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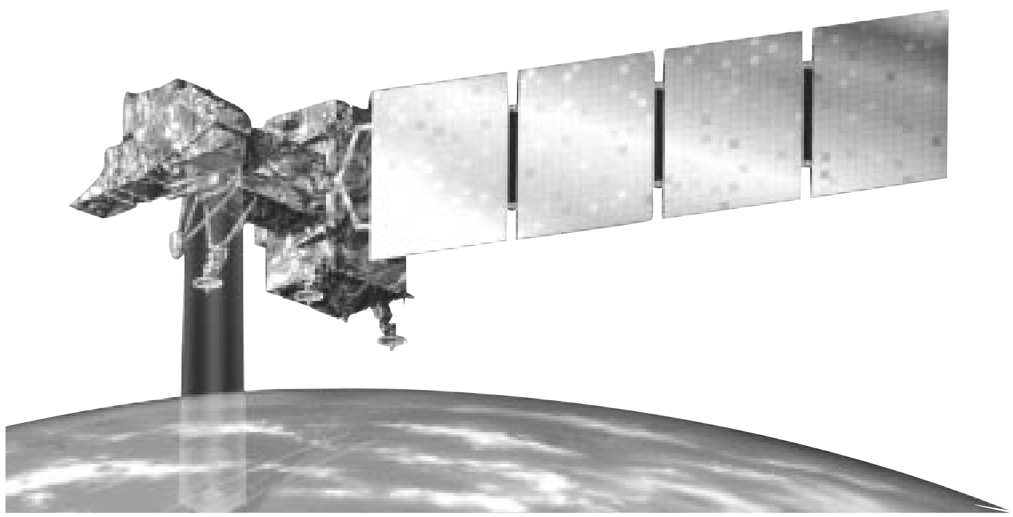
Landsat 7



science for a changing world

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LANDSAT 7 SPACECRAFT TO JOIN NASA'S EARTH SCIENCE TEAM

NASA will deploy the first major satellite in an unprecedented program to check the health of Planet Earth and understand the complex interactions that drive global change with the April 15 launch of the Landsat 7, the latest mission in the Landsat series, which has been documenting the Earth's surface for more than a quarter century.

NASA plans to launch six spacecraft over the course of the year dedicated to advancing our understanding of global change. Landsat 7's role in this effort will be to make global, high-resolution measurements of land surface and surrounding coastal regions.

The diversity of applications makes the Landsat spacecraft unique among Earth observation satellites. Landsat images have been used in everything from measuring the ebb and flow of glaciers and population changes in and around metropolitan areas, to monitoring strip mining reclamation and assessing water quality in lakes. Landsat has been used to monitor timber losses in the U.S. Pacific Northwest, map the extent of winter snow pack, and measure forest cover at the state level.

"We feel that the Landsat 7 spacecraft will dramatically enhance the use of remotely sensed data in our daily lives," said Dr. Darrel Williams, Landsat 7 Project Scientist, at NASA's Goddard Space Flight Center, Greenbelt, Md.

Every 16 days, Landsat 7 will fly over and document the condition of the entire globe. As far as scientific Earth observing satellites go, Landsat 7 is unique in that the images it collects are extremely detailed – Landsat can "see" features on the planet as small as 30 meters, compared to the geostationary GOES satellites which can only resolve objects of 4 kilometers or greater. So good are the Landsat images that scientists studying volcanoes can actually produce maps of lava flows with pinpoint accuracy.

Landsat 7 marks a new direction in the program to reduce the cost of data and increase global coverage for use in global change research. Every day, Landsat 7 will collect 250 scenes, each one containing enough digital data to fill a powerful home computer's hard drive. While previous Landsat data were often too expensive for widespread scientific use, all Landsat 7 data received at the main collecting center in Sioux Falls, South Dakota will be archived and available electronically within 24 hours and will be sold at cost.

Scientists use Landsat satellites for some very down-to-earth purposes.

Urban sprawl is one example. Observing urban areas over time with Landsat imagery can show where growth is taking place and help geographers evaluate how different urban planning programs effect population growth and land use. One of Landsat's 14 scientific teams will use Landsat observations to evaluate growth patterns of cities such as Portland, Ore. (which has strict planning and environmentally sensitive zoning laws) with other cities around the world.

Another group of scientists led by the Department of Agriculture want to use Landsat 7 data to improve on a program to help farmers and land managers increase crop yields and cut costs while reducing environmental pollution.

Scientists from NASA's partner agency in the Landsat 7 mission, the U.S. Geological Survey, want to use Landsat 7 to spot the amount and condition of dry biomass on the ground, which are potential sources for feeding wildfires that can threaten humans, animals and natural resources.

Landsat 7 is scheduled to launch on April 15, 1999 from Vandenberg Air Force Base, CA. The two-minute launch window opens at 11:32 a.m. Pacific Daylight Time.

Landsat 7 will be launched on a Delta-II expendable launch vehicle. Separation of the spacecraft from its launch vehicle will occur about 62 minutes after launch**.** Once in its final orbital position, the satellite will orbit the Earth at an altitude of approximately 438 miles (705 kilometers) with a Sun-synchronous 98-degree inclination and a descending equatorial crossing time of 10 a.m. The orbit will be adjusted so that it covers the complete Earth every 16 days. This orbit will be maintained with periodic adjustments during the 5-year life of the mission.

The instrument onboard Landsat 7 is the Enhanced Thematic Mapper Plus (ETM+). The instrument is a passive sensor, a type of remote-sensing instrument that measures solar radiation reflected or emitted by the Earth.

The instrument has eight bands sensitive to different wavelengths of visible and infrared radiation. It's improved from earlier versions. Landsat 7's Thematic Mapper has better resolution in the thermal infrared band than the instruments carried by Landsats 4 and 5. It is also far more accurate than its predecessors.

The Landsat 7 system will collect and archive an unprecedented quantity of high-quality multispectral data each day. The data will, for the first time, provide a high-resolution view of both seasonal and interannual changes in the terrestrial environment.

The USGS Earth Resources Observation Systems Data Center (EROS Data Center) in Sioux Falls, SD will process, archive, and distribute all U.S. Landsat data. The ground system at the data center in Sioux Falls, SD will be capable of capturing and processing 250 Landsat scenes per day delivering at least 100 of the scenes to users each day.

“The USGS is proud to assume added responsibility for the processing and distribution of Landsat data,” said R.J. Thompson, Landsat Program Manager, U.S. Geological Survey. “The Landsat system, conceived originally within the Department of the Interior, is an important dimension of the USGS' role in providing information for science for a changing world."

The Landsat Project Office, located at Goddard, manages Landsat development for NASA’s Office of Earth Science in Washington, DC. Goddard is responsible for the development and launch of the satellite, and the development of the ground operations system. Spacecraft operations will be performed at a Mission Operations Center at the Goddard and at the Earth Resources Observation Systems Data Center. Goddard will operate the spacecraft until Oct**.** 1, 2000, when this function is turned over to the U.S. Geological Survey**.**

The spacecraft was built by Lockheed Martin Missiles and Space in Valley Forge, PA. The instrument was built by Raytheon (formerly Hughes) Santa Barbara Remote Sensing in Santa Barbara, CA.

Landsat 7 is part of a global research program known as NASA’s Earth Science Enterprise, a long-term program that is studying changes in Earth’s global environment. The goal of the Earth Science Enterprise is to provide people a better understanding of natural environmental changes. Earth Science Enterprise data, which will be distributed to researchers worldwide at the cost of reproduction, is essential to people making informed decisions about their environment.

End of General Release

Media Services Information

NASA Television Transmission

NASA Television is broadcast on the satellite GE-2, transponder 9C, C band, 85 degrees west longitude, frequency 3880.0 MHz, vertical polarization, audio monaural at 6.8 MHz. On launch day, television coverage will begin at 10 a.m. Pacific Time (1:00 p.m. Eastern Time) and continue through spacecraft separation 62 minutes after liftoff. The schedule for television transmissions for Landsat 7 will be available on the NASA Television homepage at http://www.nasa.gov/ntv/.

Audio

Audio only will be available on the V circuits that may be reached by dialing 407/1220, 1240, 1260, 7135, 4003, 4920.

Briefings

A pre-launch briefing at Vandenberg Air Force Base is scheduled on April 14 at 11 a.m. Pacific Daylight Time (2:00 p.m. Eastern Time). The briefing will be carried on NASA Television and the V circuits.

News Center/Status Reports

The Landsat 7 News Center at the NASA Vandenberg Resident Office will open Monday, April 12 and may be reached at (805) 605-3051. Recorded status reports will be available beginning April 12 at (805) 734-2693, or at (301) 286-NEWS.

Launch Media Credentialing

Media desiring launch accreditation information should contact the U. S. Air Force Public Affairs Office at Vandenberg AFB, CA by close of business on Tuesday, April 13 (2 days before launch) at:

Telephone: 805-606-3595
FAX: 805-606-8303
E-mail: pubaffairs@plans.vafb.af.mil

Requests must be on the letterhead of the news organization and must specify the editor making the assignment to cover the launch.

Internet Information

Extensive information on the Landsat 7 mission, including an electronic copy of this press kit, press releases, facts sheets, status reports and images, is available from the Landsat 7 World Wide Web home page at http://landsat.gsfc.nasa.gov/.

Quick Facts for Landsat 7

The Landsat 7 satellite consists of a spacecraft bus provided under a NASA contract with Lockheed Martin Missiles and Space, Valley Forge, Pa. and the Enhanced Thematic Mapper (ETM+) instrument procured under a NASA contract with Raytheon (formerly Hughes) Santa Barbara Research Center in Santa Barbara, Calif.

Spacecraft
Dimensions: 14 feet long (4.3 meters) and 9 feet (2.8 meters) in diameter
Weight: 4,800 pounds (2,200 kilograms)
Science Instrument: Enhanced Thematic Mapper Plus (ETM+)
Power: Silicon cell solar array, will provide 1,550 watts of load power

Orbit: 438 miles (705 kilometers)

Launch Site: Western Test Range, Vandenberg Air Force Base, Calif.

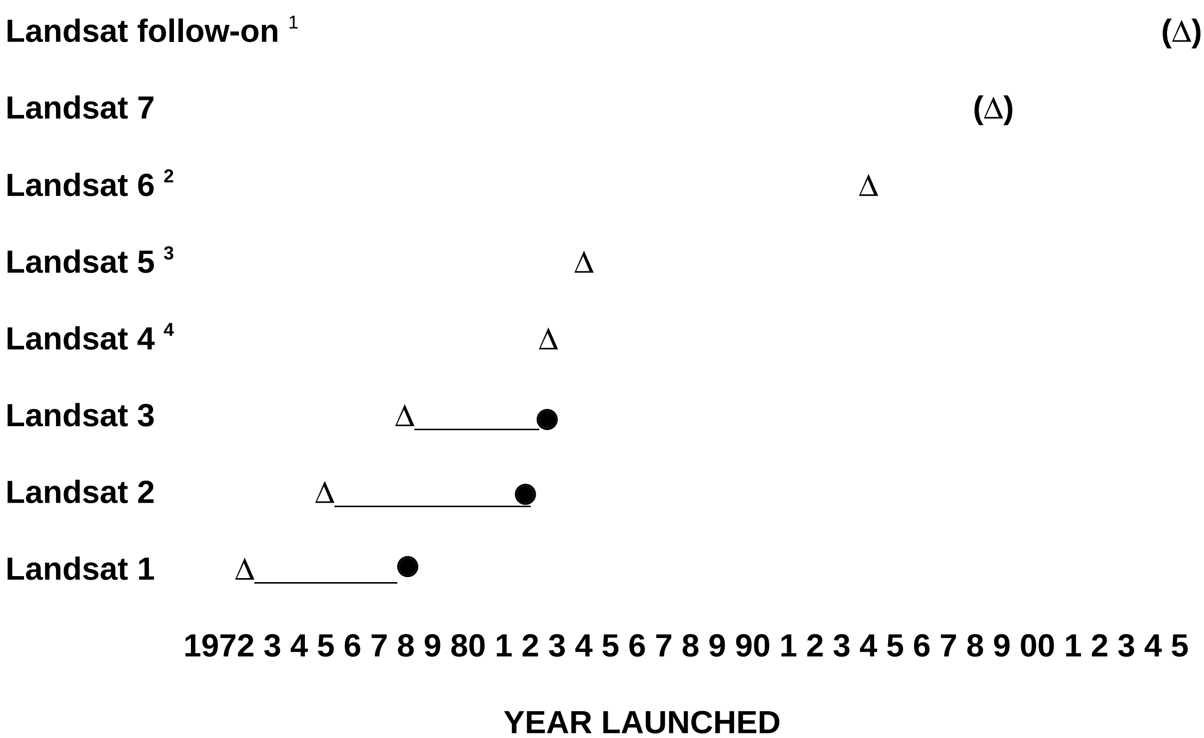
Launch Vehicle: Boeing Delta-II

Mission
Planned Launch Date: April 15, 1999
Launch Time: 11:32 a.m. PDT (2 minute window)
Spacecraft Separation: Launch + 62 minutes
First Acquisition of Landsat Signal: 67 minutes after launch and occurs in Wilhelm, Germany

Cost: $666 million, including spacecraft, instrument and first year of mission operations (does not include launch vehicle cost)

Landsat Spacecraft History

The first Landsats, originally called ERTS for Earth Resources Technology Satellite, were developed and launched by NASA between July 1972 and March 1978. During that time, a second generation of Landsat satellites was developed. Landsat 4 was launched in July 1982 and Landsat 5 in March 1984. Landsat 5 is still transmitting images. Landsat 7 was authorized by a Presidential Directive signed by President Bush in 1992.



Δ **Year Launched**
(Δ) **Launch Anticipated**
● **End of Service**

[1] ETM+ Follow –On mission scheduled for 2005
[2] Launched Oct. 5, 1994. Failed to obtain orbit
[3] Data transmission by direct downlink only
[4] No longer transmitting telemetry data

Landsat: Unique National Assets

The latest mission in the Landsat series, Landsat 7 is part of NASA's Earth Science Enterprise. Continuity of data with previous Landsat missions is a fundamental goal of the Landsat program. No other current or planned remote-sensing system, public or private, fills the role of Landsat in global change research or in civil and commercial applications.

Scientists use Landsat satellites to gather remotely sensed images of the land surface and surrounding coastal regions for global change research, regional environmental change studies and other civil and commercial purposes.

The latest mission in the Landsat series – Landsat 7 – is part of NASA's Earth Science Enterprise. Continuing an unprecedented quarter-century data set of the Earth's land surface is a fundamental goal of the Landsat program. No other current or planned remote sensing system, public or private, fills the role of Landsat in global and regional environmental change research, or in civil and commercial applications.

Landsat 7 will fulfill its mission by providing continual, comprehensive coverage of land surfaces. The Thematic Mapper onboard Landsat 7 will sense radiation in the visible, near-infrared, short-wave, and thermal infrared regions of the electromagnetic spectrum. With the combined capabilities of fine resolution and pin-point accuracy, Landsat is unmatched by other remote sensing systems.

Scientists use data from Landsat satellites to study land surfaces and coastal regions and to determine how distinct environments are affected by global and regional climate change.

Landsat 7 will monitor important natural processes and human land use such as vegetation growth, deforestation, agriculture, coastal and river erosion, snow accumulation and fresh-water reservoir replenishment, and urbanization. The repeating, extensive coverage of Landsat 7 is excellent for observing seasonal changes on continental and global scales, and Landsat's fine resolution is ideal for perceiving important detail in land surfaces.

The Landsat 7 system will offer the unique capability to seasonally monitor important small-scale processes on a global scale, such as the annual cycles of vegetation growth; deforestation; agricultural land use; erosion and other forms of land degradation; snow accumulation and melt and the associated fresh-water reservoir replenishment; and urbanization. The other systems affording global coverage do not provide the resolution needed to observe these processes in detail, and only the Landsat system provides a 26-plus year record of these processes.

Scientific Objectives

The 1992 Land Remote Sensing Policy Act identifies data continuity as the fundamental goal of the Landsat program. The scientific mission of Landsat 7 is entirely consistent with this legislated goal. The mission is to extend and improve upon the more than 26-year record of images of the Earth's continental surfaces provided by the earlier Landsat satellites. Landsat 7 also will continue providing essential land surface data to a broad, diverse community of civil and commercial users.

Images acquired by Landsat satellites were used to produce the first composite multi-spectral mosaic of the 48 contiguous United States. Landsat imagery has provided critically important information for monitoring agricultural productivity, water resources, urban growth, deforestation, and natural change due to fires and insect infestations. The data have also been used successfully for mineral exploration, to measure forest cover at the state level, and to monitor strip mining and strip mine reclamation.

The Future

In 1996, NASA started the *New Millennium Program* (NMP), designed to identify, develop, and flight-validate key instrument and spacecraft technologies that can enable new or more cost-effective approaches to conducting science missions in the 21st century.

The first of three New Millennium Program Earth orbiting missions is Earth Observing-1 (EO-1), an advanced land imaging mission that will demonstrate new instruments and spacecraft systems. EO-1 will validate technologies contributing to the reduction in cost of follow-on Landsat missions. The centerpiece of this mission is the *Advanced Land Imager* (ALI) instrument, which is one seventh the mass, power consumption and volume of the Landsat-7 imager, the Enhanced Thematic Mapper plus.

The new instrument will demonstrate remote-sensing measurements of the Earth consistent with data collected since 1972 through the Landsat series of satellites, which is used by farmers, foresters, geologists, economists, city planners and others for resource monitoring and assessment. In addition, it will acquire data with finer spectral resolution, a capability long sought by many elements of the Earth observation data user community, and it will lay the technological groundwork for future land imaging instruments to be more compact and less costly.

Landsat Research Projects

Volcanic Hazards and Lava Lakes

To understand the complex "plumbing" beneath active volcanic lave lakes and determine the amount of lava flowing from them, Luke Flynn of the University of Hawaii has been using time series of Landsat images. Much of his work has focused on the persistence of volcanic eruptions at Hawaii's Kilauea volcano, which has been continually erupting since 1983. Another objective of Flynn's research - and one critical to many residents of Hawaii - is to map active lava flows and provide advance warning to public safety officials about these natural hazards.

Flynn and other volcanologists have been using remote-sensing data from the geostationary GOES satellite to monitor volcanic eruptions in remote areas in real time. The higher resolution of Landsat data (30 meters as compared to 4 kilometers for GOES) can produce maps of lava flows with pinpoint accuracy, according to Flynn. With these maps researchers can study the evolution of individual eruptions while they are taking place.

With Landsat observations of the heat emitted during eruptions, Flynn can distinguish active lava flows from older flows that have already begun to cool. With this data, Flynn's colleague Andrew Harris is generating estimates of the amount of lava erupting onto the surface. Using similar Landsat data, Flynn produces maps of the leading edges of wildfires.

Flynn and Harris have also been working with Landsat data of active volcanic lava lakes around the world. In addition to their work in Hawaii, they are studying long-term observations of eruptions in Mexico (Popocatepetl) and Guatemala (Santa Maria and Pacaya). Once they have compiled extensive observations of an individual volcano, they create a database of areas on the volcano that are most prone to lava flow hazards. Flynn plans to produce even higher resolution maps of active lava flows (15 m) with Landsat 7.

Growth Patterns of Urban Sprawl

Traffic jams and air pollution in large metropolitan areas are sure signs of expanding populations. Across the globe, 50 percent of the world's population now lives in urban areas, a gain of over one billion individuals in the last 30 years. In the United States, urban growth can be counted in a census, but how do these expanding populations affect the landscape? Are urban areas making good use of limited space or are they succumbing to urban sprawl? How do factors like zoning policies and environmental pressures influence the expansion of populations over the land?

Jeffrey Masek and Frank Lindsy, geographers from the University of Maryland, are using Landsat data to study land use efficiency, which is the amount of land area used by increasing populations. Using Landsat data acquired between 1973 and 1996, Masek and Lindsy mapped the growth of the Washington D.C. metropolitan area.

They found that the Washington area has expanded at a rate of 8.5 square miles (22 square kilometers) per year with notably higher growth during the late 1980s, a trend that followed the regional and national economy. They also found distinct variations in the efficiency of land use among neighboring counties in Maryland and Virginia, in part reflecting the land use policies of these jurisdictions.

Observing urban areas over time with satellite imagery can also be used to make predictions about future growth. Landsat imagery can show where the growth is taking place and help geographers evaluate how different urban planning programs effect population growth and land use, according to Masek. Cities such as Portland, Ore., have strict planning and environmentally sensitive zoning laws, while many Southwestern cities have grown with few planning guidelines.

With Landsat 7 observations, Masek and colleagues intend to evaluate growth patterns of other cities around the world. With a greater number of images available, Masek can compare cities once every two years to capture detailed records of land use changes.

"Dune Reactivation" in the U. S. High Plains

More than 10 percent of the United States' High Plains region is made up of sand dunes and sand sheets that are currently stabilized by the natural grasses growing on them and by irrigated farming. If future climate change leads to increased temperatures and less rainfall in this arid region, as some climate models predict, these sandy landscapes could be "reactivated" and begin blowing as they did in the "dust bowl" years of the 1930s.

Information about the dunes in this 800,000 square-kilometer region - encompassing parts of Colorado, South Dakota, Nebraska, Kansas, Oklahoma, Texas, and New Mexico - has been available for decades. However, a systematic study of the relationship between humans and the land and land-use change on a large geographic scale is only now possible utilizing satellite observations.

Alexander Goetz, professor of geological sciences at the University of Colorado is leading a research team to create an effective way to assess how the High Plains will be affected by future climate change. Using Landsat 5 data from 1984 to the present, Goetz' team has completed a detailed study of land cover change in northeastern Colorado and is creating a 15-year database of land cover and human-induced land cover changes in the region.

One of the more striking observations is the dramatic shift from dry-land farming and flood irrigation to center-pivot irrigation since 1985. Some of the pivots are located in the dune areas and these spots would become dune reactivation sites if the irrigation were discontinued, according to Goetz.

Combining land-cover data with meteorological and future climate data in a regional climate model, Goetz plans to produce a model-based method for estimating future dune reactivation and identifying the areas with the highest potential for reactivation. The team will also investigate the potential effect of abandoning farmed and irrigated lands on dune reactivation.

Landsat 7 data will provide the researchers with many more images than are currently available, since the team will acquire images from every pass of the satellite over the region. With multiple images during a growing season, they can more precisely distinguish crop types and change. Goetz expects that by extending the Landsat data set beyond 2000, he will be able to catch a significant drought year, which will help to validate models for the effect of low rainfall in the High Plains.

Spring Run-off Contaminants in Lakes

As snow begins to melt at the close of winter, large lakes receive warm spring river run-off carrying pollutants that are potentially harmful to phytoplankton and the fish that feed on them. The warmer water initially stays near the shoreline, not mixing with the cold winter lake water. Salt, sediment, fertilizer and chemical pollutants in the run-off are concentrated in a small band of warmer water close to the shore called the thermal bar. By June, the lake's waters are well mixed, and pollutants brought into the lake are very dilute.

Most lakes in regions that have cold winters and warm summers have an annual episode of thermal bar formation. But only in large lakes does the thermal bar persist for two months and become potentially toxic to lake plants and animals.

John Schott, of the Rochester Institute of Technology's Digital Imaging and Remote Sensing Laboratory, is using Landsat imagery to help predict the extent, duration, and impacts of the thermal bar formation in the Laurentian Great Lakes. For the two months that the bar persists, it controls most of the fluid flow in the lakes and has a dramatic impact on water quality. Landsat offers the unique opportunity to study both the thermal bar processes and the direct impact on the water quality at both whole lake scales and localized scales. The combination of spectral coverage, synoptic perspective, and high resolution is a unique asset that may be used to further understand the water quality issues affecting Great Lakes coastal waters.

Schott's work may eventually be helpful in understanding how the release of industrial pollutants into the Genesee and Niagara rivers during the thermal bar formation in Lake Ontario effect the lake's ecosystem. Thermal bar formation occurs during the spring when plants and animals in the lake are in the early stages of development.

Schott and his research team are using Landsat data to determine how large-scale hydrodynamic processes in the Great Lakes control water quality. The thermal bar formation is modeled using Landsat data and three-dimensional hydrodynamic models. Eventually, the models will track the annual evolution of the thermal bar and attempt to predict the bar's formation several months in advance.

Land Use in Tropical Rain Forests

Even though tropical deforestation is a well-known problem, the rate of deforestation in the tropics is currently known to only a very general degree. Recent research using Landsat images of forest loss over a decade from the mid-1970s to mid-1980s found that an average of 6,200 square miles of forest were lost each year in the Brazilian Amazon. The annual rate in the smaller Southeast Asia region was estimated to be 4,800 square miles per year. A key problem facing scientists today is determining deforestation rates and understanding their causes and effects.

David Skole of Michigan State University is involved in several initiatives to study the rates, causes, and effects of tropical deforestation in the Amazon Basin, Southeast Asia, and Africa. Using Landsat imagery, his research analyzes changes in forest cover at a 30-meter resolution and models the effects of this on the carbon cycle. By combining satellite imagery with socioeconomic data, Skole is also searching for the economic and social causes of deforestation.

Using three different wavelength bands of Landsat Thematic Mapper imagery to quantify the vegetation characteristics, Skole's team categorizes land cover into primary rain forest, regrowing rain forest, agricultural clearings, and other classes. These data are manipulated using a geographic information system to explore patterns and rates of land cover change. The geospatially referenced information is then fed into socioeconomic and terrestrial ecosystem models to explore the causes and effects of deforestation.

Skole's team is currently analyzing Landsat 5 imagery from the 1990s for the Brazilian Amazon and Southeast Asia to develop estimates of recent tropical deforestation. In addition, they are performing multi-year studies in the Amazon basin to determine the year-to-year changes in deforestation rates. These data will be important not only in yielding the rate of deforestation but for the analysis of carbon uptake by tropical rain forests and for understanding the social and economic causes.

With the launch of Landsat 7, the amount of data available for this research will increase dramatically. Highly detailed, near-real-time analysis will be possible with the new imagery, allowing for rapid assessment of land use and land cover change.

Precision Farming and Land Management

For farmers and land managers, increasing crop yields and cutting costs while reducing environmental pollution is a constant challenge. To accomplish this goal, many farm managers are looking for new technologies to help them decide when and where to irrigate, fertilize, seed crops, and use herbicides. Currently the decisions are based on very limited data collected in "spot checks" from the ground.

Recent technological advances in geographic information systems and computer modeling are playing a part in farm management and precision farming. Using data collected by satellites, important agricultural factors like plant health, plant cover and soil moisture can be monitored from space, providing a much bigger picture of the land surface that can be combined with other technologies to help cut costs and increase crop yields.

Susan Moran, a US Department of Agriculture Agricultural Research Service soil scientist, based in Phoenix, Ariz., developed a method to help farmers with resource management by combining Landsat images with radar data from several polar orbiting satellites. Although Landsat sees the surface very clearly, its usefulness is limited because it can't see through clouds, and it only flies over a particular area once every 16 days. Most farm management decisions require information on a daily or biweekly basis. Radar can see through clouds and be collected daily, but the resolution is not as good as Landsat. The combination of radar and Landsat gives a continuous record of the land surface and vegetation health.

The thermal band on Landsat can detect crop health by seeing plants transpire, or lose moisture through their leaves-a factor directly related to plant health. When plant transpiration rates decrease, growth rates decrease and the plants appear unhealthy. Managers use this information to target where to fertilize and irrigate. Other Landsat bands can see the extent of vegetation cover while radar can pick up moisture in the soil.

The methods developed by Moran are already in use by land managers through a Cooperative Research and Development Agreement with a commercial image supplier. The 24-hour turnaround of the new Landsat 7 data will enable expanded applications of remote sensing in agricultural and natural resource monitoring.

Health of Temperate Conifer Forests

Fire, drought, and humans all can destroy forests and their ecosystems. While much attention is paid to deforestation in tropical rainforests, very few comprehensive studies have been done to address changes in the Earth's temperate conifer forests. Temperate conifer forests lie at latitudes above tropical forests and below boreal forests and account for much of the forested area in the United States and Europe.

Understanding changes occurring in temperate conifer forests is important for understanding environmental issues including wildlife habitat protection, watershed management, timber harvest, and understanding the role of human activities on changes in regional climates.

Previously, researchers have only been able to monitor changes in specific locations with Landsat data due to its limited availability. Boston University geographer Curtis E. Woodcock and colleagues used Landsat to monitor how drought in the late 1980s and early 1990s affected forests in California's Sierra Nevada. During the drought, Woodcock found that Landsat images could recognize areas where trees were dying due to lack of water, a factor making the trees more susceptible to disease and the forest more susceptible to fire.

The practice of clearcutting sections of Washington's Olympic National Forest and other state forests in the Pacific Northwest was prevalent up until the late 1980s when changes in public policy caused logging to move from public to private land. With the help of the frequent and comprehensive coverage of Landsat 7, Woodcock and colleagues plan to create a global monitoring system for temperate conifer forests. The monitoring system will measure the rates of destruction of conifer forests due to natural causes such as drought and fire and anthropogenic clearing due to harvest or development of forest lands. The monitoring system will also track the regrowth of forests and successional change in vegetation.

The new system will work in conjunction with NASA EOS land cover change studies based on the EOS Moderate-resolution Imaging Spectroradiometer (MODIS). The MODIS instrument will fly aboard the Terra satellite set for launch in July 1999, and will be used to identify large areas of significant changes in forest lands. Following up with the finer spatial resolution data from Landsat will allow determination of the type of changes and their geographic extent.

Gradual Changes in the Antarctic Ice Sheet

The stability of the West Antarctic Ice Sheet is an issue of active research and societal concern because of the potential economic impact resulting from an increase in global sea level. The West Antarctic Ice Sheet, riddled with deep crevasses and flowing ice streams, contains over 700,000 cubic miles (3 million cubic kilometers) of ice.

Researchers are studying how the ice moves and what forces cause the ice to flow. If the forces change, the ice sheets may flow much more quickly and slide off the continent into the sea. Monitoring these changes from the ground is difficult because treacherous conditions allow researchers to collect only a limited amount of measurements.

Robert Bindschadler, a glaciologist at NASA's Goddard Space Flight Center, uses Landsat data in a variety of ways to make more information available for determining the ice sheet's behavior. Landsat's high spatial resolution allows individual crevasses to be tracked over time. Using these natural markers not only provides many more velocity data to be collected, but concentrates the measurements in the most rapidly moving and most dangerous areas.

Other surface features such as flowstripes formed by rapid ice flow are also being used to uncover the history of the ice sheet. Bindschadler and colleagues have analyzed surface features on the Ross Ice Shelf, a vast area of ice attached to the continent but floating on the ocean, to determine the past 1000 years of ice flow over much of West Antarctica.

Recently Landsat data have increasingly been used to create more useful maps for scientific research. Bindschadler is combining Landsat data with past surveys of the latitude, longitude, and elevation of known locations around the Antarctic continent to create a library of image control points. The library is available on the Internet for use by researchers.

Landsat 7 data will enhance techniques developed at Goddard to study ice motion and flow history by providing finer spatial resolution, more continuous spatial coverage, and an updated view of the ever-changing Antarctic ice sheet.

Mapping Wildfire Hazards in Yosemite

In recent years, wildland fires have become more intense resulting in increased loss of human life and natural resource damage. An important factor in dealing with this problem is information on the amount and condition of dry biomass on the ground, which acts as fuel that feeds wildland fires. With information about fuels, fire managers can better predict potential fire behavior, make more informed tactical and strategic decisions, and conduct treatments to reduce the amount of dry biomass.

U. S. Geological Survey researcher Jan van Wagtendonk from the Western Ecological Research Center's Yosemite National Park station, and Ralph Root, from the USGS Center for Biological Informatics in Denver, have been examining the use of time series of Landsat Thematic Mapper imagery for developing a technique to identify fuel types based on seasonal changes in plant condition. Six Landsat scenes at one-month intervals during the 1992 growing season are being examined using hyperspectral analysis, a type of analysis that deals with large data sets with several spectral bands.

Using the time series, changes in annual grasslands, for instance, can be traced as the plants green up in the spring and dry during the summer. This fuel type can be distinguished from alpine meadows which dry at a different rate. Similarly, biomass from deciduous hardwood can be distinguished from evergreen hardwood, which retains its leaves.

Van Wagtendonk has also used single-scene Landsat images to classify different types of fuels over the past five years. Maps produced from this analysis have been used to predict the behavior of two large wildland fires in 1994 and 1995 that were being allowed to burn to meet resource objectives.

The addition of a panchromatic band on Landsat 7 will enhance the capability to distinguish tree density classes, which directly affects fuel moisture content and wind speeds near the ground. Seasonal changes can also be tracked more easily with the more frequent observations Landsat 7 will make.

U.S. Geological Survey Role in Landsat 7

The U.S. Geological Survey's, National Mapping Division, EROS Data Center, is the world's most extensive civilian repository of remotely sensed data on the Earth's land surface. Besides handling data from sensors aboard several series of satellites, the Center operates an archive of more than 8 million photographs taken from aircraft. The Center's huge and growing base of earth science information is used by scientists at the Center itself, within the private sector, and at government institutions and universities around the globe.

Largely because of burgeoning interest in resource management issues and global change studies, the Center's data and images are in increasing demand. The Center, therefore, has been busy developing innovative, inexpensive means of distributing data to a wide variety of users, making EROS a leader in information management as well as in earth science.

Why satellites?

Remotely sensed data are data that are gathered by instruments at some distance from the objects at which they are aimed. Aerial photographs, then, are a form of remotely sensed data, and they have been used for more than 60 years to make maps and perform other land-surface studies.

Since the 1960's, instruments carried by Earth-orbiting satellites have been used to detect various Earth-surface phenomena for two reasons. First, satellite-borne sensors can see large areas of the Earth's surface at once, giving scientists views of forest cover, for example, that are not feasible through more conventional means. Second, satellites orbit the Earth frequently, so that changes in these phenomena can be detected over short or long periods of time. Similar instruments could be mounted on aircraft, but covering the global areas that a satellite can, with the frequency that it affords, would be prohibitively expensive.

Organization

EROS is an acronym for Earth Resources Observation Systems. The EROS Data Center, near Sioux Falls, SD, is one of five field Centers operated by the National Mapping Division of the U.S. Geological Survey, an arm of the Department of the Interior. While the other Centers work chiefly with many forms of cartographic data, EROS concentrates on receiving, archiving, researching, and distributing remotely sensed aircraft and satellite image data.

Customer orientation

Established in the early 1970's, EROS quickly gained a reputation for fast and efficient service to customers ranging from the farmer who wants an aerial photograph of his land to the global change scientist who seeks coastal data on Tanzania. Increasingly, service to customers is on-line, instantaneously through the internet. With one of the most elaborate computer complexes in the Department of the Interior,

EROS has developed systems to deliver massive amounts of data over the Internet. This effort has led to the Center's becoming home to the sales data base for all of the National Mapping Division's digital cartographic data. For a variety of applications, customers also purchase paper copies of images and photographs, as well as digital data. EROS, therefore, offers many products on various tape media and compact discs, as well as in printed form.

Cooperators

EROS has a very broad constituency, ranging from sales of products to the public to cooperative projects with government agencies. NASA is a major partner, having recently reached an agreement with EROS for management of Earth science data. The new responsibility required doubling the physical size of the EROS facility. Partnerships also exist with the National Oceanic and Atmospheric Administration, a number of State governments, the United Nations, and a variety of other governmental and academic institutions.

Research

EROS scientists, working closely with USGS colleagues, have established themselves as major contributors to studies ranging from atmospheric migration of volcanic ash to changes in the Nation's shorelines and the relative dangers from wildfires in the summer months. A major initiative now underway at EROS is the multi-resolution land characteristics monitoring system, which will enable scientists to look at land-surface phenomena in ways not previously possible. Already, data from the program have been used to improve long-range weather forecasting, because improved understanding of ground cover enhances the ability of meteorologists to predict its interaction with the atmosphere.

Data from EROS are used not only elsewhere in the Department of the Interior, but by scientists all over the world. Research performed at the Center itself forms a significant contribution to the current scientific literature on remote sensing, earth science, and information management.

For more information on EROS or about the EDC role with Landsat 7, contact:

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External Relations
Mundt Federal Building
Sioux Falls, SD 57198
Phone: 605-594-6551
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U.S. Geological Survey
Science for a Changing World

The U.S. Geological Survey (USGS), a bureau of the Department of the Interior, is the nation's largest water, earth, biological science and mapping agency. With extensive capabilities in biology, geology, hydrology, geography and cartography, the USGS is uniquely able to provide its customers with reliable, impartial, up-to-date scientific information on a wide range of issues.

Data gathered by the USGS is used to help minimize the loss of life and property from natural disasters; contribute to the sound conservation, economic and physical development of our nation's natural resources; and enhance quality of life by monitoring water, biological, energy and mineral resources.

Every day, USGS scientists gather information in every state and territory, working in cooperation with more than 2,000 local, state and federal organizations. This information includes satellite imagery, such as that provided by Landsat instruments.

The uses of Landsat data by the USGS are many and varied. USGS researchers use Landsat data to study how land is being used and how that use changes over time. Satellite imagery is also used to study habitats and how they change with time and human intervention. In April, the Land Use History of North America Program will release Perspectives on the Land Use History of North America: A Context for Understanding Our Changing Environment – a compilation of work by USGS scientists and their federal and state partners.

After natural disasters, Landsat data also can be used to determine where the greatest damage has occurred. This particular use of Landsat data has been an important element in the USGS support of Hurricane Mitch relief and restoration efforts in Honduras. The USGS Center for the Integration of Natural Disaster Information (CINDI) devised a computer-based geographic atlas of Central America with more than 100 different types of geographic information, including Landsat imagery. The Landsat data in the CINDI atlas will help the people of Central America rebuild in areas less prone to landslides and flooding.

Another example of the use of Landsat data by the USGS is the Geographic Approach to Planning for Biological Diversity (GAP) Program. The National Gap Analysis Program's mission is to promote the conservation of biodiversity by providing conservation assessments of natural communities and native species. GAP researchers create maps of natural communities using satellite imagery, such as Landsat, and field and air video reconnaissance. GAP activities include mapping the distribution of native species; comparing the distribution of natural communities and species with the existing network of conservation areas; and delivering this information to the public and various research and management agencies.

For more information on these or any USGS research program, please contact the USGS Office of Outreach at 703.648.4460 or visit our Web site at www.usgs.gov.

Mission Facts

Launch

Landsat 7 is scheduled for launch on April 15, 1999, from the Western Test Range on a Delta-II expendable launch vehicle. At launch, the satellite will weigh approximately 4,800 pounds (2,200 kilograms). The spacecraft is about 14 feet long (4.3 meters) and 9 feet (2.8 meters) in diameter.

The ETM+ instrument is an eight-band multispectral scanning radiometer capable of providing high-resolution imaging information of the Earth's surface. It detects spectrally-filtered radiation at visible, near-infrared, short-wave, and thermal infrared frequency bands from the sun-lit Earth.

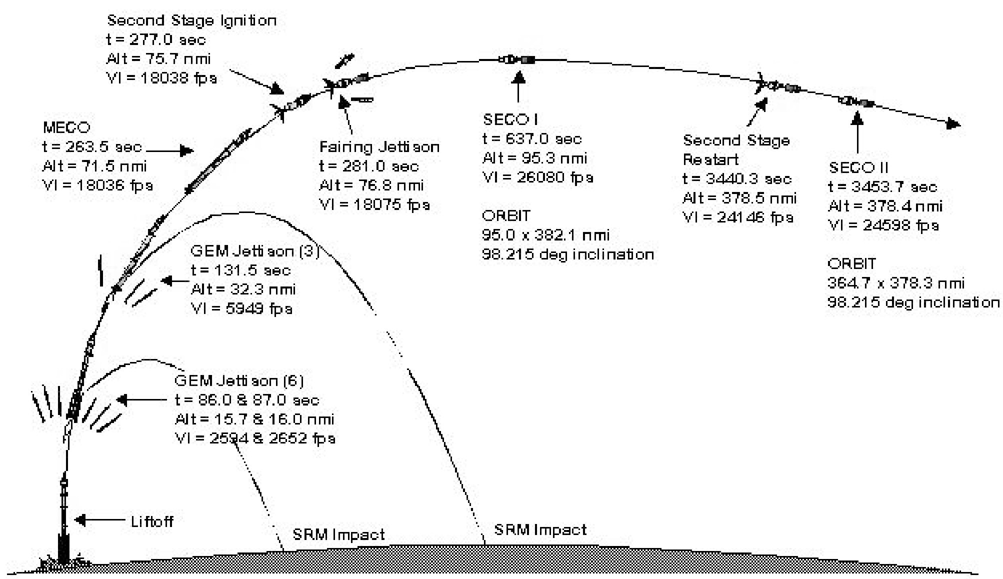
When orbiting at an altitude of 438 miles (705 kilometers), the spacecraft can take in a 115-mile (183 kilometer)-wide swath.

Nominal ground sample distances or "pixel" sizes are 49 feet (15 meters) in the panchromatic band; 98 feet (30 meters) in the six visible, near and short-wave infrared bands; and 197 feet (60 meters) in the thermal infrared band.

A Landsat World-Wide-Reference system has catalogued the world's landmass into 57,784 scenes, each scene is 115 miles (183 kilometers) wide by 106 miles (170 kilometers) long. The ETM+ will produce approximately 3.8 gigabits of data for each scene, which is roughly equivalent to nearly 15 sets of encyclopedias at 29 volumes per set.

Landsat 7 Boost Profile

EXPENDABLE LAUNCH VEHICLES



Legend:

MECO=	**Main Engine Cut Off**
SECO=	**Second Engine Cut Off**
GEM=	**Graphite Epoxy Motor**
SRM=	**Solid Rocket Motor**
FPS=	**Feet Per Second**
VL=	**Velocity (in feet per second)**
Alt=	**Altitude (in nautical miles)**
T=	**Time**

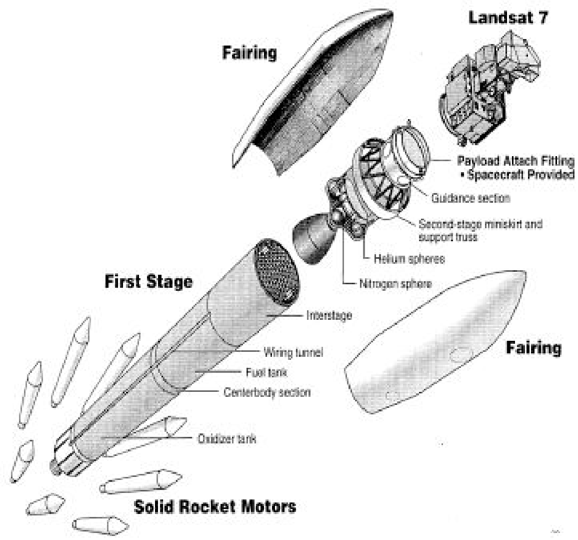
Landsat ELV Configuration and Mission Characteristics

EXPENDABLE LAUNCH VEHICLES

- Vehicle Configuration: 7920-10C
- Launch Site SLC-2 at VAFB
- Launch Period: April 15 continuous (no sensitivity to day of year)
- One launch opportunity per day (2 minute window)
  - window opens 1832 GMT
  - window closes 1834 GMT
- Weight
  - NTE 4676 lbs (including PAF)
- Margin
  - 1962 FPS Velocity Reserve
- Fairing Configuration
  - VC-6 super clean
  - use of RF reducing Blanket material
  - 5 S/C access doors (1 RF transparent)

Landsat 7

Delta II 7920-10 Launch Vehicle



Orbit

The satellite will orbit the Earth at an altitude of approximately 438 miles (705 kilometers) with a Sun-synchronous 98-degree inclination and a descending equatorial crossing time of 10 a.m. The orbit will be adjusted upon reaching orbit so that its 16-day repeat cycle coincides with the Landsat Worldwide Reference System. This orbit will be maintained with periodic adjustments for the life of the mission. A three-axis attitude control subsystem will stabilize the satellite and keep the instrument pointed toward Earth to within 0.05 degrees.

Communication/Data

A silicon cell solar array, nickel hydrogen battery power subsystem will provide 1,550 watts of load power to the satellite. A communications subsystem will provide two-way communications with the ground. The command uplink and the housekeeping telemetry downlink will be via S-band while all the science data will be downlinked via X-band. A command and data handling subsystem will provide for commanding, data collection, processing and storage. A state-of-the-art solid state recorder capable of storing 380 gigabits of data (100 scenes) will be used to store selected scenes from around the world for playback over a U. S. ground station. In addition to stored data, real-time data from the Enhanced

Thematic Mapper Plus can be transmitted to cooperating international ground stations and to the U.S. ground stations.

Landsat Ground System

The Landsat ground system includes a spacecraft control center, ground stations for uplinking commands and receiving data, a data handling facility and a data archive developed by the Goddard Space Flight Center in conjunction with the U.S. Geological Survey EROS Data Center, Sioux Falls, S.D. These facilities, augmented by existing NASA institutional facilities, will communicate with Landsat 7, control all spacecraft and instrument operations, and will receive, process, archive, and distribute ETM+ data.

The primary ground station, the data handling facility and archive are located at the EROS Data Center and will fall under USGS management following launch and on-orbit activation of the satellite. NASA will manage flight operations from the control center at the Goddard Space Flight Center until October 1, 2000, when responsibility for flight operations transfers to the U.S. Geological Survey as well. The ground system will be able to distribute raw ETM+ data within 24 hours of its reception at the EROS Data Center.

The ground system at the data center will be capable of capturing and processing 250 Landsat scenes per day and delivering at least 100 of the scenes to users each day. All 100 of these scenes can be radiometrically corrected to within five percent and geometrically located on the Earth to within 820 feet (250 meters). Uncorrected data that is ordered will contain sufficient information to allow a user to do the correction. Data captured will routinely be available for user ordering within 24 hours of its receipt at the EROS Data Center. The user will be able to query metadata and image browse data from the archive electronically to determine if it contains suitable information. If so, the data can be ordered and delivered either electronically or in a digital format by common carrier.

Calibration and Validation

The data from these satellites cannot easily be compared and integrated for the detection, monitoring and characterization of global change without calibration to common units of measurement. Calibration is essential to the role of Landsat 7 in the Earth Observing System era.

Landsat 7 will be launched as part of a planned constellation of satellites dedicated to Earth observations. The Enhanced Thematic Mapper Plus aboard Landsat 7 will be calibrated accurately in order to use its data in concert with the data from the other satellites and thereby realize the full potential of the integrated remote sensing systems under development by the Earth Science Enterprise.

The inclusion of a new full-aperture-solar-calibrator and a partial-aperture-solar-calibrator on Landsat 7 will afford improved calibration relative to the earlier Thematic Mapper and Multi-Spectral Scanner sensors on Landsats 4 and 5. These two devices will permit use of the sun, with its known exo-atmospheric irradiance, as an absolute radiometric calibration source. The data provided by the on-board solar calibrators, in conjunction with an internal calibration lamp and occasional ground-based validation experiments, will permit calibration to an uncertainty of less than five percent. This level of accuracy is consistent with the radiometric requirements for the Earth Observation System sensors.

Program/Project Management

Landsat 7 was developed as a tri-agency program between the National Aeronautics and Space Administration, the National Ocean and Atmospheric Administration (NOAA), and the Department of Interior's U.S. Geological Survey. NASA is responsible for the development and launch of the satellite, and the development of the ground system. As the operator of the national meteorological satellite system, NOAA provided its operational expertise to the developers of the ground system. USGS is responsible for receiving, processing, archiving and distributing the data.

As the operational era begins, Landsat 7 is transitioning to a dual-agency program between NASA and U.S. Geological Survey. The transition and management have been governed by a joint management plan agreed to by the three agencies; future management will be governed by a bilateral Memorandum of Understanding between NASA and U.S. Geological Survey. The Landsat Project, located at the Goddard Space Flight Center, manages Landsat development for NASA's Office of Earth Science in Washington, D.C. USGS operations will be performed at a Mission Operations Center at the Goddard Space Flight Center and at the EROS Data Center in Sioux Falls, S.D.

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Dr. Ghassem Asrar, Associate Administrator of the Office of Earth Science

Goddard Space Flight Center
Phil Sabelhaus, Landsat 7 Project Manager
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