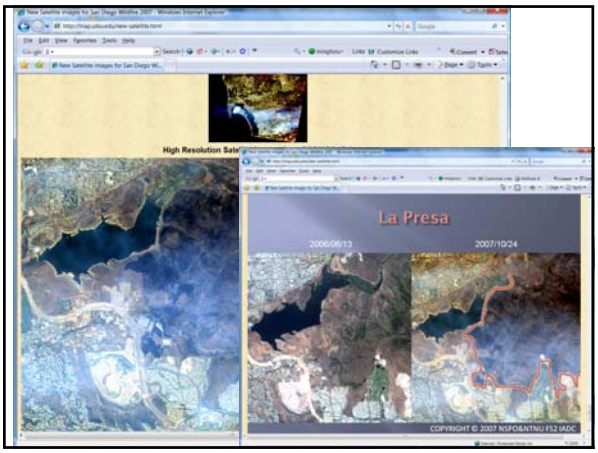
(high resolution, daily, large coverage, nature-color composites)

November 8-19, 2007, FORMOSAT-2



Near Real Time Support





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

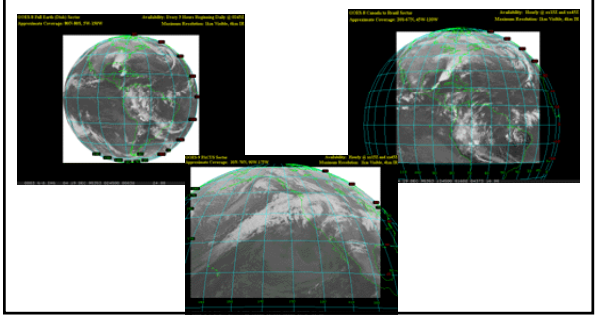
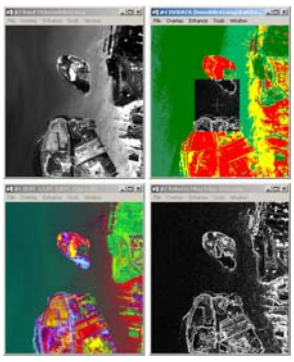
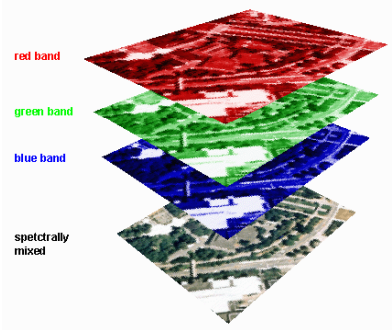


Image Products

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



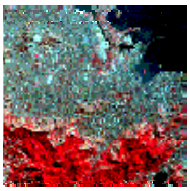
On-screen Display



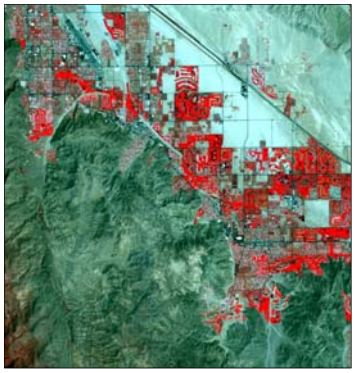
On-screen Display (cont.)

True Color

False Color IR

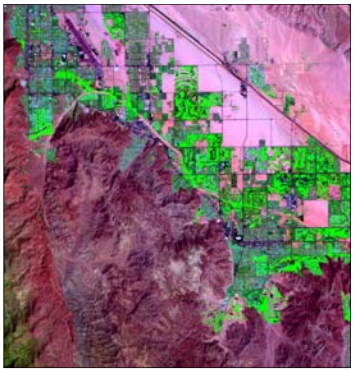


False Color



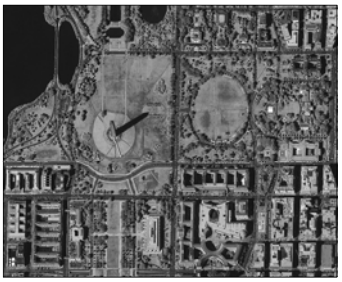
Landsat 7 Image of Palm Spring, CA
30 x 30 m
(bands 4,3,2 = RGB)

Jensen, 2000



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

Jensen, 2000

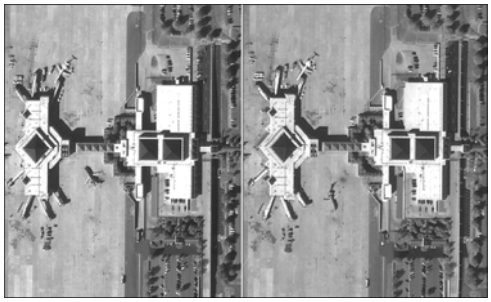


IKONOS Panchromatic Images of Washington, DC

1 x 1 m spatial resolution

Jensen, 2000

IKONOS Panchromatic Stereopair of Columbia, SC Airport



Jensen, 2000

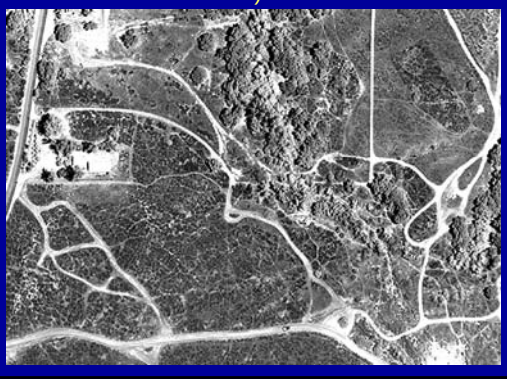
November 15, 2000

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

Panchromatic 1 x 1 m

Pan-sharpened multispectral 4 x 4 m

QuickBird Panchromatic Satellite Imagery (0.6 m)



QuickBird Pan-Sharpened Satellite Imagery (0.6 m)

QuickBird Panchromatic Satellite Imagery (0.6 m)

QuickBird Pan-Sharpened Satellite Imagery (0.6 m)