Chapter 2: "Satellites & sensors"
Part 4 out of 6

RS from the Space:

Satellite Characteristics-Orbits & Swaths:

Although ground-based & aircraft platforms may be used, satellites have several unique characteristics which make them particularly more useful for remote sensing of the Earth's surface.

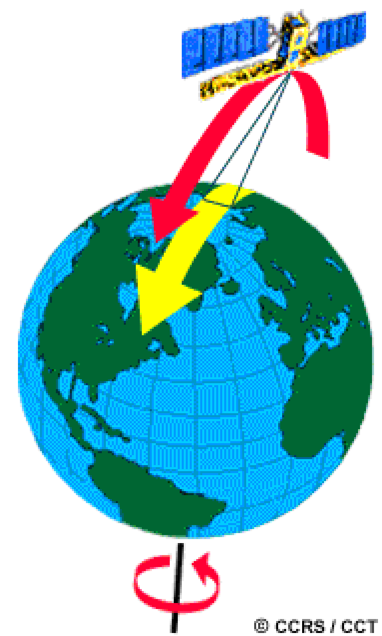
Orbit selection can vary in terms of altitude, their orientation & rotation relative to the Earth.

Satellites at very high altitudes, which view the same portion of the Earth's surface at all times have geostationary orbits.

Chapter 2: "Satellites & sensors"

Satellite Characteristics-Orbits & Swaths:

Many remote sensing platforms are designed to follow an orbit (basically north-south) which, in conjunction with the Earth's rotation (west-east), allows them to cover most of the Earth's surface over a certain period of time.



These are near-polar orbits, so named for the inclination of the orbit relative to a line running between the North & South poles.

Chapter 2: "Satellites & sensors"

Satellite Characteristics-Orbits & Swaths: (continue)

Many of these satellite orbits are also sun-synchronous such that they cover each area of the world at a constant local time of day called local sun time.

In order to minimize atmospheric & shade effects, most satellites which image in the visible, reflected, & emitted IR regions use crossing times around mid-morning as a compromise.

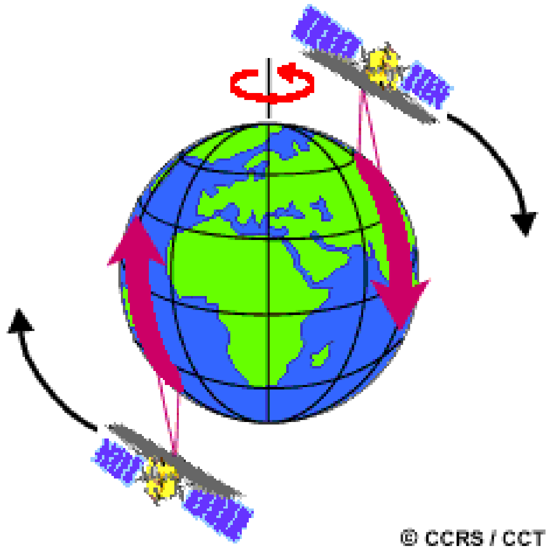
Most remote sensing satellite platforms today are in near-polar orbits, which means that the satellite travels northwards on one side of the Earth & southwards on the second half of its orbit.

Chapter 2: "Satellites & sensors"

Satellite Characteristics-Orbits & Swaths: (continue)

These are called ascending & descending passes, respectively.

If the orbit is also sun-synchronous, the ascending pass is most likely on the shadowed side of the Earth while the descending pass is on the sunlit side.



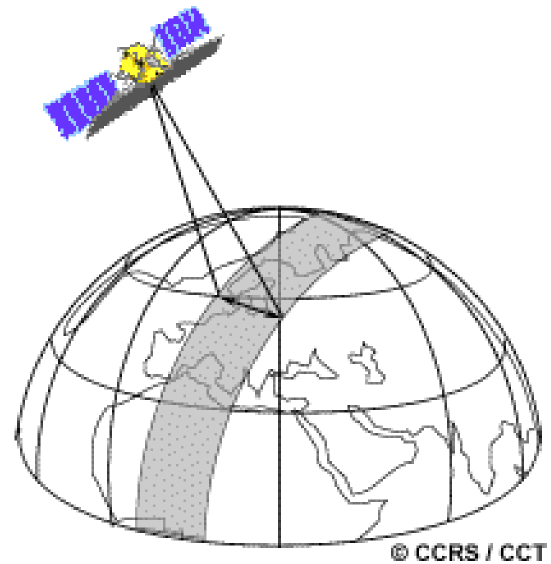
Sensors recording reflected solar energy only image the surface on a descending pass, when solar illumination is available.

Active sensors & passive sensors in the emitted radiation can also image the surface on ascending passes.

Chapter 2: “Satellites & sensors”

Satellite Characteristics-Orbits & Swaths: (continue)

The area imaged on the surface, is referred to as the swath. Imaging swaths for space-borne sensors generally vary between tens & hundreds of kilometers wide.



As the satellite orbits the Earth from pole to pole, it seems that the satellite is shifting westward because the Earth is rotating (from west to east) beneath it.

This apparent movement allows the satellite swath to cover a new area with each consecutive pass.

Chapter 2: "Satellites & sensors"

***Satellite Characteristics-Orbits & Swaths:** (continue)*

The satellite's orbit & the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits.

If we start with any randomly selected pass in a satellite's orbit, an orbit cycle will be completed when the satellite retraces its path, passing over the same point on the Earth's surface directly below the satellite (called the nadir point) for a second time.

The interval of time required for the satellite to complete its orbit cycle is not the same as the "revisit period".

Chapter 2: "Satellites & sensors"
Part 5 out of 6

RS from the Space:

Earth Observation Satellites/Sensors:

RS from the space has brought a new diminution to better understand the nature of our plant & the impact of humankind activities on the Earth.

The use of satellites as sensor platforms has made possible the acquisition of repetitive, high resolution multi-spectral data of the Earth's surface on a global basis.

Satellite images not only cover very large areas, but also have much less of image distortions due to their stable platforms' outside the atmosphere.

Chapter 2: "Satellites & sensors"

RS from the Space:

Earth Observation Satellites/Sensors : (continue)

Three Generic types of R.S. imaging satellites:

1. *Weather Satellites/Sensors.*
2. *Marine Observation Satellites/Sensors.*
3. *Land Observation Satellites/Sensors.*

Although many of the weather & marine observation satellite systems are also used for monitoring the Earth's surface, they are not optimized for detailed mapping of the land surface.

Chapter 2: “Satellites & sensors”

RS from the Space:

Earth Observation Satellites/Sensors : (continue)

Weather Satellites/Sensors

- *High coverage area,*
- *Low spatial resolution,*
- *Spectral resolution that can interact with the atmosphere.*

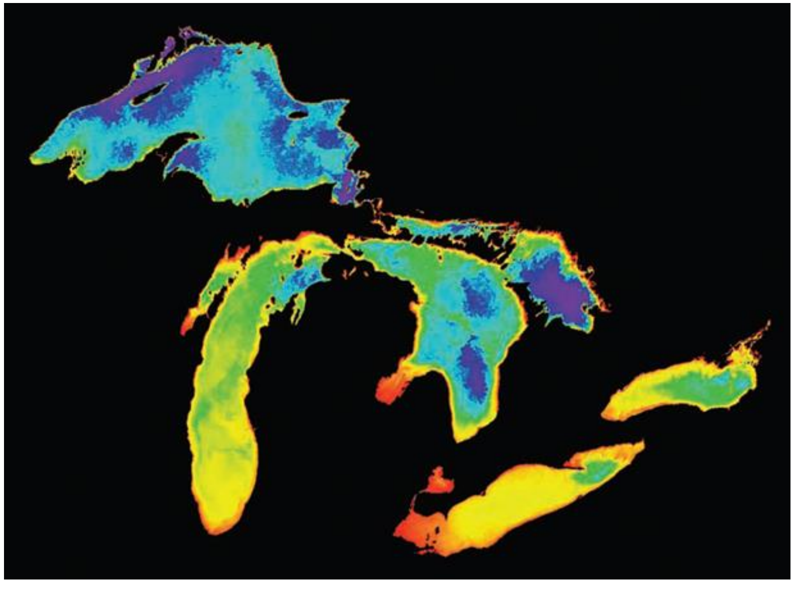
Chapter 2: “Satellites & sensors”

RS from the Space:

Earth Observation Satellites/Sensors : (continue)

Marine Observation Satellites/Sensors

- *High coverage area,*
- *Low spatial resolution,*
- *Spectral resolution that can interact with water bodies but not much with the atmosphere.*



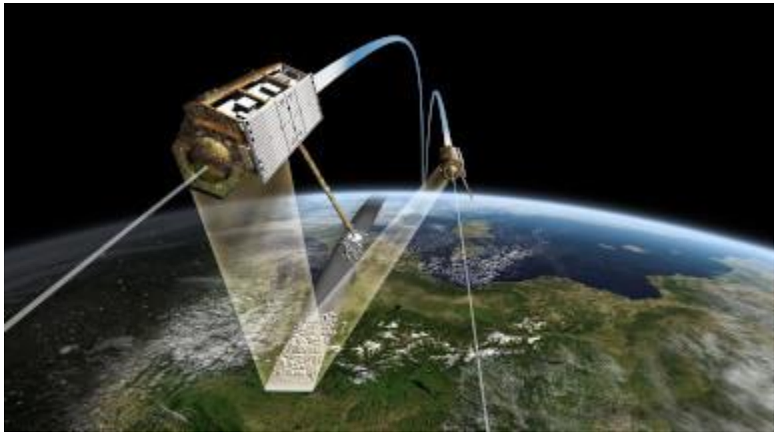
Chapter 2: “Satellites & sensors”

RS from the Space:

Earth Observation Satellites/Sensors : (continue)

Land Observation Satellites/Sensors

- *Medium to small coverage area,*
- *Medium to high spatial resolution,*
- *Spectral resolution that does not interact much with the atmosphere.*



RS from the Space:

Land Observation Satellites/Sensors:

Land Observation Satellites themselves can be divided into three gropes due to the tradeoff between coverage area, spatial & spectral resolutions;

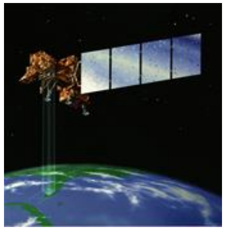
- *Large coverage area, small spatial resolution and high multispectral-band,*
- *Medium coverage area, medium spatial resolution and medium multispectral-band,*
- *Small coverage area, large spatial resolution and less medium multispectral-band.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors:

Three Exceptional Satellite Programs from the 3 different groups



Satellite Name	LANDSAT 7	SPOT 5	IKONOS
Owned by	NASA	CNES in association with the SSTC & the SNSB	Digital Globe
Year Launched	1999	2002	1999
Coverage Area	185x185 km^2	60x60 km^2	11x11 km^2
Resolutions	15 m B&W	2.5 or 5 m B&W	1 m B&W
	30 m for B, G, R, N-IR, M-IR, & M-IR2 60 m for T-IR	10 m for G, R, N-IR 20 m for M-IR	4 m color for B, G, R, & N-IR

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program;

- *In 1967, NASA initiated the Earth Resources Technology Satellite (ERTS), later became Landsat program, to be the first Land Observation Satellites program ever.*
- *It considered to be from the first group, the relatively large coverage area, small spatial resolution and high multispectral-band group.*
- *Landsat was designed as an experiment to test the feasibility of collecting multi-spectral Earth observation data from an unmanned satellite platform.*

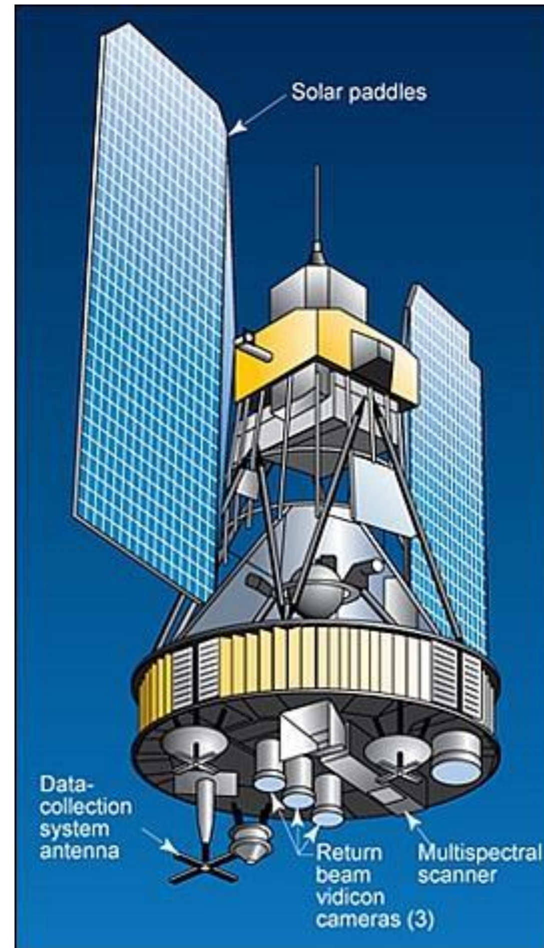
Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: *(continue)*

Landsat Program; *(continue)*

- *The first satellite designed specifically to monitor the Earth's surface, Landsat 1, was launched by NASA in 1972.*
- *Since that time, this highly successful program has collected an abundance of data from around the world from several Landsat satellites.*



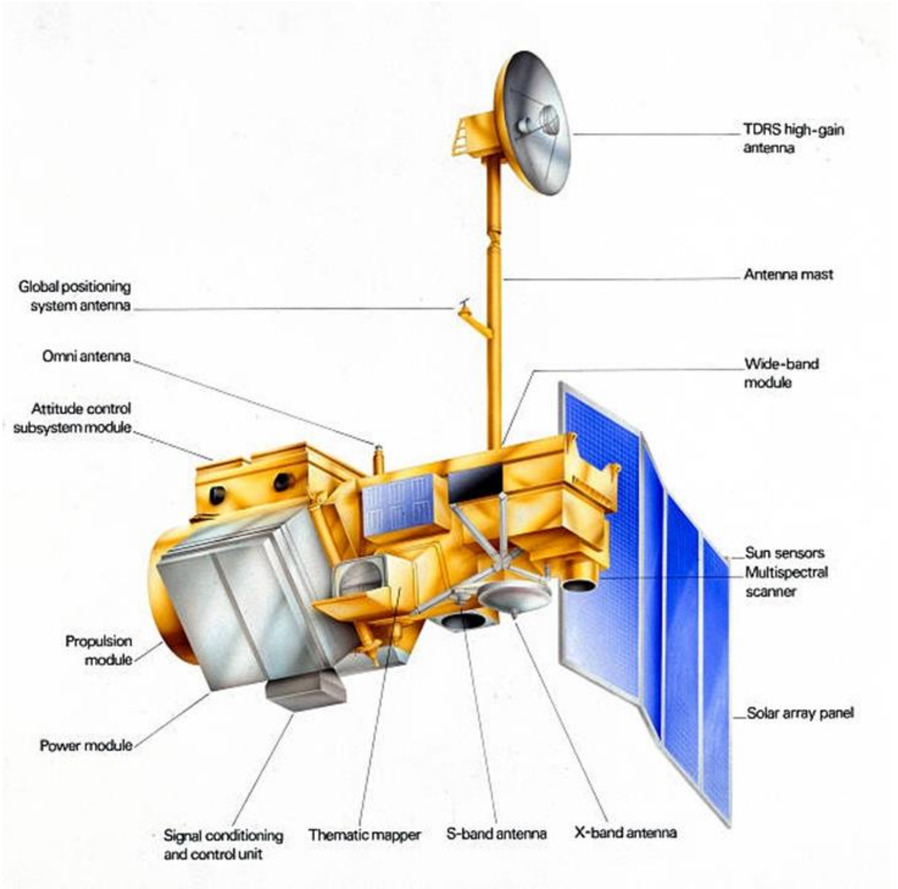
Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

- *The first three satellites (Landsats 1-3) are at altitudes around 900 km & have revisit periods of 18 days while the later satellites are at around 700 km & have revisit periods of 16 days.*

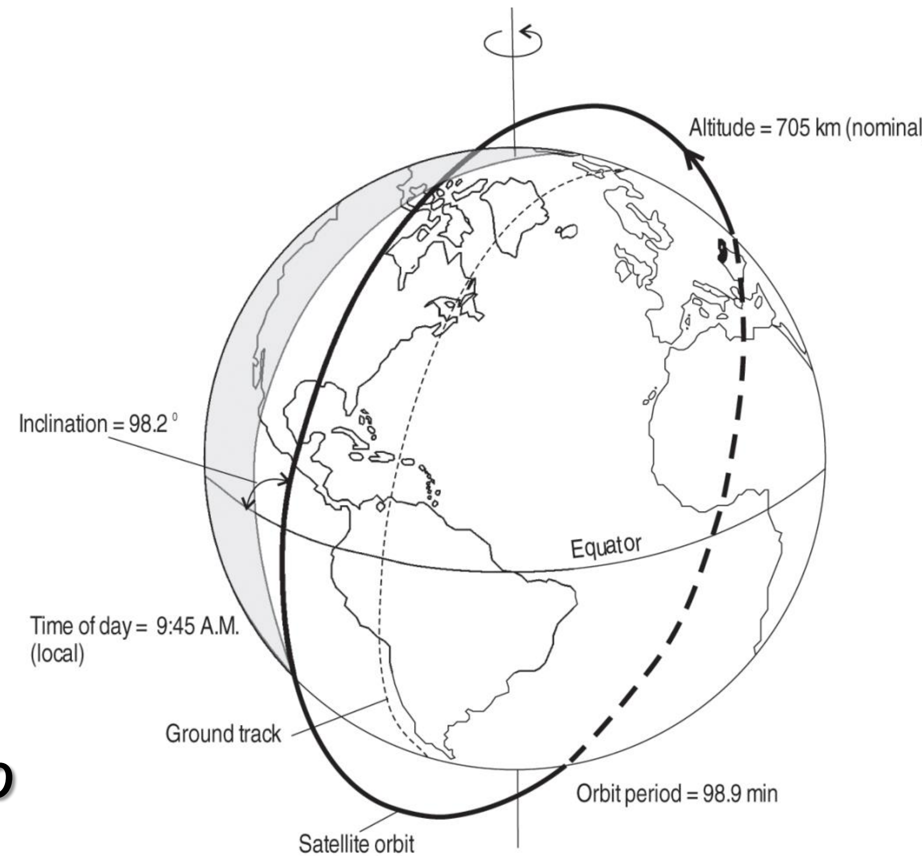


RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

- *All Landsat satellites are placed in near-polar, sun-synchronous orbits.*
- *All Landsat satellites have equator crossing times in the morning to optimize illumination conditions.*

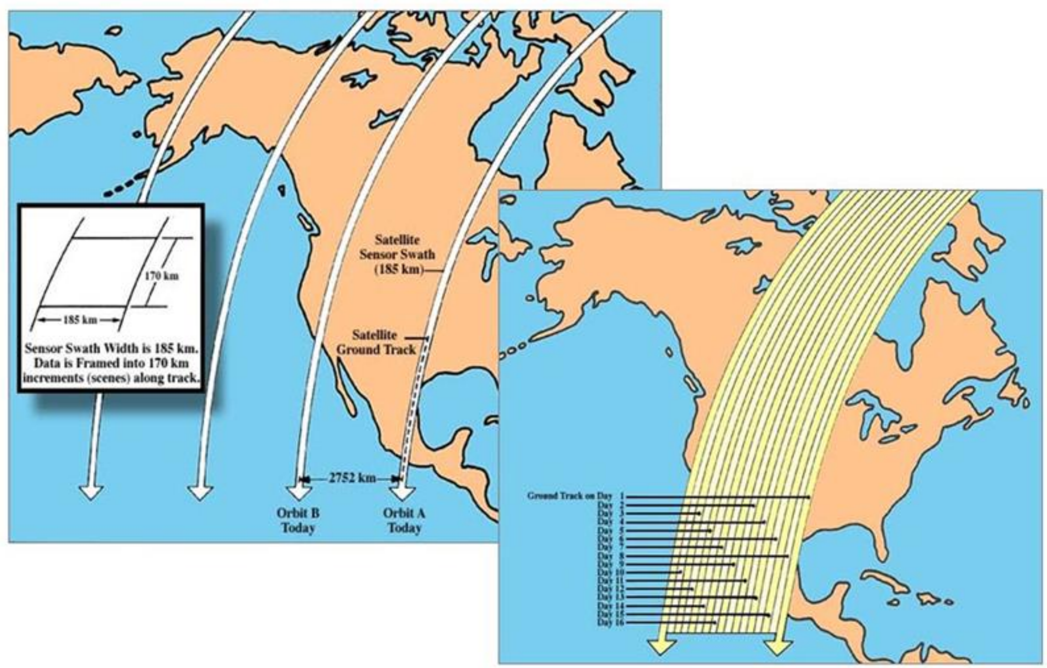


RS from the Space:

Land Observation Satellites/Sensors: **(*continue*)**

Landsat Program; (continue)

LANDSAT Satellite Orbit

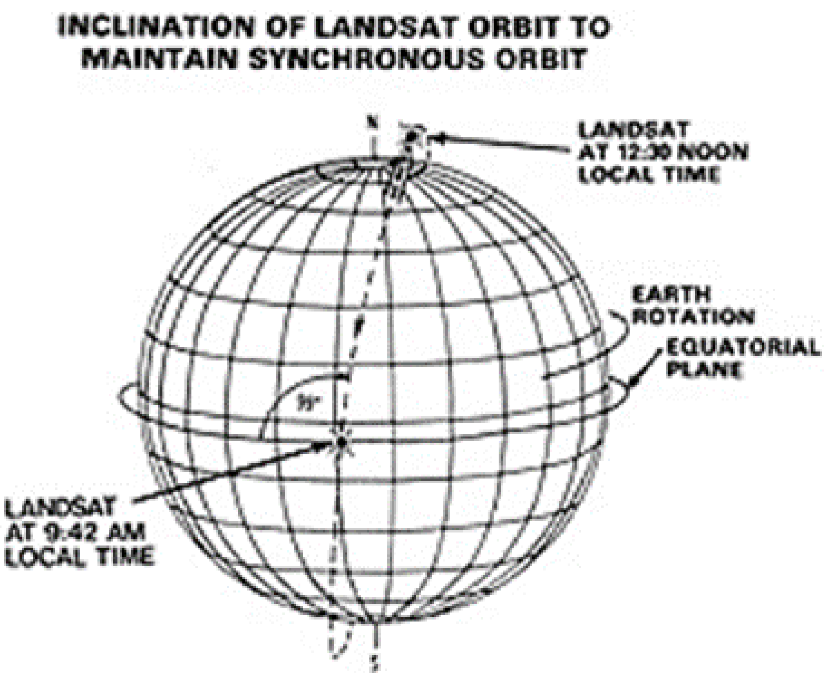


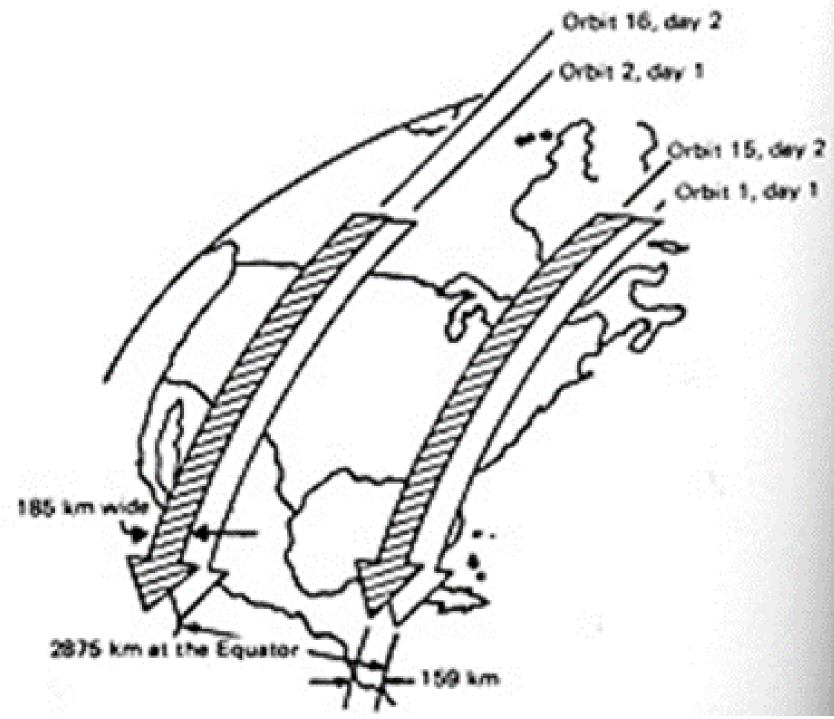
Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: ***(continue)***

Landsat Program; *(continue)*





Chapter 2: "Satellites & sensors"

RS from the Space:

***Land Observation Satellites/Sensors:* (continue)**

Landsat Program; ***(continue)***

- *A number of sensors have been on board the Landsat series of satellites, including the Return Beam Vidicon (RBV) camera systems, the MultiSpectral Scanner (MSS) systems, the Thematic Mapper (TM), the Enhanced Thematic Mapper Plus (ETM+), the Operational Land Imager (OLI) & Thermal infrared Sensor (TIRS).*
- *Each of these sensors collected data over a swath width of 185 km, with a full scene being defined as 185 km x 185 km.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

Satellite & no.	Launched	Decommissioned	Sensors	Spatial resolution (m)	Satellite altitude (km)	Satellite return period (days)
Landsat-1	23 July 1972	6 January 1978	RBV MSS	80 80	917	18
Landsat-2	22 January 1975	25 February 1982	RBV MSS	80 80	917	18
Landsat-3	05 March 1978	31 March 1983	RBV MSS	40 80 (VIS-SWIR) 240 (TIR)	917	18
Landsat-4	16 July 1982	TM failed: August 1993	MSS TM	80 30 (SWIR) 120 (TIR)	705	16
Landsat-5	01 March 1984	Operational as of January 2008	MSS TM	80 30 (SWIR) 120 (TIR)	705	16
Landsat-6	05 October 1993	Launch Failure	ETM	15 (panchromatic) 30 (SWIR) 60 (TIR)	705	16
Landsat-7	April 1999	Operational as of January 2008	ETM+	15 (panchromatic) 30 (SWIR) 60 (TIR)	705	16

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: ***(continue)***

Landsat Program; ***(continue)***

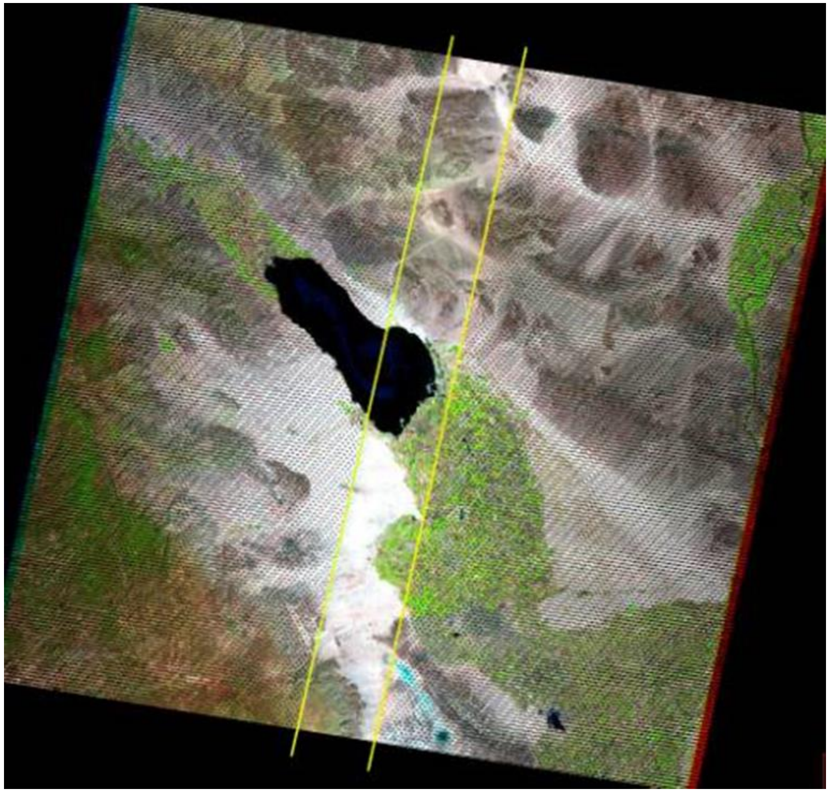
- *Sensors from these satellites are used for a wide variety of applications, including resource management, mapping, environmental monitoring, & change detection.*
- *However, after the launch failure of Landsat-6 & the problems with the Landsat-7's ETM+ problems, NASA decided in1996 to start a new supporting program named the New Millennium Program.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; *(continue)*



Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; *(continue)*

The New Millennium Program (NMP):

- *This program was design to identify, develop, & flight validate key instrument & spacecraft technologies that can enable new, more cost effective approaches to conduct science missions in the 21st century.*
- *The 1st of these NMP earth-orbiting missions is Earth Observing-1 (EO-1).*
- *Three RS instruments onboard the EO-1; the Advanced Land Imager (ALI), the Hyperion Imaging Spectrometer, & the Linear Imaging Spectrometer Array (LEISA) Atmospheric Corrector (AC).*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: **(continue)**

Landsat Program; ***(continue)***

The New Millennium Program (NMP):

- *The Hyperion Imaging Spectrometer was designed to demonstrate the ability to perform detailed spectral mapping with high radiometric accuracy.*
- *The AC is an IR camera. Image from AC can be used to remove the effects of the atmosphere from surface pictures obtained by other cameras such as ALI or ETM+.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*Landsat Program; **(continue)***

The New Millennium Program (NMP):

- *The ALI, on the other hand, represents a technology verification project designed to demonstrate comparable or improved Landsat ETM+ spatial & spectral resolutions.*
- *It also demonstrates a substantial reduction in mass, volume, & cost compared to the Landsat mission.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*Landsat Program; **(continue)***

The New Millennium Program (NMP):

- *The ALI employs a push-broom scanning technology & features 10-m resolution panchromatic & 30-m resolution multi-spectral image acquisition.*
- *The EO-1 was launched on November, 2000 into an orbit that matches within 1-min the Landsat-7 orbit, resulting in identical images for comparison purposes.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

ETM+		ALI	
Band (µm)	Resolution (m)	Band (µm)	Resolution (m)
.450 - .515	30	433 - .453	30
.525 - .605	30	.450 - .510	30
.630 - .690	30	.525 - .605	30
.750 - .900	30	.630 - .690	30
1.55 - 1.75	30	.775 - .805	30
10.40 - 12.50	60	.845 - .890	30
2.09 - 2.35	30	1.20 - 1.30	30
.520 - .900	15(pan)	1.55 - 1.75	30
		2.08 - 2.35	30
		.480 - .680	10(pan)

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

Landsat-8:

- *Landsat-8 is an American Earth observation satellite launched on February 11, 2013.*
- *It is the eighth satellite in the Landsat program; the seventh to reach orbit successfully, 5-10 years planned mission duration.*
- *Landsat-8 utilizes a two-sensor payload; the original Landsat-8 planed sensor called Operational Land Imager (OLI) and the December 2009 addition of the Thermal infrared Sensor (TIRS).*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; *(continue)*

Landsat-8:

- *OLI uses a technological approach demonstrated by the Advanced Land Imager sensor flown on NASA's experimental EO-1 satellite.*
- *Landsat-8 is the eighth satellite in the Landsat program; the seventh to reach orbit successfully.*
- *The push-broom design will result in increased sensitivity, less moving parts, and improved land surface information.*

Chapter 2: “Satellites & sensors”

RS from the Space:

Land Observation Satellites/Sensors: **(continue)**

*Landsat Program; **(continue)***

Landsat-8:

- *OLI will collect data from nine spectral bands. Seven of the nine bands will be consistent with the TM & the ETM+ sensors, providing for compatibility with the historical Landsat data, while also improving measurement capabilities.*
- *Two new spectral bands, a deep blue coastal / aerosol band and a shortwave-IR cirrus band, will be collected allowing scientists to measure water quality and improve detection of high, thin clouds.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*Landsat Program; **(continue)***

Landsat-8:

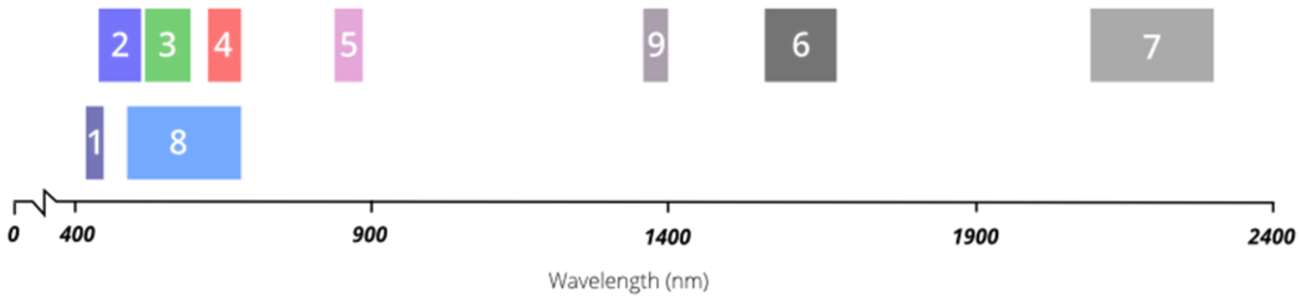
- *Providing moderate-resolution imagery, from 15 meters to 100 meters, of Earth's land surface and polar regions, Landsat-8 will operate in the visible, near-IR, short wave IR, and thermal IR spectrums.*
- *Landsat-8 will capture approximately 400 scenes a day, an increase from the 250 scenes a day on Landsat 7.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; (continue)

Landsat-8:



Spectral Band	Wavelength	Resolution
Band 1 - Coastal / Aerosol	0.433 - 0.453 µm	30 m
Band 2 - Blue	0.450 - 0.515 µm	30 m
Band 3 - Green	0.525 - 0.600 µm	30 m
Band 4 - Red	0.630 - 0.680 µm	30 m
Band 5 - ***NIR***	0.845 - 0.885 µm	30 m
Band 6 - Short Wavelength ***IR***	1.560 - 1.660 µm	30 m
Band 7 - Short Wavelength ***IR***	2.100 - 2.300 µm	30 m
Band 8 - Panchromatic	0.500 - 0.680 µm	15 m
Band 9 - Cirrus	1.360 - 1.390 µm	30 m

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*Landsat Program; **(continue)***

Landsat-8:

- *TIRS, built by the NASA Goddard Space Flight Center, will allow for thermal imaging in addition to support emerging applications such as evapotranspiration rate measurements for water management.*
- *TIRS detects the IR radiation, day & night, a first for the Landsat program.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*Landsat Program; **(continue)***

Landsat-8:

- *TIRS sensor also employ, as does the OLI sensor, the use of a push-broom sensor design in addition to a 185 kilometer cross-track field of view.*
- *Data for two long wavelength IR bands are collected with TIRS.*

Chapter 2: "Satellites & sensors"

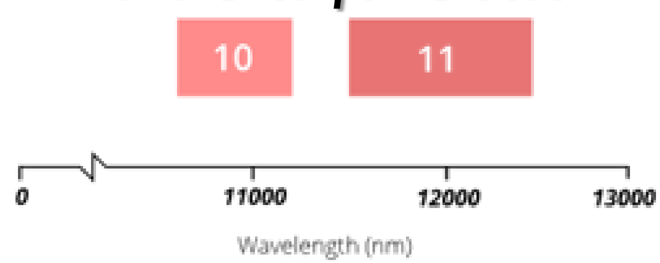
RS from the Space:

Land Observation Satellites/Sensors: (continue)

Landsat Program; *(continue)*

Landsat-8:

- *The OLI and TIRS sensors have improved signal to noise (SNR) radiometric performance, enabling 12-bit quantization of data allowing for more bits for better land cover characterization.*



Spectral Band	Wavelength	Resolution
Band 10 - Long Wavelength ***IR***	10.30 - 11.30 µm	100 m
Band 11 - Long Wavelength ***IR***	11.50 - 12.50 µm	100 m

Chapter 2: “Satellites & sensors”

RS from the Space:

***Land Observation Satellites/Sensors:* (continue)**

*Landsat Program; **(continue)***

Landsat-8:

- *Wavelengths comparisons among Landsat-7 (ETM+), EO-1 (ALI), & Landsat-8 (OLI).*

Band	Wavelength (µm)		
	Landsat 7 ETM+	EO-1 ALI	Landsat 8 OLI
Blue 1p	--	0.43–0.45	0.43–0.45
Blue 1	0.45–0.52	0.45–0.52	0.45–0.51
Green 2	0.52–0.60	0.53–0.61	0.53–0.59
Red 3	0.63–0.69	0.63–0.69	0.64–0.67
NIR 4	0.77–0.90	0.78–0.81	--
NIR 4p	--	0.85–0.89	0.85–0.88
SWIR 5p	--	1.20–1.30	1.36–1.38
SWIR 5	1.55–1.75	1.55–1.75	1.57–1.65
SWIR 7	2.09–2.35	2.08–2.35	2.11–2.29

RS from the Space:

Land Observation Satellites/Sensors: ***(continue)***

SPOT Program:

- *SPOT is a series of Earth observation imaging satellites designed & launched by CNES (National Center for Space Studies) of France, with support from Sweden & Belgium.*
- *It considered to be from the second group, the relatively medium coverage area, medium to high spatial resolution and medium multispectral-band group.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*SPOT Program: **(continue)***

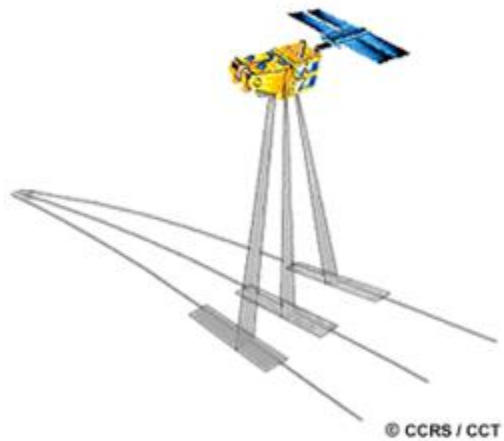
- *SPOT 1, the first satellite in this program, was launched in 1986, with successors following every 3 or 4 years.*
- *All satellites are in sun-synchronous, near-polar orbits at altitudes around 830 km above the Earth, which results in orbit repetition every 26 days.*
- *They have equator crossing times around 10:30 AM local solar time, with inclination angle of 98.7 degrees from the Equator.*

Chapter 2: "Satellites & sensors"

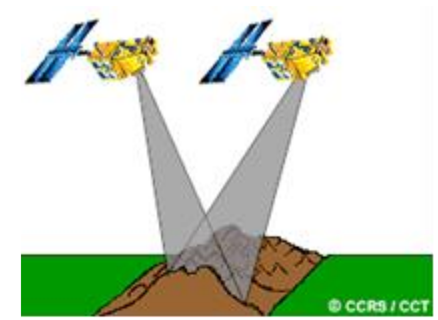
RS from the Space:

Land Observation Satellites/Sensors: (continue)

SPOT Program: **(continue)**



- *SPOT satellite program was considered revolutionary when it launched its first satellite because it was the first program to employ pointable optics which enable the program to reduce the revisit time to 3 days in some locations & to be able to produce 3D out of its images.*



- *It was also the first satellite system to employ along-track, or push-broom scanning system.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

SPOT Program: ***(continue)***

- *Each SPOT satellites has twin imaging scanning systems, which can be operated independently & simultaneously.*
- *Each imaging scanning systems is capable of sensing either in a high spatial resolution single-channel panchromatic (PLA) mode, or in a coarser spatial resolution multispectral (MLA) mode.*

Chapter 2: “Satellites & sensors”

RS from the Space:

***Land Observation Satellites/Sensors:* (continue)**

SPOT Program: ***(continue)***

- *Each SPOT satellites has 60 x 60 square km coverage area at nadir.*
- *By pointing both scanning sensors to cover adjacent ground swaths at nadir, a swath of 117 km (3 km overlap between the two swaths) can be imaged.*

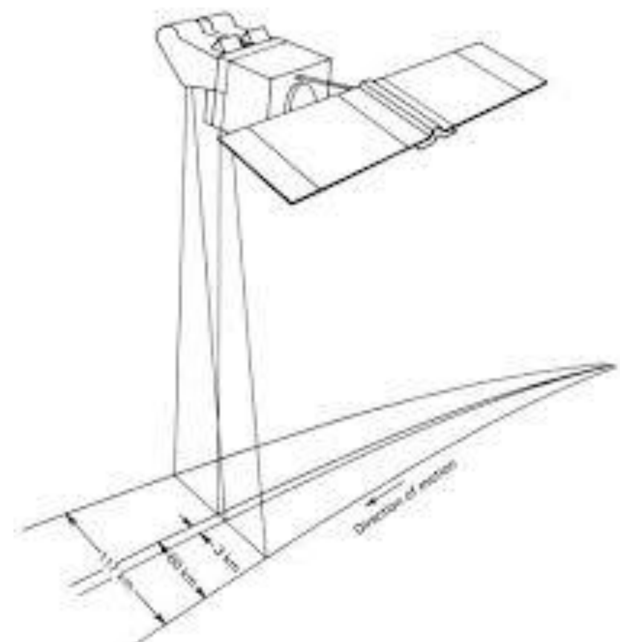


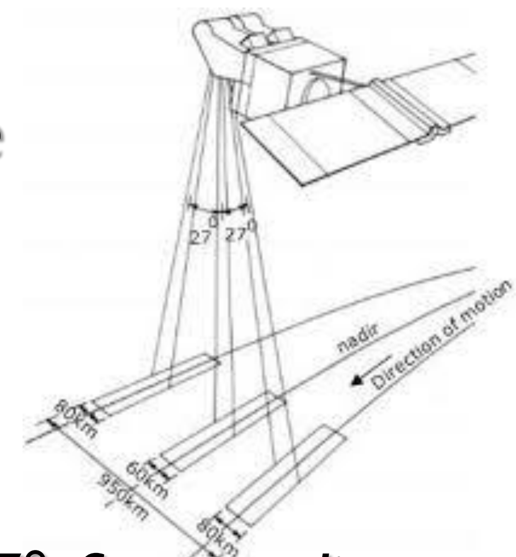
Figure 6.26 SPOT ground coverage with HRVs recording adjacent swaths. (Adapted from CNES diagrams.)

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

SPOT Program: ***(continue)***



- *The viewing angle of the sensors can be adjusted to look to either side of the satellite's vertical (nadir) track, allowing off-nadir viewing which increases the satellite's revisit capability.*
- *This ability to point the sensors up to 27° from nadir, allows SPOT to view within a 950 km swath & to revisit any location several times per week.*
- *As the sensors point away from nadir, the swath varies from 60 to 80 km in width.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

SPOT Program: *(continue)*

SPOT Program Satellite

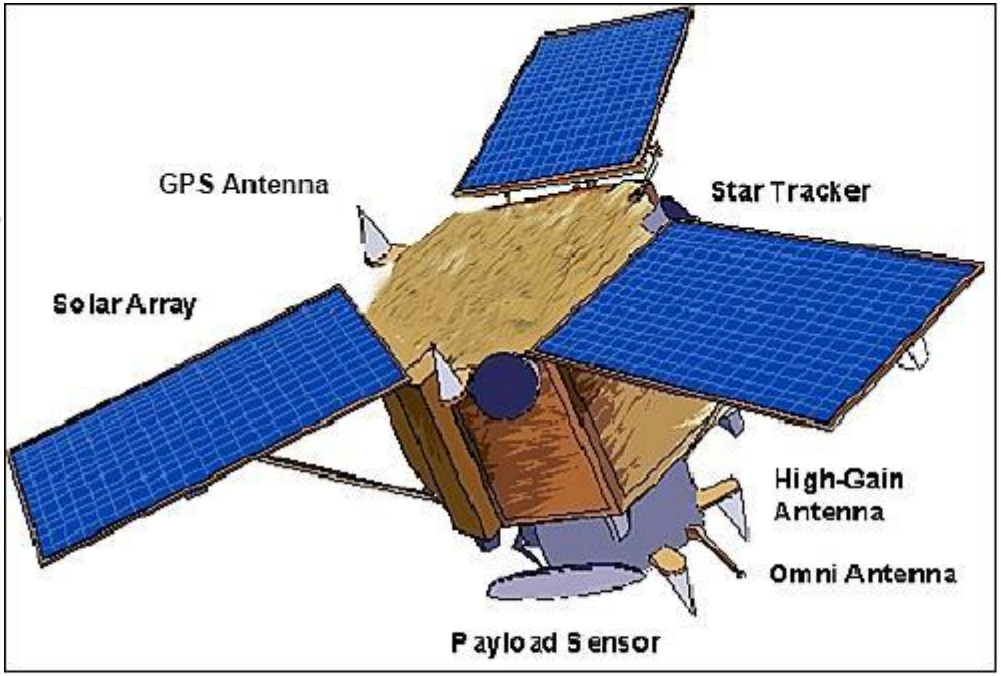
Satellite	Scanning Instrument	Spectral & spatial resolutions	Swath
SPOT – 1, 2, & 3	2 identical HRV	Panchromatic mode with 10m resolution, & Color mode; G, R, & N-IR with 20m resolution.	117Km on nadir images.
SPOT – 4	2 identical HRVIR	Panchromatic mode with 10m resolution, & Color mode; G, R, N-IR & M-IR with 20m resolution.	117Km on nadir images.
	vegetation	Color mode; B, R, N-IR & M-IR with 1.1km resolution.	2250K.
SPOT – 5	2 identical HRG	Panchromatic mode with 2.5 to 5m resolution, & Color mode; G, R, & N-IR with 10m resolution & M-IR with 20m resolution.	117Km on nadir images.
	HRS	Panchromatic mode with 10m resolution.	points forward & backward of the satellite
	vegetation	Color mode; B, R, N-IR & M-IR with 1.1km resolution.	2250km.
SPOT – 6 & 7	2 identical NAOMI	Panchromatic mode with 1.5m resolution, & Color mode; B, G, R & N-IR with 6m resolution.	117Km on nadir images.

RS from the Space:

Land Observation Satellites/Sensors: (continue)

IKONOS Program:

- *In 1999, Space Imaging made history when it successfully launched the first 1 meter commercial satellite.*



- *IKONOS is design to occupy about 680 km sun-synchronous orbit that cross the equator at 10:30 Am local solar time.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*IKONOS Program: **(continue)***

- *The ground track repeats every 11 days but the revisit time for imaging is less than 11 days.*
- *The system has the capability to collect data at angle of up to 45^{o} from vertical both in the across-track & along-track directions.*
- *The system has a swath width of 11 km at nadir. A typical image is 11 x 11 km in size, but user-specified image strips & mosaics can also be collected.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

*IKONOS Program: **(continue)***

- *IKONOS employs linear array technology & collects data in 4 m 4 multispectral bands includes: blue, green, red, & near-IR.*
- *IKONOS also collects a 1 m resolution panchromatic band.*
- *The panchromatic band & the multi-spectral bands can be combined to produce "pan-sharpened" multispectral imagery with 1 m resolution.*

RS from the Space:

Land Observation Satellites/Sensors: (continue)

IKONOS Program: ***(continue)***

- *Data are collected over radiometric resolution of 11 bits, or 2048 digital numbers.*
- *The IKONOS satellite is designed to be highly maneuverable.*
- *The system is capable of pointing to a new target & stabilizing itself within a few second.*
- *Also the IKONOS satellite has the ability to be entirely (spacecraft & optical system) pointed in the direction of data collection.*

Chapter 2: "Satellites & sensors"

RS from the Space:

Land Observation Satellites/Sensors: (continue)

IKONOS Program: *(continue)*

- Some other High resolution satellites.

Chapter 2: "Satellites & sensors"
Part 6 out of 6

Active Systems:

Microwave Observation Satellites & Sensors:

Microwave portion of the spectrum, includes wavelengths within the range of 1-mm to 1-m, has two distinctive features over different ranges of wavelengths.

The first feature is that microwaves are capable of penetrating the atmosphere under any conditions.

The second is that microwaves reflections for Earth materials have no relation with their counterparts in the visible or IR portions of the spectrum. Microwave responses afford us with a different "view" of the environment.

Chapter 2: "Satellites & sensors"

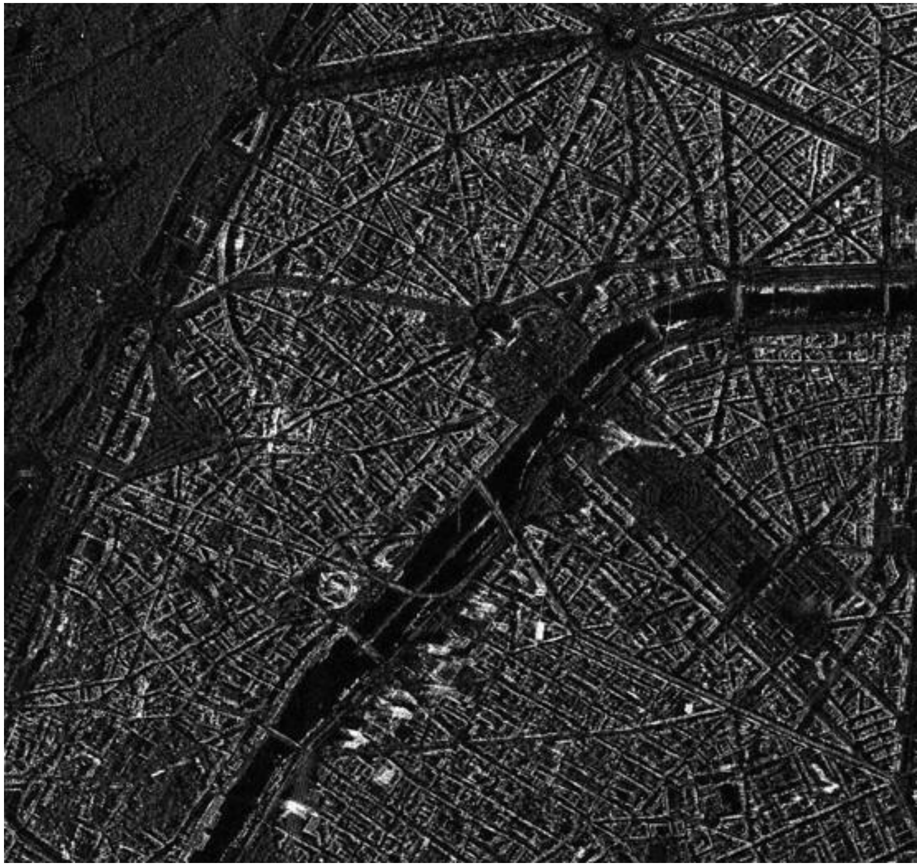
Active Systems: (continue)

RADAR:

RADAR stands for RAdio Detection & Ranging.

RADAR systems are active sensors which provide their own source of electromagnetic energy.

RADAR systems may or may not provide images.

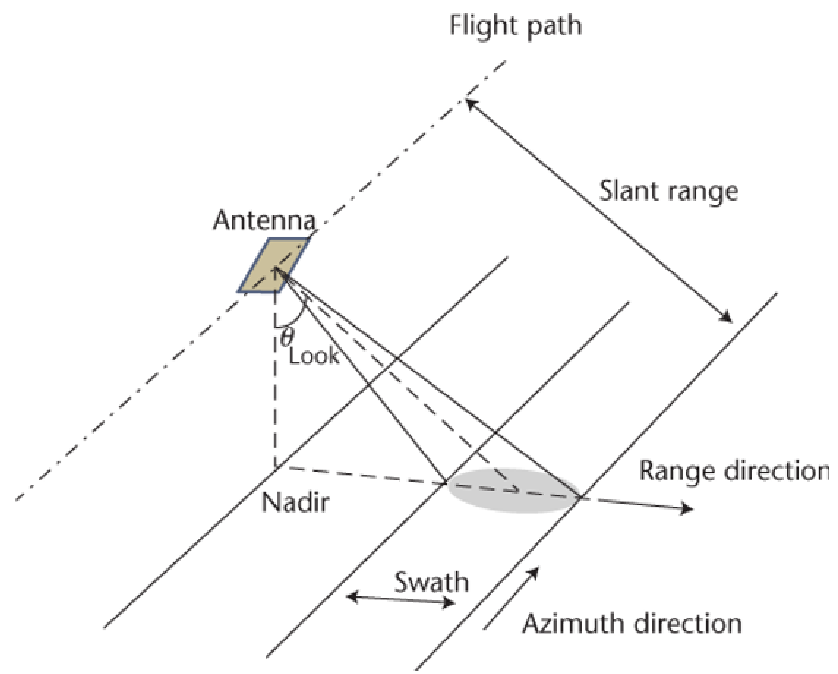


Chapter 2: "Satellites & sensors"

Active Systems: (continue)

RADAR: (continue)

RADAR systems use distance ranging instead of angular ranging in optic systems; therefore, RADAR systems are synchronous to be side looking, otherwise images from both sides of the nadir will be the same.



Active radar sensors, whether airborne or spaceborne, emit microwave radiation in a series of pulses from an antenna.

Chapter 2: "Satellites & sensors"

Active Systems: (continue)

RADAR: (continue)

Active radar sensors, whether airborne or spaceborne, emit microwave radiation in a series of pulses from an antenna.

When the energy reaches the target, some of the energy is reflected back towards the sensor. This backscattered microwave radiation is detected, measured, & timed.

By recording the range & magnitude of the energy reflected from all targets as the system passes by, a two-dimensional image of the surface can be produced

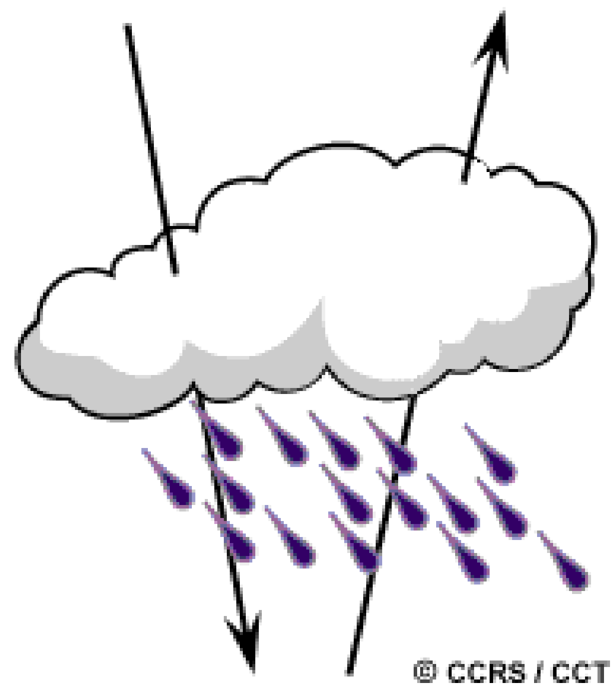
Chapter 2: "Satellites & sensors"

Active Systems: (continue)

RADAR: (continue)

Because RADAR provides its own energy source, images can be acquired day or night.

Microwave energy is able to penetrate through clouds & most rain, making it an all-weather sensor.



Chapter 2: “Satellites & sensors”

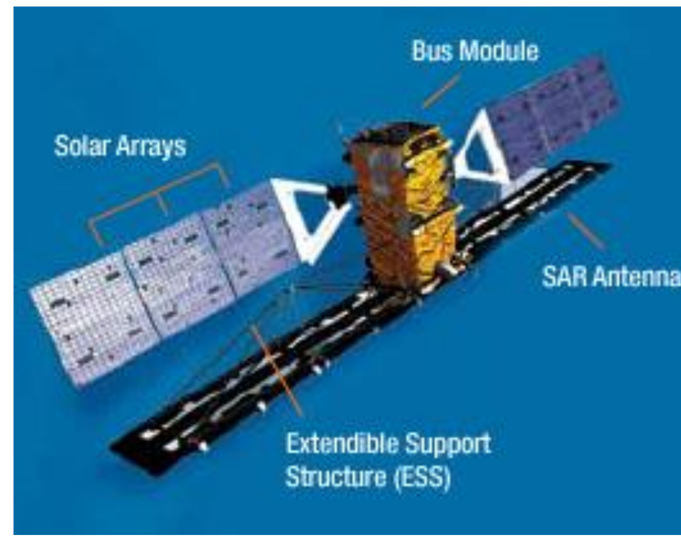
Active Systems: (continue)

RADAR: (continue)

Radarsat:

Radarsat was developed by the Canadian Space Agency, in cooperation with the US government & the private sector.

The first satellite in this program, Radarsat 1, was launched on November 1995.

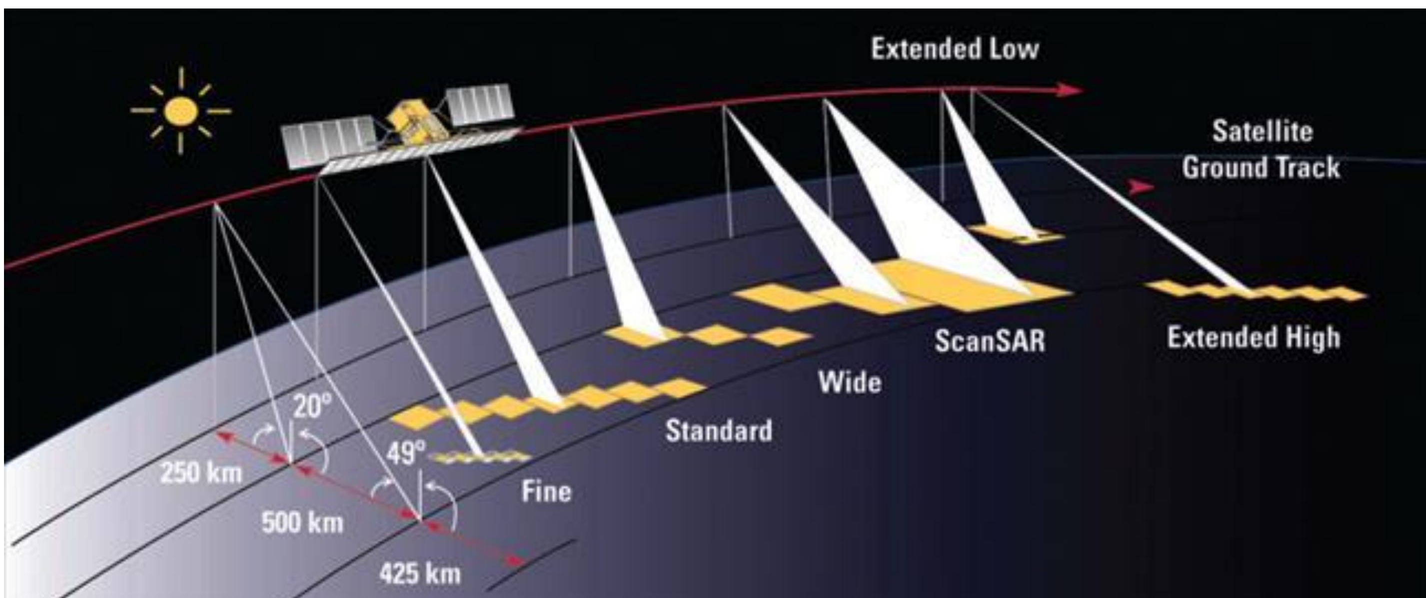


Chapter 2: "Satellites & sensors"

Active Systems: (continue)

RADAR: (continue)

Radarsat has a sun-synchronous orbit at an altitude of 798 km & inclination of 98.6o. The orbit period is 100.7minutes with a repeat cycle of 24 days.



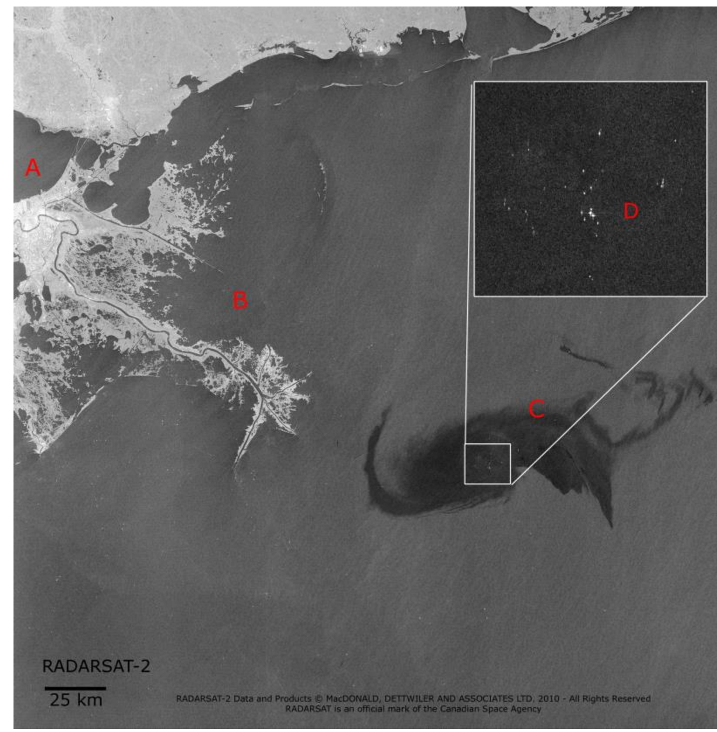
Chapter 2: "Satellites & sensors"

Active Systems: (continue)

RADAR: (continue)

Radarsat is a rightside-looking sensor, facing east during the ascending orbit & west during the descending orbit.

The antenna can be operated at various look angles & swath widths, the system provides 1-day repeat coverage over the arctic & approximately 3-day repeat coverage at mid-latitude.



Chapter 2: “Satellites & sensors”

Active Systems: (continue)

Lidar:

Lidar is an acronym for LIght Detection & Ranging, an active imaging technology very similar to RADAR.

Chapter 2: "Satellites & sensors"

Active Systems: (continue)

Lidar: (continue)

Pulses of laser light are emitted from the sensor & energy reflected from a target is detected.

Lidar is used effectively for measuring heights of features, such as forest canopy height relative to the ground surface, & water depth relative to the water surface (laser profilometer).

Lidar is also used in atmospheric studies to examine the particle content of various layers of the Earth ́s atmosphere & acquire air density readings & monitor air currents.

Chapter 2: "Satellites & sensors"

Active Systems: (continue)

Lidar: (continue)