

Special Landsat 6 Issue

Volume 7, Number 2 - Summer 1992

LANDSAT DATA USERS NOTES



Central Florida, First Image from EOSAT's New Tracking Facility

A Letter to the World Community of Landsat Data Users



EOSAT is proud to introduce the latest in the successful Landsat satellite program series — Landsat 6.

Because of the advances this new satellite will bring to the field of remote sensing, this entire Data User Note is devoted to Landsat 6 — products, applications, and technical information. With new technology in place, the data you purchase will be crisper and clearer, arrive faster, and be more economical.

One of the most important upgrades aboard Landsat 6 is the Enhanced Thematic Mapper (ETM). The ETM will have the same seven Thematic Mapper (TM) bands currently on Landsats 4 and 5, plus a panchromatic band with 15 meter spatial resolution that is co-registered with the seven bands. Clients will get the same broad multispectral view of the Earth that has been Landsat's signature for almost two decades, with the panchromatic band providing two times better resolution. (See Panchromatic Band story, on page 7)

The satellite's other features include on-board recorders to store scenes when the satellite is out of receiving range, pointable antennas so that data can be downlinked simultaneously to separate ground stations, and flexible gain settings, allowing greater radiometric resolution. These changes will improve image quality and speed delivery to our clients.

In 1985 EOSAT was awarded a contract from the Department of Commerce, following a competitive bid, to develop a commercial market for Landsat. EOSAT approached prospective users in the private sector, as well as in the government, and found a receptive audience.

We listened to our clients' needs and developed products to help them solve their problems. We cultivated national and international markets.

Our success has been remarkable. We have turned the government's research-based system into a successful operational program, doubling the amount of data processed weekly. We adjusted prices to stimulate sales (see Pricing, on page 8). By developing new technology, we streamlined our processes and eliminated redundant steps. Planning for the future, we built a new North American Landsat tracking facility in Norman, Oklahoma. And, as of October 1992, we no longer will need taxpayer money to support the operations.

We are confident that the launch of Landsat 6 — another milestone in the successful commercialization of remote sensing data — will meet our clients' remote sensing needs better than before. We are sure that the continuity, value, and usefulness of the Landsat program will reach far into the future.

This is EOSAT's commitment to our clients.

Thank you,

Arturo Silvestrini
President & CEO

LANDSAT DATA USERS NOTES

The EOSAT Landsat Data Users Notes is a quarterly publication [ISSN 0896-7091] of the Earth Observation Satellite Company, and is published without copyright or other restrictions on copying. Articles highlighting applications of Landsat data are welcome, and should be submitted as double-spaced manuscripts with properly captioned illustrations. Written material, new product announcements, and information about meetings, symposia, workshops, and remote sensing training courses should be directed to:

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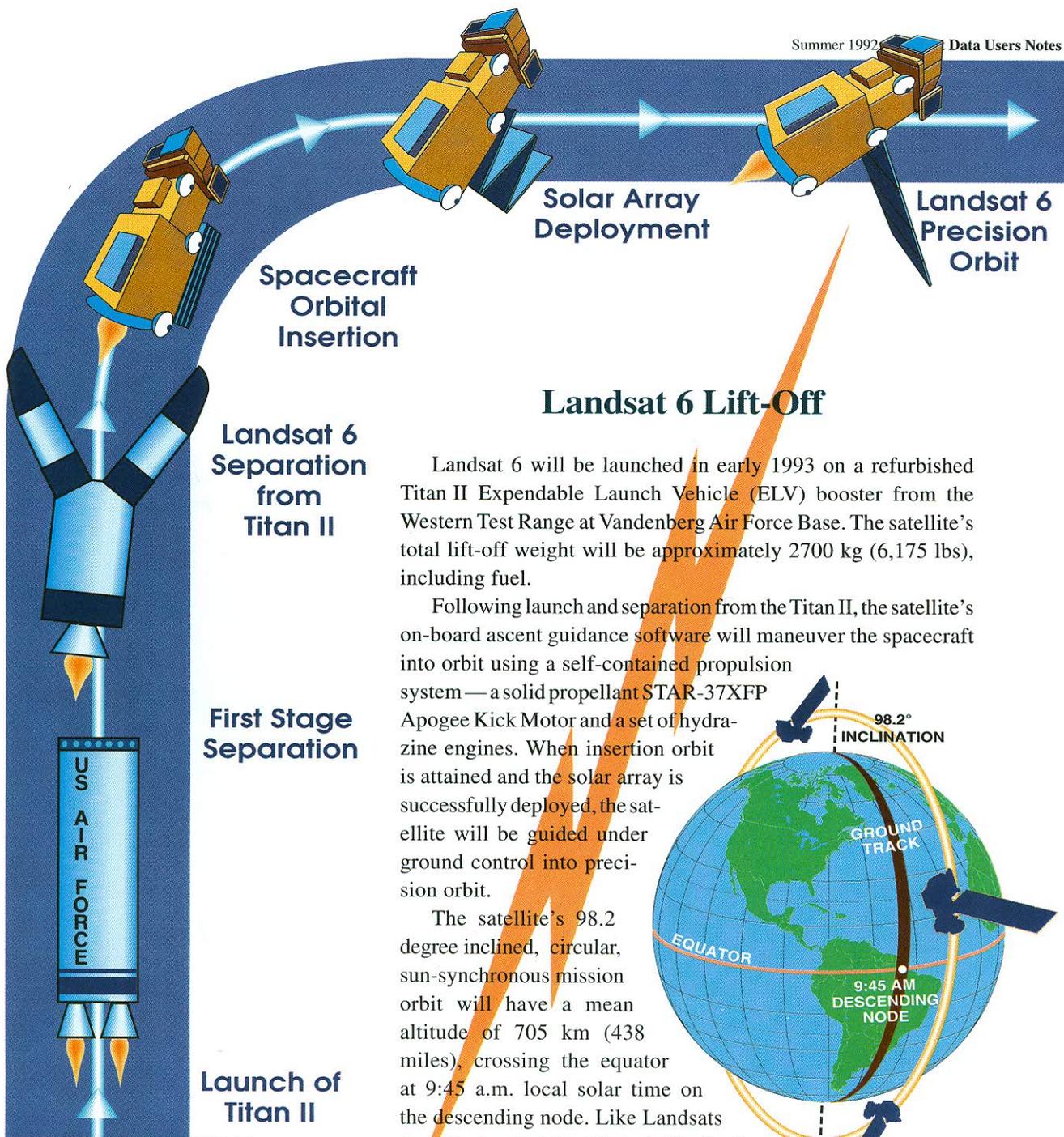
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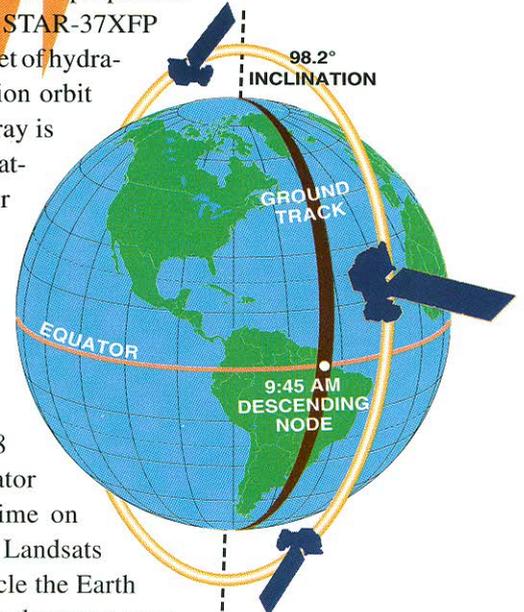


Landsat 6 Lift-Off

Landsat 6 will be launched in early 1993 on a refurbished Titan II Expendable Launch Vehicle (ELV) booster from the Western Test Range at Vandenberg Air Force Base. The satellite's total lift-off weight will be approximately 2700 kg (6,175 lbs), including fuel.

Following launch and separation from the Titan II, the satellite's on-board ascent guidance software will maneuver the spacecraft into orbit using a self-contained propulsion system — a solid propellant STAR-37XFP Apogee Kick Motor and a set of hydrazine engines. When insertion orbit is attained and the solar array is successfully deployed, the satellite will be guided under ground control into precision orbit.

The satellite's 98.2 degree inclined, circular, sun-synchronous mission orbit will have a mean altitude of 705 km (438 miles), crossing the equator at 9:45 a.m. local solar time on the descending node. Like Landsats 4 and 5, Landsat 6 will circle the Earth in 98.9 minutes, revisiting the same spot every 16 days or every 233 orbital revolutions. ❖



Titan II Photo Courtesy Martin Marietta



Ground Control Directs Precision Orbit

Landsat 6 — Merging of Tried and New Technology

Since 1972 Landsat satellites have orbited the Earth continuously, imaging nearly every meter of the planet's land masses. More than 3.1 million images have been collected and archived.

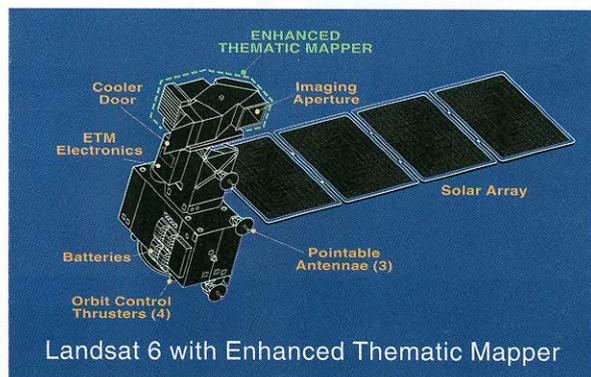
The phenomenal success of these satellites, which have far outlived their original design lives, is testimony to sound design and technology. That same dependable technology — along with many improvements and refinements — will be employed on Landsat 6, scheduled to be launched in early 1993.

With Landsat 6, EOSAT continues the tradition of chronicling the Earth's perpetual evolution. At the same time, we will deliver to our customers an expanded line of improved products more quickly and more economically.

WHAT'S NEW IN THE SKY

Drawing upon the ground-breaking technology of its successful predecessors, Landsat 6 will carry the Enhanced Thematic Mapper (ETM), an advanced version of the Thematic Mapper (TM) sensors operating on Landsats 4 and 5, which will continue to provide multispectral images at 30 meter resolution. The ETM also will carry a completely new feature: a 15 meter panchromatic band, which will measure energy in visible to near-infrared electromagnetic wavelengths.

ETM's new panchromatic band will span a portion of the visible region and extend into the near-infrared wavelengths (spectral bandwidth from 0.50 to 0.90 micrometers) to increase vegetation discrimination and haze penetration.



Landsat 6 with Enhanced Thematic Mapper



The Landsat 6 spacecraft, with the Enhanced Thematic Mapper (ETM) mission sensor mounted on the top, in a chamber prior to Acoustics Testing. The three steerable X-band antennas and the stowed solar array (large blue panels, center) are also visible in the photo.

EOSAT specifically chose 15 meter resolution for the panchromatic band, as opposed to 10 meter or less, to fit the downlink data into the Landsats 4 and 5 85 Mbps data stream in order to reduce the upgrade costs to international ground stations.

The 15 meter pixels allow a 4-to-1 overlay with the 30 meter pixels. Any smaller pixel size would produce too much data to fit the 85 Mbps stream.

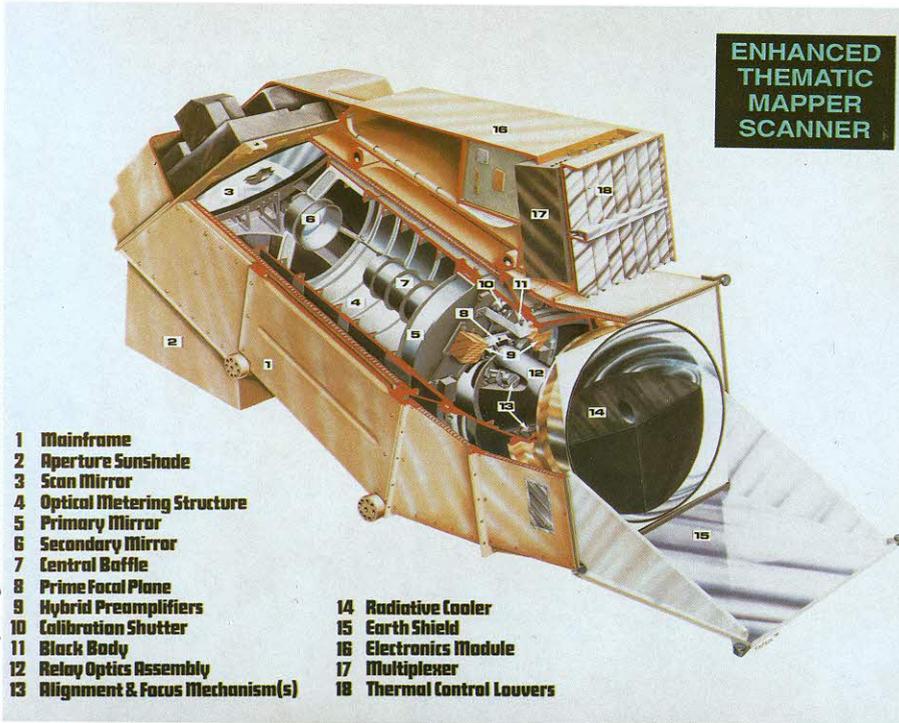
Co-registration of the panchromatic and multi-spectral data is another very

significant improvement on Landsat 6 because it will save substantial processing time and money. The panchromatic band and bands 1 through 4 are on the satellite's prime focal plane assembly, which contains 96 detectors. (The pan band alone will consist of 32 individual detectors.) The array of all 96 detectors on a common substrate means that panchromatic band data are co-registered with ETM's other four bands, making for more efficient processing. Bands 5, 6, and 7 are on the cold focal plane (which contains 36 detectors).

Data from Landsat 6 will be crisper, clearer, and more accurate because of greater radiometric resolution provided by

Courtesy GE Astro Space Division

Courtesy Hughes Santa Barbara Research Center



tape recorders, which have been flight-proven, so that data can be acquired from any area in the world and stored until the satellite is back within range of the new Oklahoma receiving station. This feature will allow EOSAT to obtain and process customer orders more quickly.

WHAT'S NEW ON THE GROUND

EOSAT also has ushered in a number of major improvements on the ground that result in finer products and faster delivery to our customers.

A new North American data tracking station in Norman, Oklahoma, gives us complete coverage for the contiguous United States for the first time, streamlining data acquisition.

Advancements in data processing will help us in our goal to improve quality control. Our cloud cover assessment procedures are made manually and digitally. For the manual assessment, we use three bands instead of one, adjusting the look-up table to enhance the image for viewing. This provides a more accurate cloud cover assessment.

We also now can further analyze a scene for anomalies by viewing an image, as well as studying statistics, before it is shipped to a customer. These improve-

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high and low gain settings. Although radiometric resolution is the same as Landsats 4 and 5, the gains can be set for individual bands. The low gain is similar to the gains on Landsats 4 and 5 and the high gain can be used over low reflectance areas, such as water for bathymetric studies.

A gain feature commanded from the

ground means that the sensor sensitivity can be adjusted to predicted ground brightness. Standard gains, set according to the needs of each geographic location, will be published in EOSAT's path-row map. Our customers can request a particular gain setting when orders are placed.

Landsat 6 will carry two high data rate

**Down to Earth:
Getting Your Data**

A well-established network of satellite receiving stations currently collects Landsat data around the world. During the Landsat 6 era, the 7-band multispectral and high-resolution panchromatic image data will be downlinked to an expected 15 international facilities, planned to grow to 18.

Landsat 6 will transmit up to three high-data rate X-band downlinks to three acquisition stations simultaneously. Multiple frequencies from each steerable antenna will transmit both the seven-band multispectral and the panchromatic image data to a single station.

A key addition to Landsat's worldwide network is EOSAT's new satellite tracking and receiving facility in Oklahoma, USA. The new station's development and operation have been funded entirely by EOSAT, assuring EOSAT's steadfast commitment to the Landsat pro-

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EOSAT's new satellite tracking and receiving station at Norman, Oklahoma, has an unobstructed view of the horizon for the receiving antenna and is free of frequency interference from local radio transmissions.

Getting Your Data

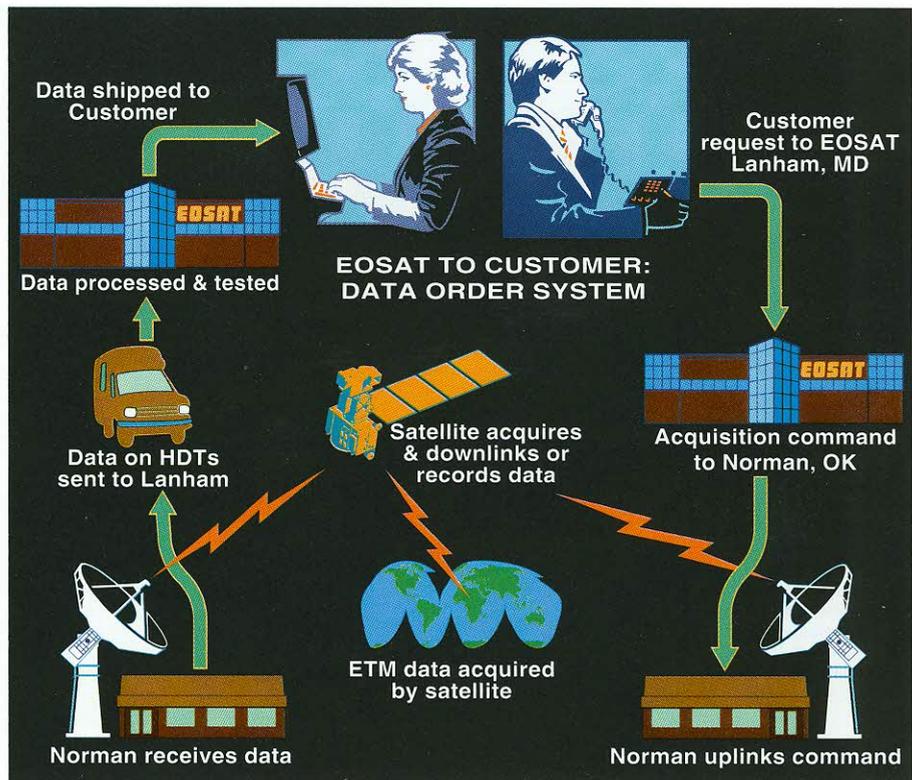
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gram and to providing customers with the highest quality data possible.

To request an acquisition, a customer calls EOSAT's customer services department at the U.S. headquarters in Lanham, Maryland (301-552-0537). Our technical team takes over from there. ➡➡➡

The acquisition command is transmitted from headquarters to the new Oklahoma facility by modem for uplinking to the satellite. The Landsat 6 spacecraft provides a 72-hour stored command capability for autonomous imaging operations. The stored commands execute orders, such as when to switch on the ETM and recorders and assigning antennas to transmitters for ground station reception. These commands as well as the ephemeris/star catalog, will be uplinked daily.

In response to the acquisition command, the sensor switches on at the assigned time to acquire the customer's order.



About the Norman Satellite Tracking Facility

EOSAT's new Landsat satellite tracking facility, located near Norman, Oklahoma, opened on May 8, 1992. The ground station, which began operating in June, receives Earth image data acquired by Landsats 4 and 5 and will acquire image data from Landsat 6 after it is launched in early 1993.

The site, located seven miles southwest of Norman, was chosen because its mid-continent location provides real-time data downlink capability covering the contiguous United States. The station handles functions that used to be performed by two separate North American ground stations, streamlining acquisition procedures for faster order fulfillment. The station will receive real-time image data for an expanded area of North and Central America (*see coverage, Vol. 6, No. 2, - Summer 1991*) and recorded image data of other locations acquired when Landsat 6 is outside the Norman receiving area.

The facility is operated out of a 4,300 square foot building with a newly installed satellite antenna. The station's antenna and radio frequency subsystems will receive X-band imagery data and S-band telemetry data from the satellite and will transmit uplink command data to the satellite via S-band. The Oklahoma station has an unobstructed view of the horizon for the receiving antenna and is free from frequency interference from local radio transmissions.

An existing Swedish Space Corporation site in Kiruna, Sweden, will serve as a backup tracking station for Landsat 6. ❀

About the Cover

The first image acquired from EOSAT's new Oklahoma tracking facility was of Central Florida on April 2, 1992. Cape Canaveral is along the Florida coast, lower right. The light purple area west of the Cape is Orlando. Lake George, at top center, is bordered on the south and west by the bright green of Salt Springs National Forest. Red and green agriculture fields border the north shore of Lake Apopka, central lower half of image. Walt Disney World is just south of Lake Apopka. TM Bands 7,4,2 (RGB). ❀

When the satellite is within receiving range of the Oklahoma facility, the data is downlinked directly to the ground station. At other times the data is stored on one of the satellite's two tape recorders and relayed when the spacecraft re-enters the Norman receiving area.

The Oklahoma station records the downlinked data on 28-track high density tapes and sends the tapes by commercial carrier to the Lanham facility for processing. The scene is screened to assess cloud cover and is carefully reviewed before being shipped to the customer. ❀

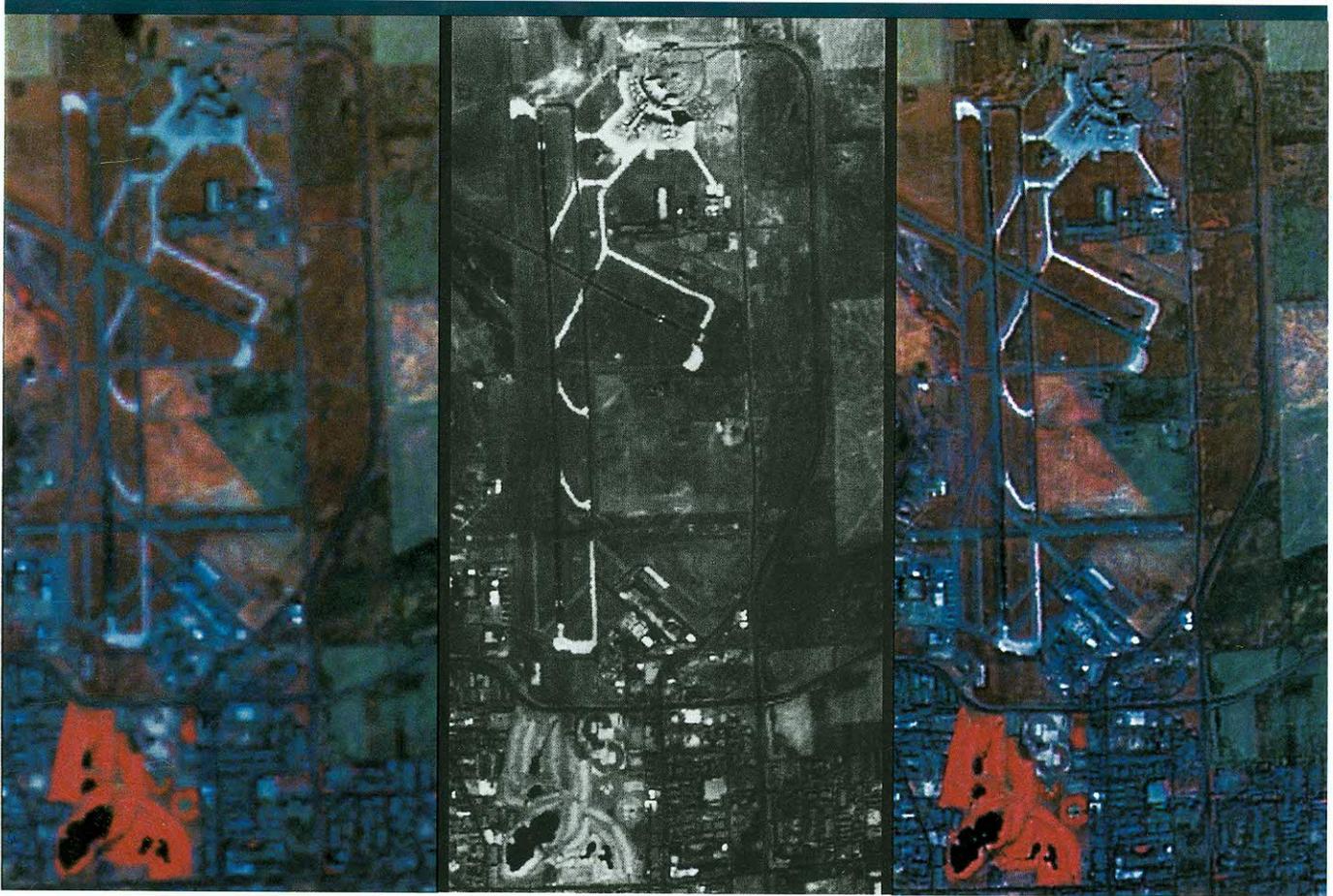
Landsat 6 Technology

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ments will assure that our customers receive quality products.

This next generation Landsat will ensure that EOSAT continues to provide wide area and, with its predecessors, even more repetitive coverage of the Earth. ❀

For information please contact:
EOSAT Company
Customer Services Department
1-800-344-9933
or International: 01-301-552-0537



Left: TM bands 4, 3, 2 (RGB) of Calgary, Canada. Center: This simulated pan image of the Calgary Airport, collected from an aircraft scanner, was acquired at a 7.5 meter ground resolution and resampled to 15 meters. The spectral band width is 0.5 to 0.9 micrometers. Right: Pan and TM data are merged. The 30 meter TM data was replicated to 15 meters and co-registered with the TM.

Panchromatic Data Applications

For all remote sensing applications — from environmental monitoring to mineral exploration and land use analyses — Landsat 6 ETM data will build on EOSAT's solid history of providing timely, accurate information to support important environmental, economic, and industrial decision making.

The panchromatic band's 15 meter resolution and spectral range (0.5-0.9 μm) reaches into the near-infrared wavelengths. This range was selected to be similar to infrared aerial photography (Kodak infrared Aerographic 2424 film with Wratten #12 filter), which has been used in aerial photography studies of vegetation. In addition to different vegetation types, this band shows man-made objects such as roads, houses, and runways.

Many users will benefit from the increased resolution of the panchromatic

band. Geologists will better identify structural features. Users of Geographic Information Systems will have increased mapping capability. Resource managers will have more detailed land use data.

By including near-infrared wavelengths, the pan data will provide more useful information than a band with visible wavelengths only. It will be good for delineating land-water boundaries for coastal zone management; discriminating vegetation and vigor; for mapping crop type and penetrating haze. There is some evidence that this wider band has been more useful than narrower bandwidths for differentiating tree types and identifying insect infestations.

For visual interpretation, the pan data will have characteristics of traditional panchromatic photography — imaging the visible wavelength — with the added advantages of infrared imagery.

The pan data can also be merged with the multispectral data to spatially sharpen

the 30 meter multispectral bands for better identifying cultural features, delineating land cover boundaries, and locating training sites.

To illustrate the capabilities of Landsat 6 data, a simulated data set was acquired over Calgary on September 8, 1991, by aircraft scanner, and by Landsat 5 on October 15, 1991. The pan simulation covered a 3 x 7.6 kilometer ground area at the Calgary Airport. The TM data was systematically corrected to a Universal Transverse Mercator projection and 30 meter pixel size. To merge the data the 30 meter TM data was resampled to 15 meters to achieve a common size for all pixels. The pan data was acquired at 7.5 meter ground resolution and resampled to 15 meters.

EOSAT is offering Landsat 6 simulation of the eight-band Thematic Mapper data on disk. The cost of the disk is \$25 to cover handling. For information, please call EOSAT's Customer Services Department, 301-552-0537. ❖

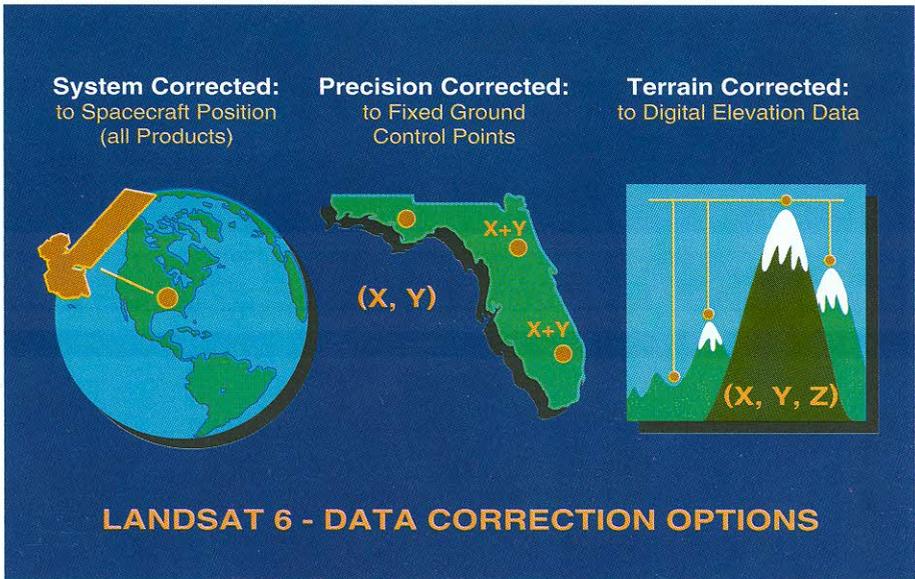
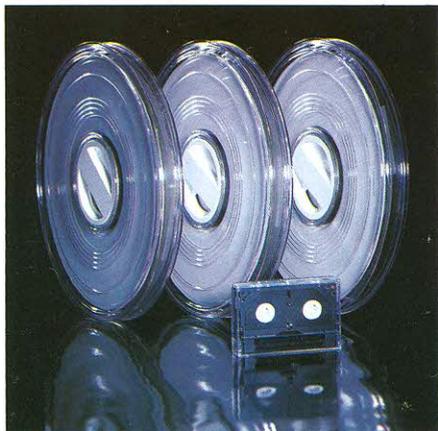
EOSAT Expands Product Line

Landsat 6's new operational system, already in place at EOSAT, currently is providing customers with improved products and services. Data from Landsat 6 will further enhance those improvements.

For example, Landsats 4 and 5 data is available in digital and photographic form and can be ordered as either full scenes (185km x 170km), subscenes (100km x 100km) or map sheets (1/2° by 1°, approximately 55.5km x 111 km). All digital products are radiometrically corrected and available in customer-specified size, map projection, Earth ellipsoid, pixel size, and level of geometric precision.

Digital products can be either path-oriented or map-oriented. Path-oriented products follow the satellite's path and heading. Map-oriented products, usually made north-up, are processed to customer specifications. Map-oriented products are available in three levels of geometric correction — system corrected, precision-corrected (using ground control points to adjust the satellite's predicted position to its actual geodetic position), or terrain-corrected (using elevation data to adjust relief displacement). Digital data is available on 9-track computer compatible tapes (CCTs) or 8mm tape cartridges. (See photo at bottom.)

To maintain continuity, Landsat 6 will use the same Worldwide Reference System (WRS) as used with Landsats 4 and 5. The WRS, a grid-coordinate system of paths and rows, provides a standardized approach for locating Landsat scenes and makes selecting Landsat images easy for the user. ❖



EOSAT offers Landsat data users three levels of precision control for map-oriented products: System-corrected data (automatically applied to all products); Precision-corrected and Terrain-corrected, both of which are available as customer options.

EOSAT: Taking a Byte Out of Your Taxes

In October 1992, EOSAT will assume the total cost of operating Landsats 4 and 5, as well as Landsat 6, following its launch. By reaching this phase in the commercialization process, EOSAT reduces the cost of Landsat operations to the U.S. taxpayer from \$20 million per year to zero.

What does this mean to our customers? The assurance that EOSAT, whose success and viability depends upon satisfied patrons, must continually provide products and services that meet their needs at prices they can afford.

EOSAT has been preparing for financial independence from the government since we assumed operations of the Landsat satellite program in 1985. Charged by the Department of Commerce to develop a commercial market for Landsat data, we set in motion marketing strategies that would assure a loyal and dependable customer base.

Our customers have benefited from state-of-the-art products and services provided by a market-driven, customer-oriented company whose very survival depends upon satisfied customers.

To stimulate sales and create an expanded demand for the Landsat data, EOSAT reduced costs, dropped the \$800 "new acquisition" fee charged by the government, and lowered prices overall.

The 1992 price for TM data, adjusted for inflation, is the same as charged by the federal government in 1985. This represents a 21% decrease in prices. With Landsat 6, EOSAT will also lower fees to foreign ground stations.

During this growth period, EOSAT has also successfully faced the competition from the French remote sensing company, SPOT Image; when computed on a per-square-mile basis, SPOT's fees are five times greater than EOSAT's. EOSAT's images are 185km x 170km, while SPOT's are 60km x 60km.

The successful development of a commercial market, offering competitive prices, improving technology, and increasing efficiency will enable EOSAT, in October, to assume the operating costs of Landsats 4 and 5, as well as for Landsat 6. Revenues from the sales of data and services exceed the cost of operations. Again there will be no cost to the taxpayer.

The commercialization process has stretched the market and has encouraged the development of diverse products and services. ❖

