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Landsat Data

A Brief History of the Landsat Program

In the mid-1960's, the National Aeronautics and Space Administration (NASA) embarked on an initiative to develop and launch the first Earth-monitoring satellite to meet the needs of resource managers and earth scientists. The U.S. Geological Survey (USGS) entered into a partnership with NASA in the early 1970's to assume responsibility for archiving data and distributing data products. 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. Designated initially as the "Earth Resources Technology Satellite-A" ("ERTS-A"), it used a Nimbus-type platform that was modified to carry sensor systems and data relay equipment. When operational orbit was achieved, it was designated "ERTS-1."

The satellite continued to function beyond its designed life expectancy of 1 year and finally ceased to operate on January 6, 1978, more than 5 years after its launch date. The second in this series of Earth resources satellites (designated "ERTS-B") was launched January 22, 1975. It was renamed "Landsat 2" by NASA, which also renamed "ERTS-1" as "Landsat 1." Three additional Landsats were launched in 1978, 1982, and 1984 (Landsats 3, 4, and 5). (See table 1).

NASA was responsible for operating the program through the early 1980's. In January 1983, operation of the Landsat system was transferred to the National Oceanic and Atmospheric Administration (NOAA). In October 1985, the Landsat system was commercialized and the Earth Observation Satellite Company, now Space Imaging EOSAT, assumed responsibility for its operation under contract to NOAA. Throughout these changes, the USGS EROS Data Center (EDC) retained primary responsibility as the Government archive of Landsat data. The Land Remote Sensing Policy Act of 1992 (Public Law 102-5555) officially authorized the National Satellite Land Remote Sensing Data Archive and assigned responsibility to the Department of the Interior. In addition to its Landsat data management responsibility, the EDC investigates new methods of characterizing and studying changes on the land surface with Landsat data.

Characteristics of the Landsat System

Landsats 1 through 3 operated in a near-polar orbit at an altitude of 920 km with an 18-day repeat coverage cycle. These satellites circled the Earth every 103 minutes, completing 14 orbits a day. Eighteen days and 251 overlapping orbits were required to provide nearly complete coverage of the Earth's surface with 185-km wide image swaths. The amount of swath overlap or sidelap varied from 14 percent at the Equator to a maximum of approximately 85 percent at 81 degrees north or south latitude. These satellites carried two sensors: a return beam vidicom (RBV) and a multispectral scanner (MSS). The MSS sensor scanned the Earth's surface from west to east as the satellite moved in its descending (north-to-south) orbit over the sunlit side of the Earth. Six detectors for each spectral band provided six scan lines on each active scan. 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 (see table 2). Only the MSS sensor on Landsat 3 had a fifth band in the thermal-IR. The RBV sensor was essentially a television camera and did not achieve the popularity of the MSS sensor.

Landsats 4 and 5 carry both the MSS and the thematic mapper (TM) sensors; however, routine collection of MSS data was terminated in late 1992. They orbit at an altitude of 705 km and provide a 16-day, 233-orbit cycle with a swath overlap that varies from 7 percent at the Equator to nearly 84 percent at 81 degrees north or south latitude. These satellites were also designed to collect data over a 185 km swath. The MSS sensors on board Landsats 4 and 5 are identical to the ones that were carried on Landsats 1, 2, and 3. The MSS and TM sensors primarily detect reflected radiation from the Earth in the visible and IR wavelengths, but the TM sensor has seven spectral bands, providing more radiometric information than the MSS sensor (see table 2). The wavelength range for the TM sensor is from the visible (blue), through the mid-IR, into the thermal-IR part of the electro-magnetic spectrum. Sixteen detectors for the visible and mid-IR wavelength bands in the TM sensor provide 16 scan lines on each active scan. Four detectors for the thermal-IR band provide four scan lines on each active scan. The TM sensor has a spatial resolution of 120 m for the thermal-IR band and 30 m for the other six radiometric bands.

All of the Landsats have been in sun-synchronous orbits with equatorial crossing times ranging from 8:30 a.m. (local time) for Landsat 1, to 9 a.m. for Landsat 2, to the current time of approximately 9:45 a.m. for Landsat 5.

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 are being used to support a wide range of applications in such areas as global change research, agriculture, forestry, geology, resources management, geography, mapping, water quality, and oceanography.

Table 1. Background information and status of Landsat satellites
[Text and table from "Historical Landsat Data Comparisons, Illustrations of the Earth's Changing Surface," U.S. Department of the Interior, U.S. Geological Survey, EROS Data Center, March 1995]

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	*	TM and MSS
Landsat 5	March 1, 1984	**	TM and MSS
Landsat 6	October 5, 1993	***	ETM
Landsat 7	Fall 1998****		ETM+*****

* In standby mode.
** Operational.
*** Never achieved orbit.
**** Anticipated launch.
***** The sensor onboard Landsat 6 was called the enhanced thematic mapper (ETM). Landsat 7 will carry the enhanced thematic mapper plus (ETM+).

Table 2. Band Designation

TM

The TM sensor operates in seven spectral bands in Landsats 4 and 5, designated as follows:

Landsats	4 & 5		
Bands	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 estimating soil moisture.
	7	reflected-IR	Useful for mapping hydrothermally altered rocks associated with mineral deposits.

MSS

Below are the MSS band designations, which are different for Landsats 1, 2, and 3 and Landsats 4 and 5:

Landsats	4 & 5	1, 2, & 3		
Bands	1	4	green	Emphasizes sediment-laden water and delineates areas of shallow water.
	2	5	red	Emphasizes cultural features.
	3	6	near-infrared	Emphasizes vegetation boundary between land and water, and landforms.
	4	7	near-infrared	Best penetration of atmospheric haze, emphasizes vegetation, boundary between land and water, and land forms.

Information

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