Quick History of Remote Sensing

Galileo: 1609
His most stunning (and controversial!) discovery was of satellites orbiting Jupiter, dashing the concept of an Earth-centered universe with all objects revolving around the Earth.

Professor Thaddeus Lowe, 1861
In 1861, Lowe went up in a balloon near Cincinnati Ohio, to make weather observations. Unfortunately, strong winds carried him to South Carolina, where he was arrested by the Confederacy as a Union spy.

Eventually released, he believed that tethered balloons could be used for reconnaissance. After viewing a demonstration, President Lincoln agreed and authorized the US Army Balloon Corps in 1862. Despite its advantages, the unit was deactivated in 1863. Balloons had a not-surprising tendency to draw enemy fire.

The Bavarian Pigeon Corps: 1903
Realizing that balloons were dangerous as observation posts, and the use of kites were uncertain, an innovative attempt was to attach a light camera to a carrier pigeon. These cameras took a picture every thirty seconds as the pigeon winged its way along a straight course to its home shelter. Releasing the birds behind enemy lines presented a problem, as the pigeons were rather sticky to hungry troops who shot them down.

The problem of random flight paths and tasty pigeons was solved by two bicycle repairmen in Ohio.

Photos from an Aeroplane: 1909
The first photographs from an aircraft were taken by L. P. Bonvillain, a passenger of Wilbur Wright, during a demonstration flight in France.

The first motion picture was taken by an Italian photographer accompanying Wilbur on a later flight.

Value during war time
By the end of World War I, the value of aerial reconnaissance was obvious to both sides of the conflict. By the last offensive, the Germans were collecting over 4,000 pictures per day and during the last four months, the US Army collected over 1 million.

Balloons are still used today for low level remote sensing.
In this example, a Canon Rebel, 8mb camera is suspended from a weather balloon and pulled by a vehicle.

Gaspard Felix Tournachon, 1859
The First Aerial Photographer, Tournachon, also known as Nadar, was a famous French photographer and balloonist whose goal was to make land surveys from aerial photographs. Although not particularly successful, he did catch the eye of the military.
Constance Baddington Smith, a Royal Air Force photo interpreter was one of the first to prove the value of aerial photos to identify top-secret activities of the other side using stereo photography. At first she did not know what she was looking at. She was the first to identify a launching site of the V-1 Buzz Bomb at the German experimental station at Peenemunde on the Baltic Coast.

The photo at the right is of a V-2 launching ramp. The V-2 Rocket is the predecessor of the launch vehicles we use today to launch remote sensing platforms – among other things.

The photo at the right is of a V-2 launching ramp. The V-2 Rocket is the predecessor of the launch vehicles we use today to launch remote sensing platforms – among other things.

The Global Hawk UAV belongs to a new series of advanced and autonomous remote sensing platforms able to fly across the globe with little or no supervision.

The Global Hawk UAV belongs to a new series of advanced and autonomous remote sensing platforms able to fly across the globe with little or no supervision.

Able to fly at 80,000 feet ASL, these new UAV’s are lightweight, autonomous, and can carry significant payloads for it’s size and weight.

With a 247 foot wingspan, Helios can fly to above 93,000 feet ASL. Future models will be designed to stay aloft for more than 6 months. The Helios weighs approximately 1,600lbs which translates to about .81lbs/sq. ft. of wing. The top speed is 27mph with a take-off speed of ~15 mph. The aircraft is solar powered with a polymer-electrolyte (oxygen/hydrogen) fuel cell for night time activity.

Apollo 8 returned the first pictures of the Earth from deep space (1968). Images from the Apollo 9 multispectral four-lens camera were digitized and used to develop techniques for processing Landsat data, which, in 1969, was still four years away.
Civilian Satellite Remote Sensing: 1972
Earth Resources Technological Satellite (ERTS-1)

Renamed as Landsat (Land Satellite), this program has been in continuous operation since July of 1972 providing images of the earth every 14-16 days. The current platform is Landsat 7 which may be the last of the series.

Landsat MSS

- On Landsat 1, 2, 3, 4, 5
- Spatial Resolution: 80m
- Radiometric Resolution: 
- Spectral Resolution: 4 spectral bands - Green, Red, and NIR
- 570 mile orbit (for Landsat 1, 2, 3) Oscillating mirror
- One swath = 185 km x 474 km
- Each spectral band has 6 detectors
- 474 Meters / 6 Detectors = 79 Meter ground resolution

NOAA-AVHRR

Advanced Very High Resolution Radiometer
Onboard NOAA's Polar Orbiting Environmental Satellite (POES) platform
Visible, NIR, Thermal
1.1 km Resolution - local area coverage (LAC)
4 km Resolution - global area coverage (GAC)
Used for meteorological studies
Gaining popularity for global modeling
Broad spectral bands
Not ideally suited for vegetation but used to determine general patterns.

The NOAA-AVHRR is the only sensor that provides daily views of the entire globe. Successive images taken during a 10-day span are routinely mosaicked to generate a cloud free image of the Earth. These images are used to track vegetation patterns over the span of a year. This facilitates global modeling efforts.

Multiple images per year provides analysis of vegetation growth

QuickBird

Little Cottonwood Canyon (Snowbird and Alta, Utah) 280mi ASL, 2.3ft resolution

While not suitable for large scale applications, this data provides a regional estimate of biomass and is routinely used for wildland fire management.
An overriding strategy of remote sensing organizations is to integrate various sensors trained at different surface and atmospheric features to understand the parts that make up the Earth System.

Image taken from NASA promotional material

Commercial industry moving toward spatial resolution and competition with aerial photography

Public sensors moving towards increased spectral and radiometric resolution and focusing applications on earth based research

Digital Aerial Orthophotography (B/W)

Digital Orthophotoquads

Complete, State-Wide Coverage of Utah and Most other States

From Virtual Utah http://earth.gis.usu.edu/utah
Digital Color Orthophotography
NAIP (Nat. Color and NIR)

NAIP Color 1 meter imagery for Utah
Complete, State-Wide Coverage of Utah and Most other States
From Virtual Utah http://earth.gis.usu.edu/utah

Benefits of Temporal 1 Meter Imagery

Landsat TM
- On Landsat 4,5, & 7
- Spatial Resolution: 30/120 and 15/30/90 (L7)
- Radiometric Resolution: 256
- Spectral Resolution: 7 spectral bands: Blue/Green, Green, Red, NIR, MIR, MIR, Thermal
- 420 mile orbit
- Oscillating mirror design acquires data with each sweep in both directions
- One swath = 185 km x 474 m
- Each spectral band has 16 detectors except for the thermal band which has 4 detectors.
- 474 Meters / 16 Detectors = 29.625 Meter Ground Resolution
- 474 Meters / 4 Detectors = 118.5 Meter Ground Resolution Thermal
- 16 day repeat cycle

SPOT - 4
- HRV - High resolution visible
- March 24, 1998 launch date
- Spatial Resolution: 20m color/ 10m b/w
- Spectral Resolution: 4 spectral bands: Blue, Green, Red, NIR
- Radiometric Resolution: 256
- 832 km orbit
- Repeat Interval: 36 days vertical/ 2.5 days oblique
- Sensor Type: Linear array (push-broom)
- Panchromatic - 6,000 pixels/line
  - 0.51 - 0.73 µm
- Multispectral - 3,000 pixels/line
  - 0.50 - 0.59 µm Green
  - 0.61 - 0.68 µm Red
  - 0.79 - 0.89 µm NIR
  - 1.58-1.75 µm Short Wave Infrared
- One swath = 60 km
- 2 HRV’s that can be positioned two ways
- Large swath (both HRV’s combined)
- Off-nadir up to 27 Degrees

Satellite Probatoire d’ Observation de la Terre (SPOT)
- www.spot.com
- One swath = 60 km
- 2 HRV’s that can be positioned two ways
- Large swath (both HRV’s combined)
- Off-nadir up to 27 Degrees
Indian Remote Sensing (IRS)

- Panchromatic: Pan 0.5-0.75 µm, 2.5 m spatial resolution, 70 km swath, Stereo, Repeat coverage: 24 days at equator
- IRS-1C 1995:
  - WFS: 0.62-0.68 µm
  - NIR: 0.77-0.86 µm
  - Repeat coverage: 5 days at equator

Contact Information:
www.spacesimaging.com

The Multi-angle Imaging SpectroRadiometer (MISR)

- MISR is the world's first commercial micro-meter resolution 3D and 4 meter color Earth-observing satellite. MISR will enable us to produce imagery that can be used in a variety of research and commercial applications, including urban planning, and terrestrial monitoring, supporting natural disaster assessment.

- The change in reflection at different view angles, and how different types of atmospheric particles (aerosols), cloud forms, and land-surface covers can be seen at different wavelengths; in the right image color variations show how these wavelengths; in the right image color variations show how different parts of the scene reflect light differently at blue, green, and red view angles.

http://www-nssdc.gsfc.nasa.gov/planetary/MISR.html

Clouds and the Earth’s Radiant Energy System Experiment (CERES)

- CERES products include both solar reflected and Earth-emitted radiation from the top of the atmosphere to the Earth’s surface.
- Indian Remote Sensing (IRS) data, which build upon the foundation laid by previous missions, will lead to a better understanding of the role of clouds and the energy cycle in global climate change.
- The Multi-angle Imaging SpectroRadiometer (MISR) will provide a unique perspective on cloud properties and their impact on climate by measuring the scattering of sunlight by clouds at different view angles.
Measurements of Pollution in the Troposphere (MOPITT)

During the five-year mission, MOPITT will continuously scan the atmosphere below it to provide the world with the first long-term, global measurements of carbon monoxide and methane gas levels in the lower atmosphere.

http://www.science.sp-agency.ca/J1-MOPITT(Eng).htm

This MOPITT image shows the relative amount of CO over North America from March 5-7, 2000.

http://visibleearth.nasa.gov/Sensors/Terra/MOPITT.html

The Moderate Resolution Imaging Spectroradiometer (MODIS)

The MODIS Instrument will view the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands. These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS will play a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.

http://modis.gsfc.nasa.gov/

April 28th, 2004
Fires in China and Russia caused mostly by agricultural burning captured by the Moderate Resolution Imaging Spectrometer (MODIS).

April 28th, 2004
Dust storm in Nevada captured by the Moderate Resolution Imaging Spectrometer (MODIS).

Flooding along the Mississippi River, Arkansas

April 17th, 2004

April 27th, 2004

Temporal Frequency of MODIS

September 1, 2007
September 2, 2007
September 3, 2007
September 4, 2007
September 5, 2007
September 6, 2007
The primary objective for the ASTER mission is to obtain high spatial resolution global, regional and local images of the Earth in 14 spectral bands.

ASTER is a cooperative effort between NASA and Japan's Ministry of International Trade and Industry, with the collaboration of scientific and industry organizations in both countries. The ASTER instrument consists of three separate instrument subsystems, each dedicated to a different spectral region and has its own telescope(s).

The JERS-1 mission is focused on Earth resources, geology, agriculture, forestry, land use, sea ice monitoring and coastal monitoring. It is a box type satellite in a sun synchronous sub-recurrent orbit.

The RADARSAT system was developed under the management of the Canadian Space Agency (CSA) in cooperation with provincial governments and the private sector.

At the heart of RADARSAT is an advanced radar sensor called Synthetic Aperture Radar (SAR). SAR is a microwave instrument that sends pulsed signals to Earth and processes the received reflected pulses.