Satellite Transmission

TCET 3222

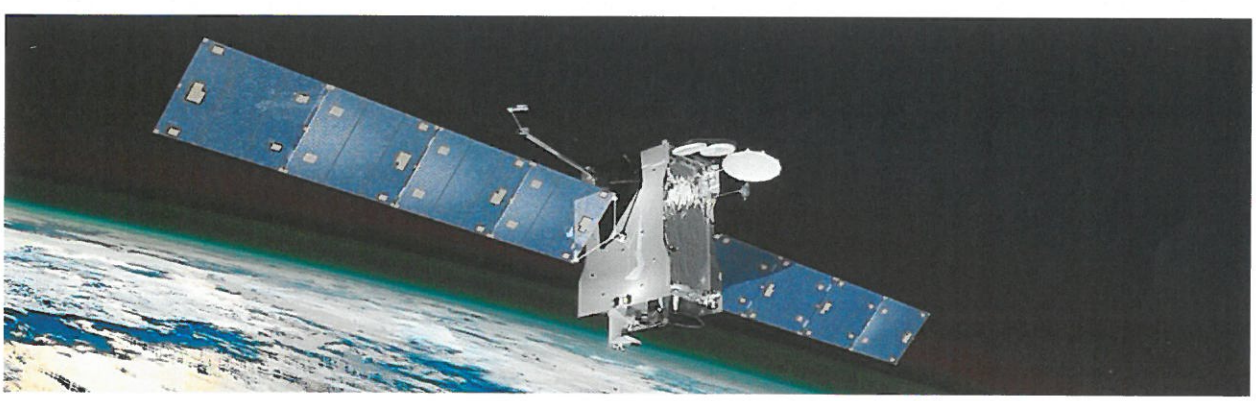
Earth Resource Satellites

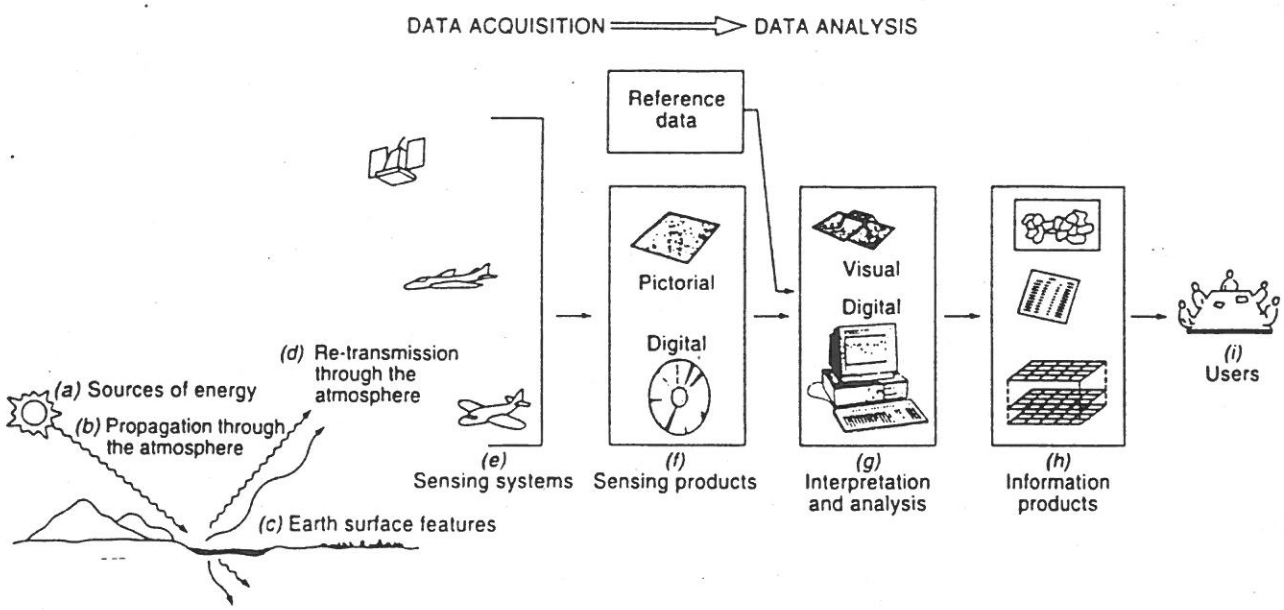
&

Applications

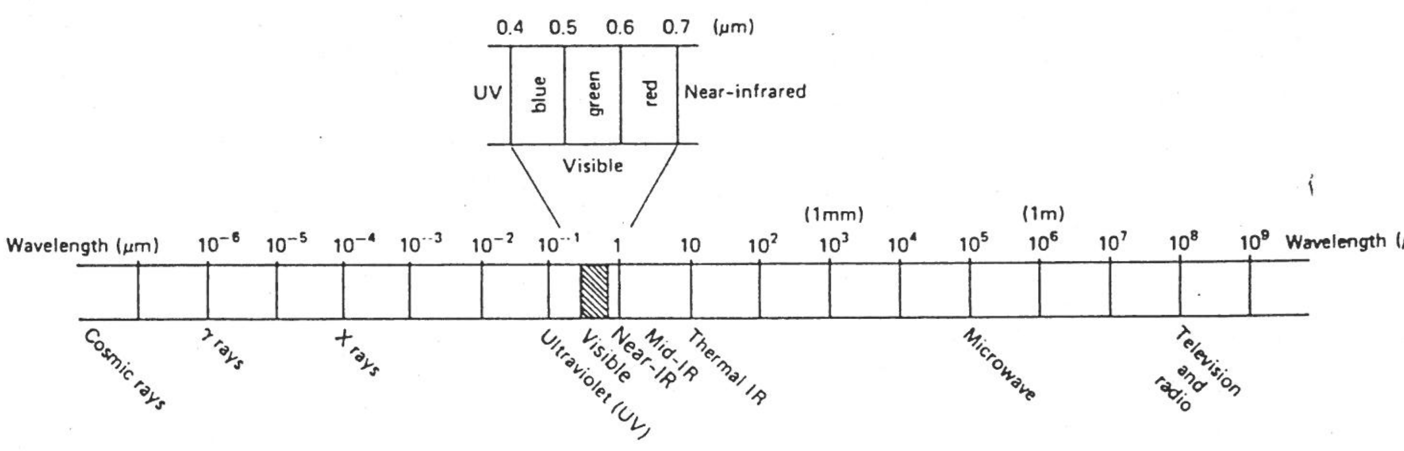
Professor Mohammad Razani

CHAPTER 7

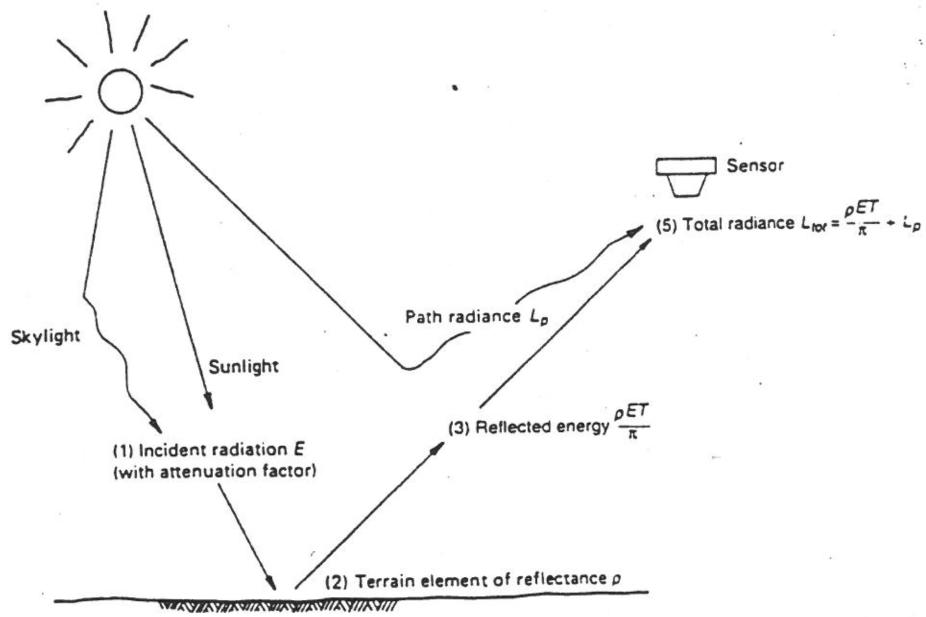




Electromagnetic remote sensing of Earth resources (1)



The Electromagnetic Spectrum (1)



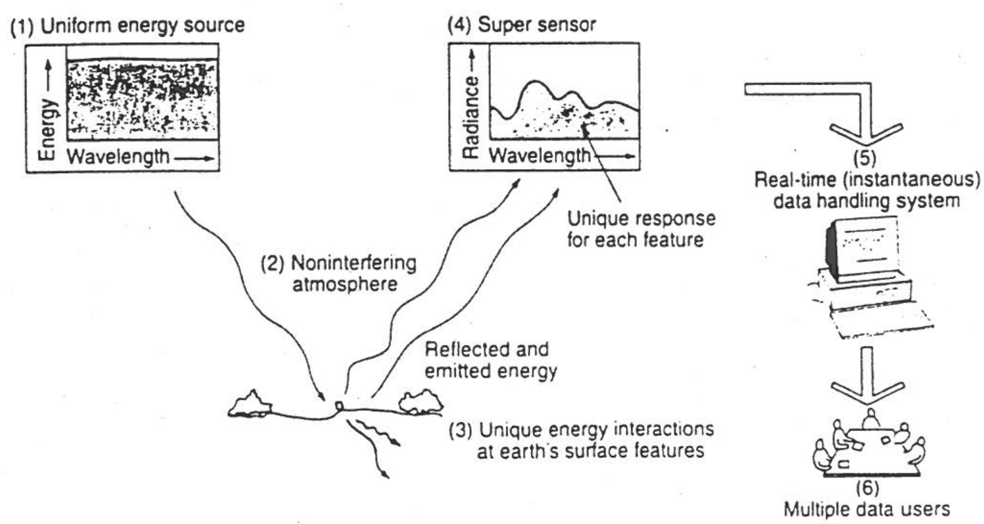
Atmospheric effects influencing the measurement of reflected solar energy. Attenuated sunlight and skylight (E) is reflected from a terrain element having reflectance ρ. The attenuated radiance reflected from the terrain element ($\rho ET/\pi$) combines with the path radiance (L_p) to form the total radiance (L_{tot}) recorded by the sensor.

$$L_{tot} = \frac{\rho ET}{\pi} + L_p$$

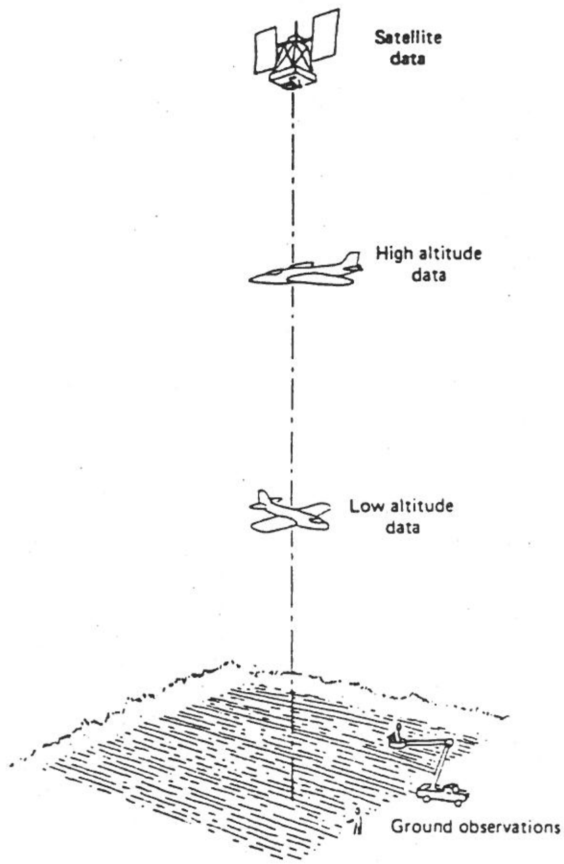
where

L_{tot} = total spectral radiance measured by sensor
ρ = reflectance of object
E = irradiance on object, incoming energy
T = transmission of atmosphere
L_p = path radiance, from the atmosphere and not from the object

Atmospheric effects (1)



Components of an ideal remote sensing system (1)



Multistage remote sensing concept (1)

Current and future remote sensing satellites (2)

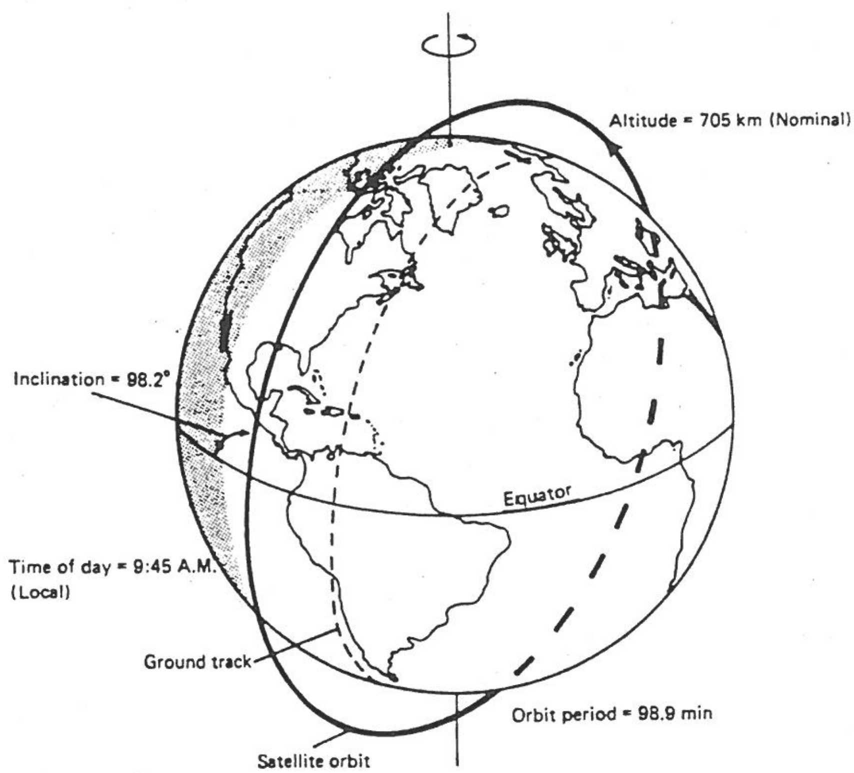
Country	Owner/ Object	Program	Date	Instr. Type	Resolution (in meters)			Color Bands	Stereo Type
					P	M	R		
India	G/O	IRS-1A	'88	P&M		36 72		4	
	G/O	IRS-1B	'91	P&M		36 72		4	CT
	G/O	IRS-P2	'94	M		36		4	
	G/O	IRS-1C	'95	P&M	10	20		4	CT
	G/O	IRS-1D	'95	P&M	10	20		4	CT
Japan	G/O	J-ERS	'92	R&M		24	30	4	CT
U.S.	G/O	ADEOS	'96	P&M	8	16		4	CT
	G/O	Landsat 5	'84	M		30		7	
	G/E	TRW Lewis	'96	P&M	5	30		384 (?)	
	G/E	CTA Clark	'96	P&M	5	15		3	FA
	C/O	Earth Watch	'96	P&M	3	15		3	FA
	C/O	Earth Watch	'97	P&M	3	4		4	FA
	C/O	Eyeglass	'97	P	1				FA
	C/O	Space Imaging	'97	P&M	1	4		4	FA
	G/O	Landsat 7	'98	P&M	15	30		7	
	C/O	Space Imaging	'98	P&M	1	4		4	FA
	G/O	EOS AM-2 L-8	'04	P&M	10	30		7	FA
U.S./Japan	G/O	EOS AM-1	'98	M	15	15		14	FA
France	G/O	SPOT 3	'93	P&M	10	20		4	CT
	G/O	SPOT 4	'97	P&M	10	20		4	CT
	G/O	SPOT 5a	'99	P&M	5	10		4	FA
	G/O	SPOT 5b	'04	P&M	5	10		4	FA
ESA	G/O	ERS-1	'91	R			30		
	G/O	ERS-2	'95	R			30		
	G/O	ENVISAT	'98	R			30		
Russia	G/O	Resours-02	'95	M		27		3	
	G/O	Almaz 2	'96	R			5		
China/Brazil	G/O	CBERS	'95	P&M	20	20		7	CT
	G/O	CBERS	'96	P&M	20	20		7	CT
Canada	G/O	Radarsat	'95	R			9		
Korea	G/O	KOMSAT	'98	P&M	10	10		3	FA

M-Multispectral; P-Panchromatic; G-Government Funded; C-Commercially Funded; O-Operational; E-Experiment; FA-Fore & After; CT-Cross Track; R-Radar

Characteristics of Landsat-1 to –7 Missions (2)

Satellite	Launched	Decommissioned	RBV Bands	MSS Bands	TM Bands	Orbit
Landsat-1	July 23, 1972	January 6, 1978	1–3 (simultaneous images)	4–7	None	18 days/900 km
Landsat-2	January 22, 1975	February 25, 1982	1–3 (simultaneous images)	4–7	None	18 days/900 km
Landsat-3	March 5, 1978	March 31, 1983	A–D (one-band side-by-side images)	4–8[a]	None	18 days/900 km
Landsat-4	July 16, 1982[b]	—	None	1–4	1–7	16 daya/705 km
Landsat-5	March 1, 1984	—	None	1–4	1–7	16 days/705 km
Landsat-6	October 5, 1993	Failure upon launch	None	None	1–7 plus panchromatic band (ETM)	16 days/705 km
Landsat-7	April 15, 1999	—	None	None	1–7 plus panchromatic band (ETM+)	16 days/705 km

[a]Band 8 (10.4–12.6 μm) failed shortly after launch.
[b]TM data transmission failed in August 1993.



Sun-synchronous orbit of Landsat-4 and -5. (Adapted from NASA diagram.)

Sensors Used on Landsat-1 to –7 Missions (2)

Sensor	Mission	Sensitivity (µm)	Resolution (m)
RBV	1, 2	0.475–0.575	80
		0.580–0.680	80
		0.690–0.830	80
	3	0.505–0.750	30
MSS	1–5	0.5–0.6	79/82[a]
		0.6–0.7	79/82[a]
		0.7–0.8	79/82[a]
		0.8–1.1	79/82[a]
	3	10.4–12.6[b]	240
TM	4, 5	0.45–0.52	30
		0.52–0.60	30
		0.63–0.69	30
		0.76–0.90	30
		1.55–1.75	30
		10.4–12.5	120
		2.08–2.35	30
ETM[c]	6	Above TM bands plus 0.50–0.90	30 (120 m thermal band) 15
ETM+	7	Above TM bands plus 0.50–0.90	30 (60 m thermal band) 15

[a]79 m for Landsat-1 to -3 and 82 m for Landsat-4 and -5.
[b]Failed shortly after launch (band 8 of Landsat-3).
[c]Landsat-6 launch failure.

Thematic Mapper Spectral Bands (2)

Band	Wavelength (µm)	Nominal Spectral Location	Principal Applications
1	0.45–0.52	Blue	Designed for water body penetration, making it useful for coastal water mapping. Also useful for soil/vegetation discrimination, forest type mapping, and cultural feature identification.
2	0.52–0.60	Green	Designed to measure green reflectance peak of vegetation (Figure 1.10) for vegetation discrimination and vigor assessment. Also useful for cultural feature identification.
3	0.63–0.69	Red	Designed to sense in a chlorophyll absorption region (Figure 1.10) aiding in plant species differentiation. Also useful for cultural feature identification.
4	0.76–0.90	Near IR	Useful for determining vegetation types, vigor, and biomass content, for delineating water bodies, and for soil moisture discrimination.
5	1.55–1.75	Mid IR	Indicative of vegetation moisture content and soil moisture. Also useful for differentiation of snow from clouds.
6[a]	10.4–12.5	Thermal IR	Useful in vegetation stress analysis, soil moisture discrimination, and thermal mapping applications.
7[a]	2.08–2.35	Mid IR	Useful for discrimination of mineral and rock types. Also sensitive to vegetation moisture content.

[a]Bands 6 and 7 are out of wavelength sequence because band 7 was added to the TM late in the original system design process.

Landsat-7 (3)

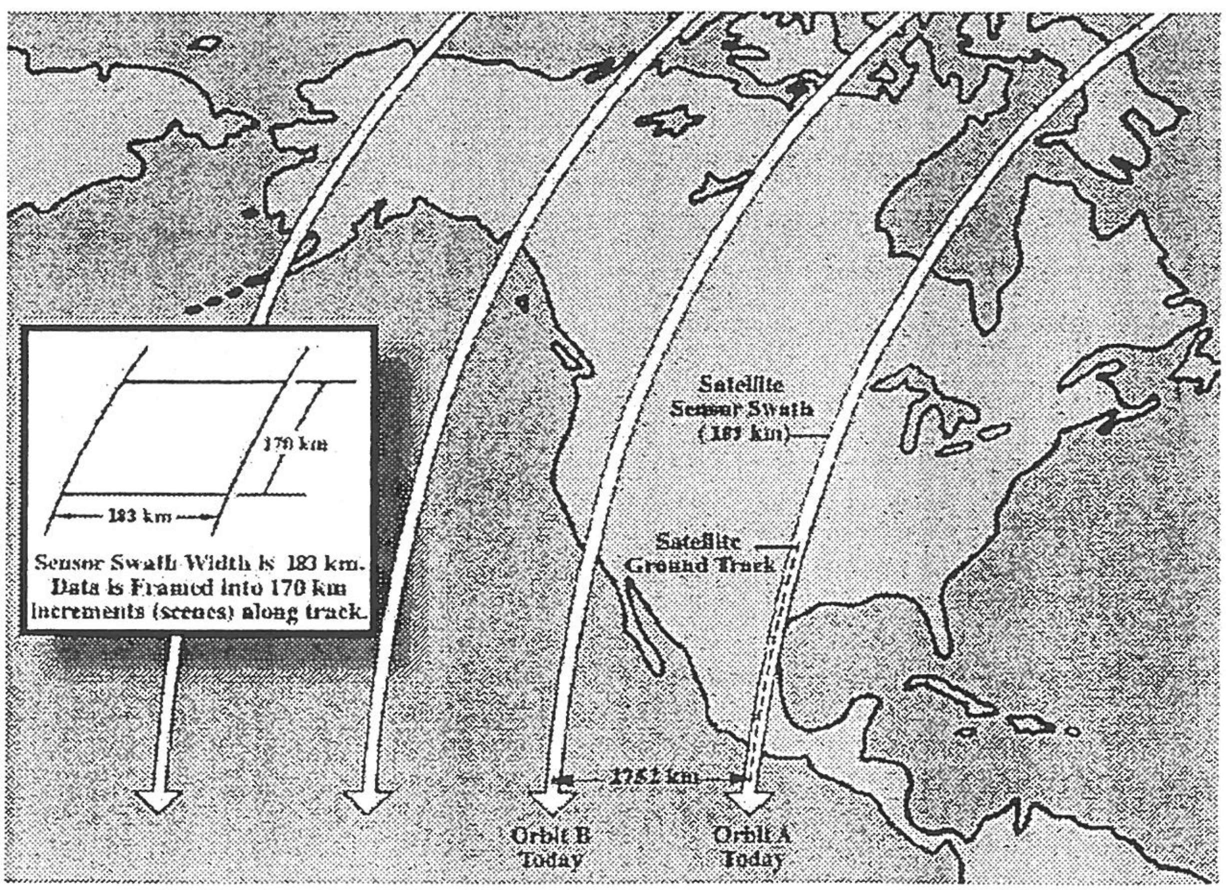
Summary:

The launch of the Landsat-7 satellite on April 15, 1999, marks the addition of the latest satellite to the Landsat satellite series. The Earth Resources Technology Satellite (ERTS) Program launched the first of a series of satellites (ERTS 1) in 1972. Part of the National Aeronautics and Space Administration's (NASA) Earth Resources Survey Program, the ERTS Program and the ERTS satellites were later renamed Landsat to better represent the civil satellite program's prime emphasis on remote sensing of land resources. Landsats 1, 2, and 3 carried the multispectral scanner (MSS) sensor and experimental return beam vidicon cameras. The Landsat-4 satellite carried the MSS and thematic mapper (TM) sensors as does the still currently flying Landsat-5 satellite. The sixth satellite in the Landsat series was unsuccessfully launched and did not achieve orbit. The Landsat-7 satellite carries the enhanced thematic mapper plus (ETM+) sensor. The launch of the Landsat-7 satellite is part of an ongoing mission to provide quality remote sensing data in support of research and applications activities.

Data Set Introduction:

The Landsat-7 system is another step in the development and application of remotely sensed satellite data for use in managing the Earth's land resources. As with earlier Landsat systems, the Landsat-7 platform, along with its enhanced thematic mapping sensor, provides for new capabilities in remote sensing of the Earth's land surface.

Landsat-7 data are collected from a nominal altitude of 705 kilometers in a near-polar, near-circular, Sun-synchronous orbit at an inclination of 98.2 degrees, imaging the same 183-km swath of the Earth's surface every 16 days.



The orbital pattern equates to a 233-orbit cycle with a swath sidelap that varies from approximately 7 percent at the Equator to nearly 84 percent at 81 degrees north or south

The Landsat-7 satellite's payload includes the ETM+ sensor. The ETM+ sensor is an enhanced version of the TM sensor flown aboard the Landsat-4 and -5 satellites, but most closely approximates the ETM sensor lost on board the Landsat-6 satellite. Sensor enhancements include the addition the panchromatic band and two gain ranges, improved spatial resolution the thermal band, and the addition of two solar calibrators.

The ETM+ sensor is designed to collect, filter, and detect radiation from the Earth in a 183-kilometer swath as it passes overhead, providing the necessary cross-track scanning motion while the Landsat-7 spacecraft's orbital motion provides an along-track scan. Daytime data are collected during the satellite's descending mode, while nighttime data are during the satellite's ascending mode.

Spectral bandwidths for the ETM+ sensor are determined through the combined response of all the system's optical path mirrors (e.g., secondary, scan line corrector), spectral filters, and individual detectors. The spectral filters, located immediately in front of each detector array, predominately establish the optical bandpass for each spectral band. The filter housing for the prime focal plane contains filters for bands 1 through 4 and for band 8 (the panchromatic band). The filter housing for the cold focal plane assembly contains filters for bands 5 through 7. Following is a comparison of bandwidths between the TM sensor flown aboard the Landsat-4 and -5 satellites and the ETM+ sensor flown aboard the Landsat-7 satellite:

TM AND ETM+ SPECTRAL BANDWIDTHS								
Bandwidth (μ) Full Width - Half Maximum								
Sensor	Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8
TM	0.45 - 0.52	0.52 - 0.60	0.63 - 0.69	0.76 - 0.90	1.55 - 1.75	10.4 - 12.5	2.08 - 2.35	N/A
ETM+	0.45 - 0.52	0.53 - 0.61	0.63 - 0.69	0.78 - 0.90	1.55 - 1.75	10.4 - 12.5	2.09 - 2.35	.52 - .90

A discrete spectral shift that occurred with the Landsat-5 TM sensor has been attributed largely to filter outgassing. Steps have been taken to make the ETM+ sensor more resistant to this phenomenon. In addition, filters on the ETM+ sensor have shown significant improvement in band-

responses as compared to the filters in the TM sensor flown aboard the Landsat-4 and -5 satellites.

Objective/Purpose:

Landsat-7 mission objectives include:

- Maintaining Landsat data continuity by providing data that are consistent in terms of data acquisition, geometry, spatial resolution, calibration, coverage characteristics, and spectral characteristics with previous Landsat data.
- Generating and periodically refreshing a global archive of substantially cloud-free, Sun-lit, land-mass imagery.
- Continuing to make remote sensing satellite data available to domestic and international users and expanding the use of such data for global change research in both the Government and private commercial sectors.
- Promoting interdisciplinary research via synergism with other EOS observations, in particular, orbiting in tandem with the Terra satellite for near coincident observations.

Summary of Parameters:

Nominal orbit parameters for the Landsat-7 spacecraft include:

Parameter	Value
Launch Date:	April 15, 1999
Orbit:	Sun Synchronous, Near Polar
Nominal Altitude:	705 Kilometers, Near Circular
Inclination:	98.2 Degrees
Nodal Period:	98.8 Minutes
Equatorial Crossing Time:	10:00 a.m., Local (Descending)

Related Data Sets:

Since the 1970's, Landsat satellites have been collecting multispectral images of the Earth's land surface. This unique data archive has played important role across disciplines as a tool used toward achieving understanding of the Earth's land surfaces and human impacts on the environment. Landsat satellite orbital paths, sensors, and communications capabilities have changed over the years as the Landsat program continues to evolve (see Table).

LANDSAT SATELLITES 1-7						
System	Launch (End of Service)	Sensors	Resolution (meters)	Communications	Alt. Km	R Days
Landsat 1	07/23/72 (01/06/78)	RBV MSS	80 80	Direct downlink with recorders	917	18
Landsat 2	01/22/75 (02/25/82)	RBV MSS	80 80	Direct downlink with recorders	917	18
Landsat 3	03/05/78 (03/31/83)	RBV MSS	40 80	Direct downlink with recorders	917	18
Landsat 4*	07/16/82	MSS TM	80 30	Direct downlink TDRSS	705	16
Landsat 5	03/01/84	MSS TM	80 30	Direct downlink TDRSS**	705	16
Landsat 6	10/05/93 (10/05/93)	ETM	15 (pan) 30	Direct downlink with recorders	705	16
Landsat 7	04/15/99	ETM+	15 (pan) 30 60	Direct downlink with recorders (solid state)	705	16

Alt. = Altitude
R = Revisit Interval
D = Data Rate
* TM data transmission failed in August 1993.
** Current data transmission by direct downlink only. No recording capability.

Applications:

Landsat data have been used in both national and international arenas for a variety of government, public, and private applications, including land and water management, global change research, oil and mineral exploration, agricultural yield forecasting, pollution monitoring, land surface change detection, and cartographic mapping.

As part of NASA's EOS project, the science mission of the Landsat-7 project is targeting regional and global assessments of land cover dynamics. The Landsat-satellite is scheduled to systematically acquire imagery from across the using a Long-term Acquisition Plan. The Plan is designed to insure coverage of full seasonal and interannual changes in planetary vegetation patterns, also addressing the issue of cloud cover.

Following are examples of research projects using Landsat data:

- **Dune Reactivation (Goetz):** More than 10 percent of the High Plains region of the United States consists of sand dunes and sand sheets that are stabilized by the growth of natural grasses and by irrigated farming. According to some climate models, sandy landscapes could be reactivated (i.e., start blowing as was the case in the 1930's). Using Landsat data, Goetz and his team have completed a detailed study of land cover change northeastern Colorado, creating a data base of land cover and human-induced land cover changes in the region that spans 15 years. With data from Landsat 7, Goetz plans to extend the data base past the year 2000. is expected that it will be possible to catch a significant drought year, which will help to validate models on the effect of low rainfall in the High Plains.

- **Gradual Changes in the Antarctic Ice Sheet (Bindschadler):** The stability of the West Antarctic Ice Sheet directly correlates to increases in the global sea level. Monitoring changes in the ice sheet is difficult from the ground, because dangerous conditions prohibit the collection of extensive measurements. Bindschadler and his team used Landsat data to analyze surface features on the Ross Ice Shelf, a vast area of ice that attached to Antarctica but that is floating on the ocean, in order to study the history of ice flows over much of West Antarctica. The team plans to use Landsat-7 data with its finer spatial resolution and continuous spatial coverage to monitor the continued ice motion and flow history of this Antarctic ice sheet.

- **Growth Patterns of Urban Sprawl (Masek):** Studies using Landsat data can show where growth is taking place in urban areas and can be used as a by geographers in evaluating the possible effects of urban planning programs on population growth and land use. Masek and colleagues use Landsat data to study land use efficiency. They plan to use Landsat-7 to evaluate growth patterns in cities around the world. With more satellite imagery available, it is possible to compare cities more frequently in order to compile records of land use changes in greater detail.

- **Health of Temperate Conifer Forests (Woodcock):** Both natural and human activities may lead to the destruction of forests and their ecosystems. Woodcock discovered that with Landsat data he could recognize areas where trees were dying due to lack of water, a factor that made the trees more susceptible to disease and forests more susceptible to fire. Woodcock and colleagues plan to use Landsat-7 data to create a global monitoring for temperate conifer forests.

- **Land Use in Tropical Rain Forests (Skole)**: Even though tropical deforestation is a well-known problem, scientists face the problem of determining deforestation rates and of understanding their causes and effects. Currently, Skole's team is analyzing Landsat-5 imagery in order to develop estimates of recent tropical deforestation. With the launch of the Landsat-7 satellite, the amount of data available for analyses such these increases dramatically, allowing for more rapid assessment of land use and land cover change.

- **Mapping Wildfire Hazards (van Wagtendonk)**: Wildland fires result in loss of life and in damage to natural resources. Dry biomass on the ground as a fuel in feeding wildland fires. With information about fire fuels, fire managers can better predict potential fire behavior, make more informed tactical and strategic decisions, and introduce treatments that reduce the amount of dry biomass. Van Wagtendonk and colleagues use Landsat data in time series, identifying fuel types based on seasonal changes in plant condition. The addition of a panchromatic Landsat band enhances the capability to distinguish tree density classes -- an important development, because density directly affects fuel moisture content and wind speeds near the ground.

- **Precision Farming and Land Management (Moran)**: Farm managers are looking for new technologies to help in deciding when and where to irrigate, fertilize, seed, and apply herbicides. In a method developed by Moran, Landsat data are combined with radar data to study plant transpiration rates, information that managers use to determine where and when to fertilize. The increased availability of satellite data through the of the Landsat-7 satellite provides for expanded applications of remote sensing data to agricultural and natural resources monitoring projects.

- **Spring Run-off Contaminants in Lakes (Schott)**: In the spring, run-offs of salt, sediment, fertilizer, and chemical pollutants concentrate in a band of warmer water close to the lake shore, called a thermal bar, until the warm run-off waters and the cold lake waters have had an opportunity to mix. In larger lakes, it may take up to two months for the run-off and lake waters to mix, posing a potential danger to lake plants and animals (e.g., phytoplankton, fish). Schott uses Landsat data to help predict the extent, duration, and impacts of thermal bar formations on water quality. Schott and his research team model the formation of thermal bars, using Landsat data and three-dimensional hydrodynamic models. Schott plans to use the models to track the annual evolution of thermal bars and to attempt the prediction of thermal bars months in advance of their formation.

- **Volcanic Hazards and Lava Lakes (Flynn)**: Using Landsat data to observe heat emitted during volcanic eruptions, Flynn is able to distinguish active lava flows from older lava flows that have already begun to cool. After compiling extensive observations of individual volcanoes, a data base is created that details areas that are the most prone to the hazards of lava flows. Flynn and colleagues also have been using Landsat data to study active volcanic lava lakes from around the world. In addition to maps they have already generated using Landsat data, they plan to produce higher resolution maps of active lava flows using Landsat-7 data.

Theory of Measurements:

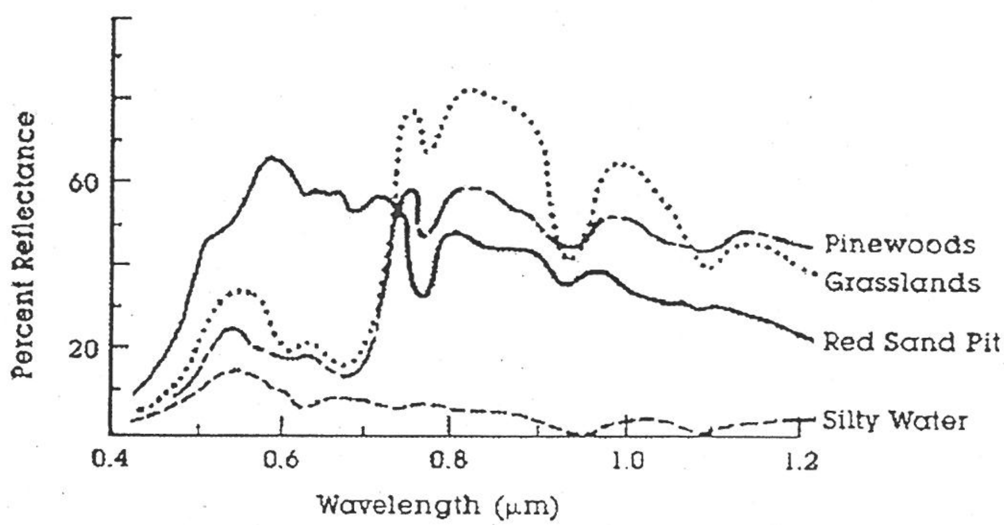
On striking the atmosphere, land surface, or ocean surface, transmitted solar radiation is characterized as one of three types of energy response:

- **Absorptance:** Radiation which is absorbed through electron or molecular reactions within the medium encountered. A portion of the energy incorporated can then be re-emitted (as emittance), largely at longer wavelengths, so that some of the Sun's radiant energy engages in heating the target, giving rise to a thermal response.

- **Reflectance:** Radiation which is, in effect, being reflected (and away from the target at different angles (depending in part on surface roughness as well as on the angle of the Sun's direct rays relative to surface inclination), and some radiation being directed back on line with the observing sensor.

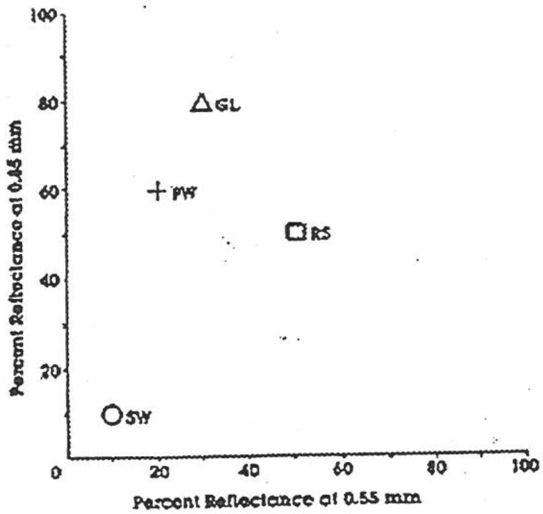
- **Transmittance:** Radiation which penetrates into certain surface media such as water.

The Landsat-7 system is designed to measure reflected radiation; data that, in turn, are used to deduce surface conditions and materials. For any given material, the amount of emitted and reflected radiation varies by wavelength. Therefore, substances or classes of ground cover may be identified and separated by their spectral signatures as shown in the figure below.



There is a direct correlation between objects and their relative reflectances. For example, the reflected radiation from healthy green growing vegetation may be highly visible in one wavelength or spectral band while the same reflected radiation may be barely visible, if visible at all, in another wavelength or spectral band. Thus, in principle, various surface materials may be recognized and distinguished from each other through differences in relative provided there is some suitable method for measuring these differences as a function both of wavelength and of intensity of returned radiation (as a fraction or percent of the amount of the irradiating radiation).

The four surface materials shown in the following figure (GL representing grasslands, PW representing pinewoods, RS representing red sand, and SW representing silty water) may be characterized as distinct.



Each of the materials has been plotted according to its percent of reflectance for two wavelengths or spectral bands. When more than two wavelengths are involved, the plots in multi-dimensional space tend to increase the separability among different materials. This spectral separation is the basis for the multispectral remote sensing employed by the ETM+ sensor flown aboard the Landsat-7 satellite.

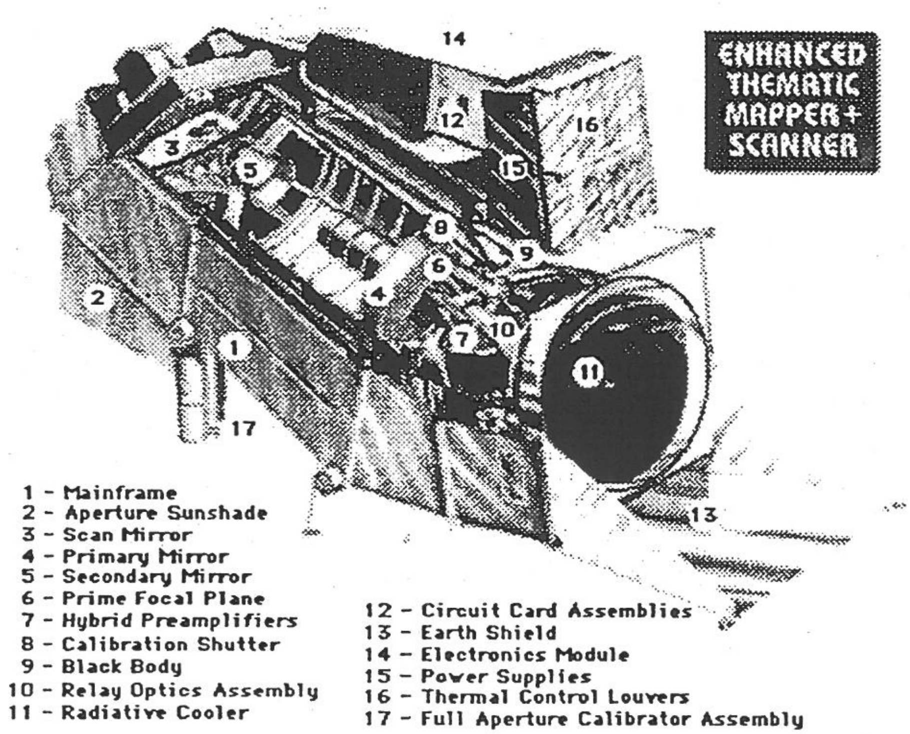
Acquisition Materials and Methods:

Acquisition Equipment:

Landsat ETM+ sensor flown aboard the Landsat-7 satellite.

Sensor/Instrument Description:

The Landsat ETM+ sensor is a nadir-viewing, eight-band multispectral scanning radiometer capable of providing high-resolution imaging information of the Earth's surface. The sensor is a derivative of the TM sensor flown aboard Landsat satelites 4 and 5 with modifications that include the addition of the panchromatic band and two gain ranges, improvements to the spatial resolution of the thermal band, and the addition of two solar calibrators. Principle sensor components include scan mirror assembly, a Ritchey-Chretien telescope, a scan line detector, the primary focal plane, relay optics, the cold focal plane, a radiative cooler, and spectral filters (see Sensor/Instrument Measurement Geometry below for more information on these components).

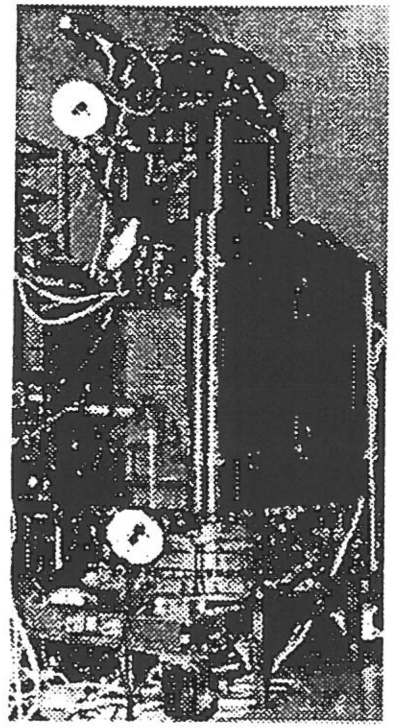


Collection Environment:

Satellite Platform.

Source/Platform:

The Landsat-7 satellite was built by Lockheed Martin Missiles & Company, Inc., at their Valley Forge, Pennsylvania, facility and was launched on April 15, 1999, from the Western Test Range, Vandenberg Air Force Base, California. The spacecraft is 14 feet long, 9 feet diameter, and weighs approximately 4,800 pounds.



Landsat-7 spacecraft.

The Landsat-7 satellite is designed to fly a 705-kilometer, Sun-synchronous, Earth mapping orbit with a 16-day repeat cycle. Its payload is a single nadir-pointing instrument, the ETM+ sensor. Communications are provided through the satellite's S-band and X-band. The S-band is used for command and housekeeping telemetry operations while the X-Band is used for instrument data downlink. A 378-gigabit solid state recorder can hold 42 minutes of instrument data and 29 hours of housekeeping telemetry, concurrently. Power is provided by a single Sun-tracking solar array and two 50-amp-hour, nickel-hydrogen batteries. Attitude control is provided through four reaction wheels (pitch, yaw, roll, and skew), three 2-channel gyros with celestial drift updating, a static Earth sensor, a 1750A processor, and torque rods and magnetometers for momentum unloading. Orbit control and backup momentum unloading is provided through a blow-down monopropellant hydrazine system with a single tank containing 270 pounds of hydrazine, associated plumbing, and twelve 1-pound-thrust jets.

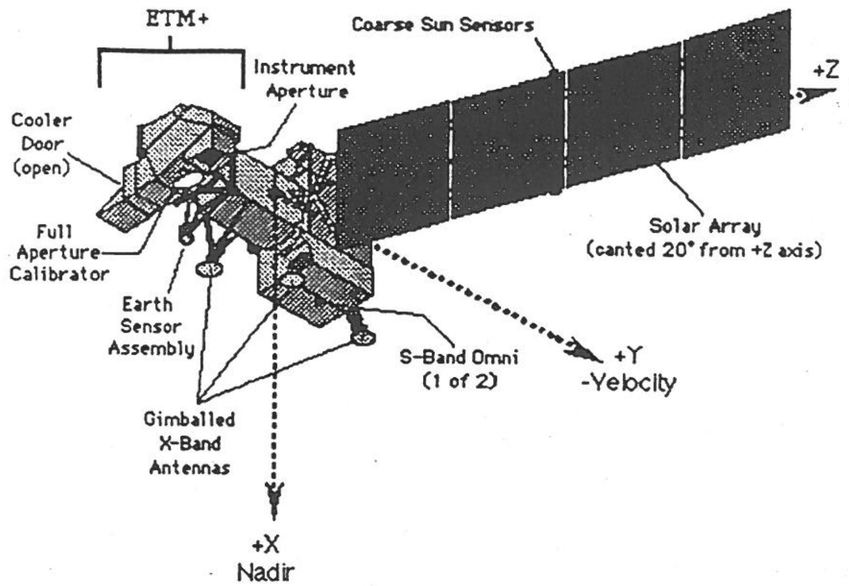


Diagram of Landsat-7 satellite components.

Satellite subassemblies include:

- Lower Equipment Module: This module is a secondary structure equipment. In addition, a payload attach fitting is mounted on the aft end of this module, providing structural and electrical interfaces to the launch vehicle, a Boeing Delta-II rocket.

- Equipment Support Module: This module houses equipment a uniform temperature environment.

- Instrument Pallet Assembly: This module is used for mounting ETM+ sensor.

The structural subassemblies accommodate seven functional including the command and data handling subsystem, the attitude control subsystem, the reaction control subsystem, the electrical power subsystem, the thermal control subsystem, the communication subsystem, and the ETM+ payload.

Source/Platform Mission Objectives:

The latest in the Landsat series, the Landsat-7 satellite is to provide a vehicle for continuing the flow of global change information to users worldwide. The Landsat-7 satellite fulfills its mission by providing repetitive, synoptic coverage of continental surfaces and by collecting data in spectral bands that include the visible, near-infrared, shortwave, and thermal infrared portions of the electromagnetic spectrum.

Key Variables:

Emissivity
Infrared Imagery
Land Cover
Reflectance
Reflected Infrared
Thermal Infrared
Visible Imagery

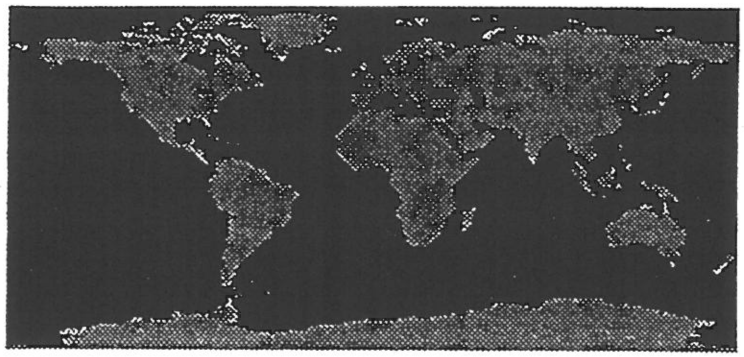
Spatial Characteristics:

Landsat-7 data are collected from a nominal altitude of 705 kilometers in 183-kilometer swaths, providing global coverage.

Spatial Coverage:

Platform:
    Near-polar orbiting system
Sensor:
    Latitude coverage--81 degrees north to 81 degrees south
    Longitude coverage--180 degrees east and west

Spatial Coverage Map:



Spatial Resolution:

The following table on band characteristics contains on spatial resolution.

LANDSAT-7 ETM+ BAND CHARACTERISTICS					
Band Number	Spectral Range (µ)	Ground Resolution (m)	Data Lines Per Scan	Data Line Length (bytes)	Bits Per Sample
1	.450 to .515	30	16	6,600	8
2	.525 to .605	30	16	6,600	8
3	.630 to .690	30	16	6,600	8
4	.775 to .900	30	16	6,600	8
5	1.550 to 1.750	30	16	6,600	8
6*	10.40 to 12.50	60	8	3,300	8
7	2.090 to 2.35	30	16	6,600	8
8	.520 to .900	15	32	13,200	8

List of Acronyms:

A/D -- Analog-to-Digital
CRaM -- Combined Radiometric Correction Model
ERTS -- Earth Resources Technology Satellite
FAC -- Full Aperture Solar Calibrator (also FASC)
ECS -- EOSDIS Core System
EDC DAAC -- EROS Data Center Distributed Active Archive Center
EOS -- Earth Observing System
EOSDIS -- Earth Observing System Data and Information System
EROS -- Earth Resources Observation Systems
ETM+ -- Enhanced Thematic Mapper Plus
GeoTIFF -- Geographic Tagged Image File Format
GLIS -- Global Land Information System
HDF -- Hierarchical Data Format
IC -- Internal Calibrator
IFOV -- Instantaneous Field of View
IAS -- Image Assessment System
ISSCP -- International Satellite Cloud Climatology Project
LPGS -- Level-1 Product Generation System
LPS -- Landsat Processing System
LTAP -- Long-Term Acquisition Plan
MSCD -- Mirror Scan Correction Data
MSS -- Multispectral Scanner
NASA -- National Aeronautics and Space Administration
NOAA -- National Oceanic and Atmospheric Administration
PAC -- Partial Aperture Solar Calibrator (also PASC)
PCD -- Payload Correction Data
SBRS -- Santa Barbara Remote Sensing
SIS -- Spherical Integrating Source
SLC -- Scan Line Corrector
SME -- Scan Mirror Electronics
TM -- Thematic Mapper
TMC -- Thematic Mapper Calibrator
URL -- Uniform Resource Locator
USGS -- United States Geological Survey
WRS -- Worldwide Reference System
EOSDIS Acronym List

Chapter 9 References:

(1): Remote Sensing and Image Interpretation; Lillesand/Kiefer by John Wiley & Sons, Inc., 1979

(2): INTERNET Site

(3): LANDSAT Documents