Landsat: A Global Land-Observing Program

The Landsat Program is a joint effort of the U.S. Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) to gather Earth resource data using a series of satellites. NASA was responsible for developing and launching the spacecrafts. The USGS is responsible for flight operations, maintenance, and management of all ground data reception, processing, archiving, product generation, and distribution. A primary objective of the Landsat Program is to ensure a collection of consistently calibrated Earth imagery.

Landsat's mission is to establish and execute a data acquisition strategy that ensures the repetitive acquisition of observations over the Earth's land mass, coastal boundaries, and coral reefs and to ensure that the data acquired are of maximum utility in supporting the scientific objective of monitoring changes in the Earth's land surface.

A Brief History of the Landsat Program

In the mid-1960s, stimulated by success in planetary exploration using unmanned remote sensing satellites, the Department of the Interior, NASA, the Department of Agriculture, and others embarked on an ambitious initiative to develop and launch the first civilian Earth-observing satellite to meet the needs of resource managers and earth scientists. The USGS assumed responsibility for archiving the data acquired by the new program and for distributing the anticipated data product.

On July 23, 1972, NASA launched the first in a series of satellites designed to provide repetitive global coverage of the Earth's land masses. Landsat, originally named "ERTS" for Earth Resources Technology Satellite, has continued to provide high-quality, moderate-resolution data depicting the land and coastal regions of the planet. As a result of subsequent satellites launched in the Landsat series, there is a continuous set of Landsat data from mid-1972 until the present.

NASA was responsible for operating the system through the early 1980s, with the USGS having responsibility for archiving the data and producing image products. In January 1983, a plan was made to transfer operation of the Landsat Program to the private sector. The first step of this plan required transfer of the Landsat system operation to the Landsat Commercialization Division of the National Oceanic and Atmospheric Administration (NOAA). In October 1985, the Earth Observation Satellite Company (EOSAT), now Space Imaging, assumed responsibility for Landsats 4 and 5 under contract to NOAA. This contract was transferred to the USGS in 1998, but Space Imaging continued to operate Landsats 4 and 5 until mid-2001, when it returned responsibility to the U.S. Government. Throughout these changes, the USGS retained primary responsibility for long-term preservation as the Government archive of Landsat data. The Landsat Program underwent additional management changes with the passage of the Land Remote Sensing Policy Act of 1992. This act, which returned Landsat Program management to the Government under joint management of the Department of Defense (specifically, the U.S. Air Force (USAF)) and NASA, created the legislative mandate for the National Satellite Land Remote Sensing Data Archive and assigned this responsibility to the Department of the Interior.

Landsat Program management structure changed repeatedly from 1992 through 1998, from NASA/USAF/USGS to NASA/NOAA/USGS to NASA/USGS. The USGS assumed operational responsibility for the Landsat Program in 1999, but NASA continued flight operations for Landsat 7 until 2000, when the USGS implemented a new flight operations contract. In mid-2001, the USGS also assumed responsibility for Landsats 4 and 5 flight operations.

Satellite	Launched	Decommissioned	Sensors
Landsat 1	July 23, 1972	January 6, 1978	MSS and RBV*
Landsat 2	January 22, 1975	February 25, 1982	MSS and RBV*
Landsat 3	March 5, 1978	March 31, 1983	MSS and RBV*
Landsat 4	July 16, 1982	June 30, 2001	MSS and TM
Landsat 5	March 1, 1984	(Operational)	MSS and TM
Landsat 6	October 5, 1983	(Did not achieve orbit)	ETM**
Landsat 7	April 15, 1999	(Operational)	ETM+**

*The return beam vidicom (RBV) was essentially a television camera and did not achieve the popularity of the MSS sensor.

**The sensor onboard Landsat 6 was called the enhanced thematic mapper (ETM). Landsat 7 carries the enhanced thematic mapper plus (ETM+)

Characteristics of the Landsat System

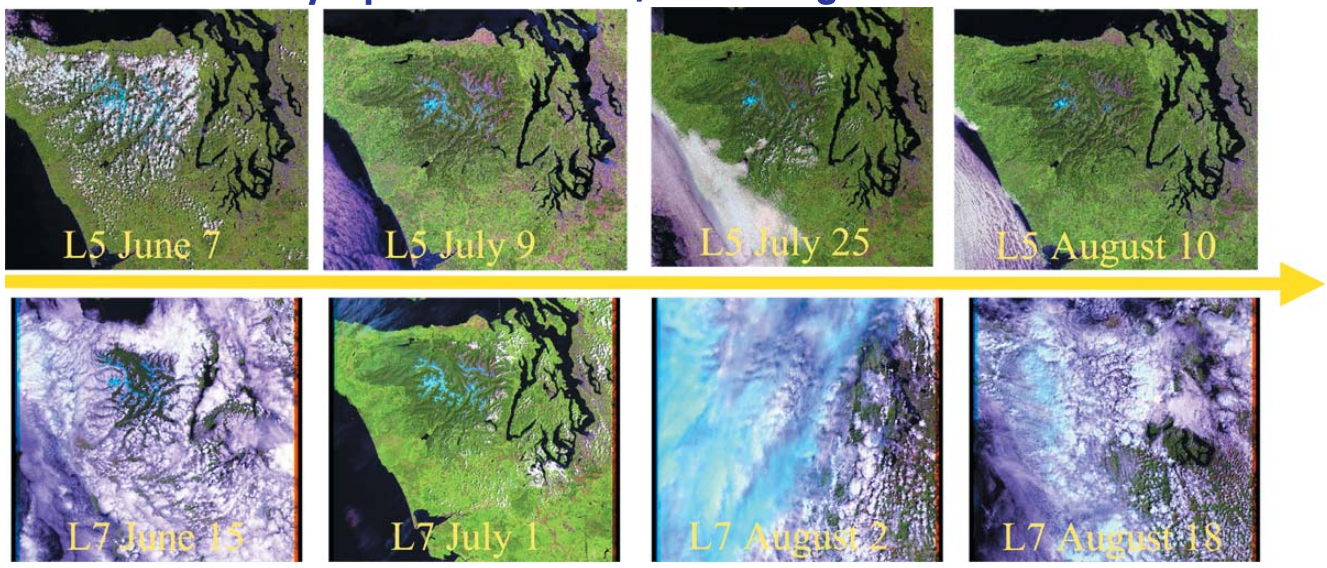
All Landsat satellites have flown in a Sun-synchronous orbit. This allows the satellite to maintain a constant orientation between the Earth and the Sun. As a result, the mean Sun time at each point in the orbit remains fixed. For example, equatorial crossing times range from 8:30 a.m. (local time) for Landsat 1, to 9 a.m. for Landsat 2, and to approximately 10:00 a.m. for Landsats 5 and 7.

Landsats 1, 2, and 3 operated in a near-polar orbit at an altitude of 920 km. These satellites circled the Earth every 103 minutes, completing 14 orbits a day. It took 18 days and 251 overlapping orbits to provide nearly complete coverage of the Earth's surface with 185-km image swaths.

The primary sensor aboard Landsats 1, 2, and 3 was the multispectral scanner (MSS). The MSS sensor scanned the Earth's surface across the satellite track as the satellite moved in its descending (north-to-south) orbit over the sunlit side of the Earth. The combination of scanning geometry, satellite orbit, and Earth rotation produced the global coverage necessary for studying land surface change. The resolution of the MSS sensor was approximately 80 m, with radiometric coverage in four spectral bands from the visible green to the near-infrared (IR) wavelengths. The MSS sensor on Landsat 3 had a fifth band in the thermal-IR wavelength.

Landsats 4 and 5 carried both the MSS and a new, improved thematic mapper (TM) sensor. The MSS sensors onboard Landsats 4 and 5 were identical to the one that was carried on Landsat 3. The MSS and TM sensors detect reflected or emitted energy from the Earth in the visible and IR wavelengths. TM bands 1-5 and 7 collect reflected energy; band 6 collects emitted

Value of the Acquisition Cycle for Images - Olympic Peninsula, Washington



These images were taken by Landsats 5 and 7 from June through August 2001. They illustrate why regular repeated coverage by multiple satellites helps to ensure cloud-free images are acquired for users.

Band Designation

The TM sensor (Landsats 4 and 5) and the ETM+ sensor (Landsat 7) operate in seven spectral bands, shown in the table below:

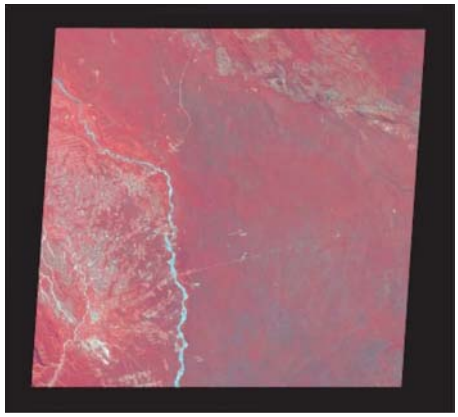
Spectral Bands	Use
1 blue-green	Useful for bathymetric mapping and distinguishing soil from vegetation and deciduous from coniferous vegetation.
2 green	Emphasizes peak vegetation, which is useful for assessing plant vigor.
3 red	Discriminates vegetation slopes.
4 Reflected IR	Emphasizes biomass content and shorelines.
5 Reflected IR	Discriminates moisture content of soil and vegetation; penetrates thin clouds.
6 Thermal IR	Useful for thermal mapping and estimated soil moisture.
7 Reflected IR	Useful for mapping hydrothermally altered rocks associated with mineral deposits.

Note: Landsat 7 also carries a panchromatic band (visible through near infrared) with 15-m resolution for "sharpening" of multispectral images.

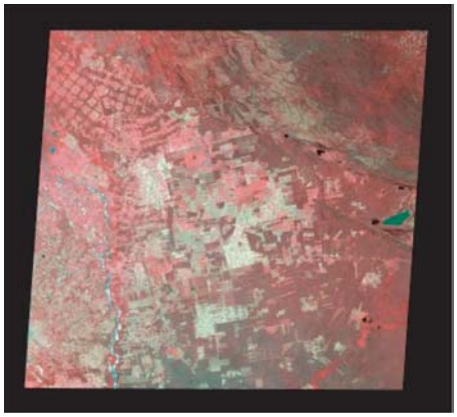
The four MSS band designations are numbered differently for Landsats 1, 2, and 3 and Landsats 4 and 5:

Landsats 1,2, & 3 Spectral Bands	Landsats 4 & 5 Spectral Bands	Use
Band 4 green	Band 1 green	Emphasizes sediment-laden water and delineates areas of shallow water.
Band 5 red	Band 2 red	Emphasizes cultural features.
Band 6 near IR	Band 3 near IR	Emphasizes vegetation boundary between land and water, and landforms.
Band 7 near IR	Band 4 near IR	Penetrates atmospheric haze best, emphasizes vegetation, boundary between land and water, and landforms.

energy. The TM sensor has a spatial resolution of 120 m for the thermal-IR band and 30 m for the six reflective bands. The newest satellite in the series, Landsat 7, carries the enhanced thematic mapper plus (ETM+), with 30-m visible and IR bands, a 60-m spatial resolution thermal band, and a 15-m panchromatic band. Failure of onboard electronics halted data collection by Landsat 4 in 1993. The spacecraft was maintained on orbit as a test bed until it was decommissioned in June 2001. Landsats 5 and 7, the two remaining operational satellites, orbit at an altitude of 705 km, and each provides a 16-day, 233-orbit cycle. (The two satellite orbits are offset, allowing 8-day repeat coverage.) These satellites were also designed to collect data over a 185-km swath.



Bolivia clear cutting - 1987



Bolivia clear cutting - 2000

Applications of Landsat Data

Landsat data have been used by government, commercial, industrial, civilian, military, and educational communities in the United States and worldwide. They support a wide range of applications in such areas as global change research, agriculture, forestry, geology, resource management, geography, mapping, water quality, and oceanography.

Landsat 7 is providing the global science community with a wealth of data. As of January 2003, the three ground stations managed by the USGS had collected over 300,000

scenes for the U.S. archive; more than 30 percent have 10-percent or less cloud cover. This network of ground stations allows virtually global coverage.

The consistency of the Landsat data over the three decades of acquisition offers opportunities to compare land cover changes over periods of time. The advances made in data reception and processing permit rapid access to imagery in times of natural or manmade disaster. For example, resource managers in Colorado battling a large forest fire were able to receive Landsat 7 data in the field within hours of an overpass.

Landsat Data Continuity Mission

Landsat has provided the science community with an important archive of land feature observations. Plans are underway for the next generation of land-observation systems. The Landsat Data Continuity Mission (LDCM) is a cooperative effort between the U.S. Government and the private sector to ensure continuity of Landsat-like data well beyond the duration of the Landsat 7 mission. Landsat 7, with its nominal design life to end in mid-2004, is currently expected to last at least through 2008. After a launch scheduled for late 2006, LDCM is expected to begin full operations early in 2007. At that point, the Government will be purchasing—from the commercial satellite's owner/operator–seasonal global datasets of Landsat-like scenes at the average rate of 250 per day (the same rate as Landsat 7 scene acquisitions by the USGS). All such Government-procured LDCM data will be delivered to the USGS EROS Data Center for archive, access, and public distribution without user restrictions, as with the Landsat 7 Program. The scientific-data procurement contract will be in effect through 2012, with an option for a 5-year extension.

Information

Information about the Landsat Program and Landsat holdings in the U.S. archive can be found at: landsat7.usgs.gov.

Or by contacting:

EROS Data Center
Customer Services
Mundt Federal Building
Sioux Falls, SD 57198
Telephone: 605-594-6151
Fax: 605-594-6589
E-mail: custserv@usgs.gov

Information about LDCM is available at: ldcm.usgs.gov

For information on other USGS products and services, call 1-888-ASK-USGS or visit the general interest publications Web site on mapping, geography, and related topics at erg.usgs.gov/isb/pubs/pubslists/.

For additional information, visit the ask.usgs.gov Web site or the USGS home page at www.usgs.gov.