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What is the naming convention for Landsat Collections Level-1 scenes?

The Landsat Collection 1 Level-1 product identifier includes the Collection processing levels, processing date, collection number, and collection tier category:

LXSS_LLLL_PPPRRR_YYYYMMDD_yyyymmdd_CC_TX

Where:

- L = Landsat
- X = Sensor (“C”=OLI/TIRS combined, “O”=OLI-only, “T”=TIRS-only, “E”=ETM+, “T”=“TM, “M”=MSS)
- SS = Satellite (”07”=Landsat 7, “08”=Landsat 8)
- LLL = Processing correction level (L1TP/L1GT/L1GS)
- PPP = WRS path
- RRR = WRS row
- YYYYMMDD = Acquisition year, month, day
- yyyymmdd - Processing year, month, day
- CC = Collection number (01, 02, …)
- TX = Collection category (“RT”=Real-Time, “T1”=Tier 1, “T2”=Tier 2)

Example: LC08_L1GT_029030_20151209_20160131_01_RT

Means: Landsat 8; OLI/TIRS combined; processing correction level L1GT; path 029; row 030; acquired December 9, 2015; processed January 31, 2016; Collection 1; Real-Time

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The Worldwide Reference System (WRS)- WRS path and row

The Worldwide Reference System (WRS) is a global notation system for Landsat data. It enables a user to inquire about satellite imagery over any portion of the world by specifying a nominal scene center designated by PATH and ROW numbers. The WRS has proven valuable for the cataloging, referencing, and day-to-day use of imagery transmitted from the Landsat sensors.

The Landsat 1-3 WRS-1 notation assigns sequential path numbers from east to west to 251 nominal satellite orbital tracks, starting with number 001 for the first track which crosses the equator at 65.48 degrees west longitude. A specific orbital track can vary due to drift and other factors; thus, a path line is only approximate. The orbit is periodically adjusted after a specified amount of drift has occurred in order to bring the satellite back to an orbit that is nearly coincident with the initial orbit.

Row refers to the latitudinal center line of a frame of imagery. As the satellite moves along its path, the observatory instruments are continuously scanning the terrain below. The instrument signals are transmitted to Earth and correlated with telemetry ephemeris data to form individual framed images. During this process, the continuous data are segmented into individual frames of data known as scenes. Landsats 1-3 scene centers are chosen at approximately 25-second increments of spacecraft time in either direction from the equator with each scene equal to approximately 163 km (101 miles) on the Earth's surface plus about 10 percent in-track overlap (5 percent for Landsat 3) added by the ground processor. A total of 119 Landsats 1-3 daylight scenes are possible along one descending satellite path. A complete orbit of 6196 seconds, when divided by 25 seconds, yields 247.84 intervals; 248 scenes per complete orbit (descending and ascending) were selected as the standard.

The framing is uniform for each orbit. The adjacent east-west scenes have scene center locations at the same nominal latitude. A notation of Row numbers can, therefore, be applied to identify all scenes occurring at the same latitude. Row 060 corresponds to latitude 0 (equator). Row 059 is immediately north of this, and the progression continues to latitude 80 degrees, 1 minute and 12 seconds north, which is Row 001. Row 119 is at latitude 80 degrees, 1 minute and 12 seconds south.

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The combination of a Path number and a Row number uniquely identifies a nominal scene center. The Path number is always given first, followed by the Row number. The notation 127-043, for example, relates to Path number 127 and Row number 043.

Landsats 1-3 orbital parameters cause each consecutive daily track to be shifted west 25.8 degrees of longitude at the equator, corresponding to 2872 km (1784 miles). Each succeeding day of Landsat 1-3 coverage overlapped the coverage of the preceding day. This constitutes one complete coverage cycle, consisting of 251 orbits, taking exactly 18 days and providing complete global coverage between 82 degrees north latitude and 82 degrees south latitude. The consecutive day sidelap resulted in a minimum of 14 percent at the equator to nearly 85 percent at extreme latitudes. A combination of data processing and orbital adjustment keep the error in the individual framed image centers of any geographical area on the Earth within 37 km (23 miles) in the across-track direction and 30 km (19 miles) in the along-track direction.

Landsats 4, 5, 7, 8 (and soon 9) have Earth coverage similar to Landsats 1-3. However, the lower altitude results in a different swathing pattern. Landsat 5 and 7 (and Landsat 4 prior to its decommissioning) operate in a repetitive, circular, sun-synchronous, near-polar orbit at a nominal altitude of 705.3 km (438.4 miles) measured at the equator. The descending orbital node time is 9:45 AM +/- 15 minutes at the equator with an orbital period of 98.9 minutes, completing 14 9/16 orbits per day and viewing the entire Earth every 16 days.

Each consecutive daily track is spaced 2752 km (1709 miles or 24.7 degrees) west of the previous orbit at the equator. Each succeeding day's track is shifted at the equator to the west 10.8 degrees of longitude corresponding to 1204 km (748 miles).

Coverage sidelap of adjacent orbits for the Landsat 4 and 5 MSS sensors are a minimum of 7.3 percent at the equator to nearly 84 percent at extreme latitudes (see table below). Successive orbits and framing operations are controlled to assure no more than 18 km (11 miles) variation in the across-track direction.

The Landsat 4, 5, 7, 8, and 9 Worldwide Reference System-2 (WRS-2) is an extension of the global Landsat 1 through 3 WRS-1 and utilizes an orderly Path/Row system in a similar fashion. There are, however, major differences in repeat cycles, coverage, swathing patterns and Path/Row designators due to the large orbital differences of Landsats 4 and 5 compared to Landsats 1 through 3.

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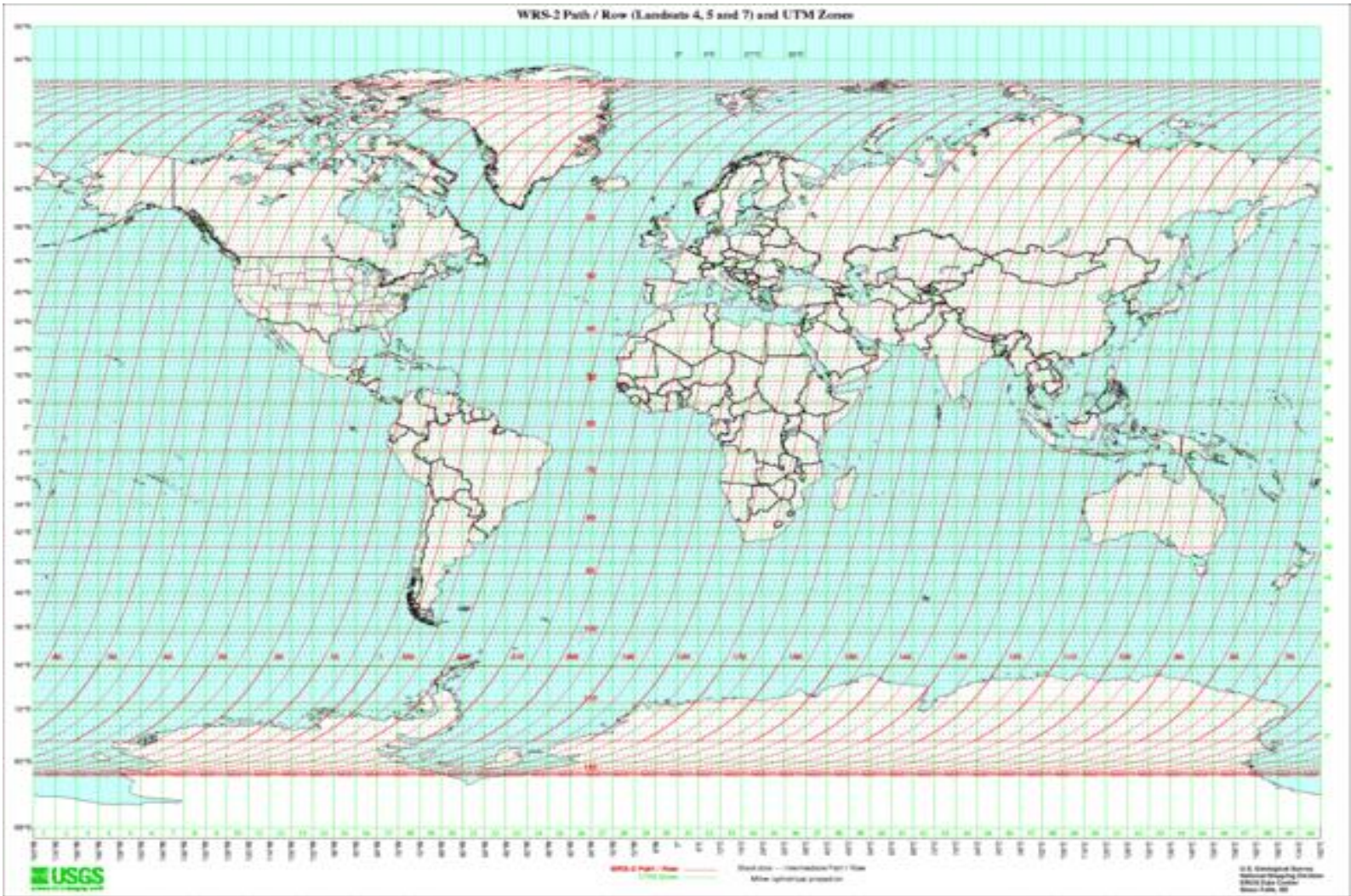
The 16-day ground coverage cycle for Landsats 4–9 was accomplished in 233 orbits. Thus, for Landsats 4–9, the WRS-2 system is made up of 233 paths numbered 001 to 233, east to west, with Path 001 crossing the equator at 64.60 degrees west longitude.

Landsat 4–9 scenes are chosen at 23.92-second increments of spacecraft time in both directions calculated from the equator in order to create 248 Row intervals per complete orbit. Note that this is the same as the Landsat 1 through 3 WRS-1 system. The Rows have been positioned in such a way that Row 60 coincides with the equator during the descending node on the day side part of the orbit and Row 184 during the ascending node. Row one of each Path starts at 80 degrees, 47 minutes north latitude and the numbering increases southward to a maximum latitude 81 degrees, 51 minutes south (Row 122) and then turns northward, crosses the equator (Row 184), and continues to a maximum latitude of 81 degrees, 51 minutes north (Row 246). Row 248 is located at latitude 81 degrees 22 minutes north whereupon another Path begins.



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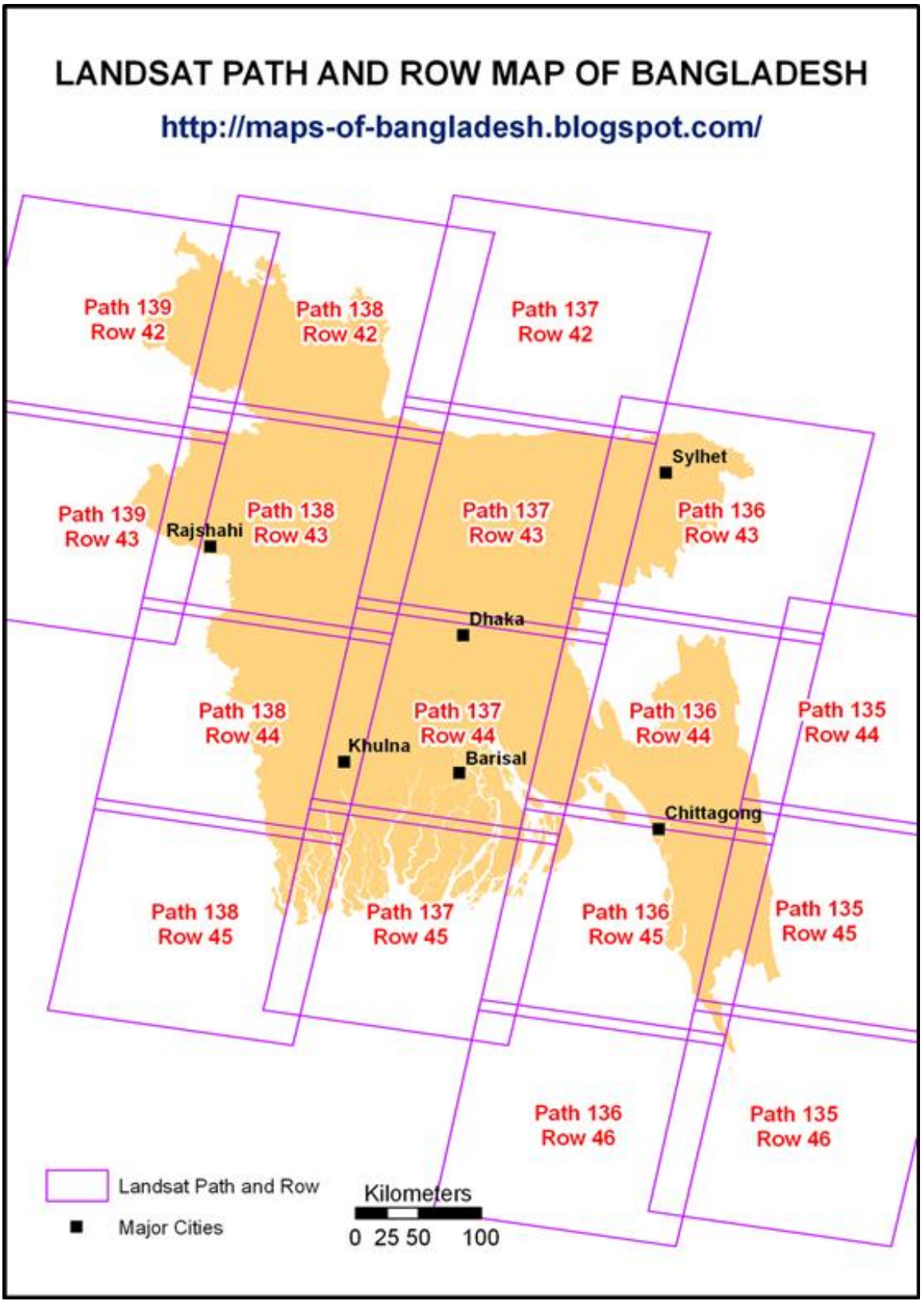

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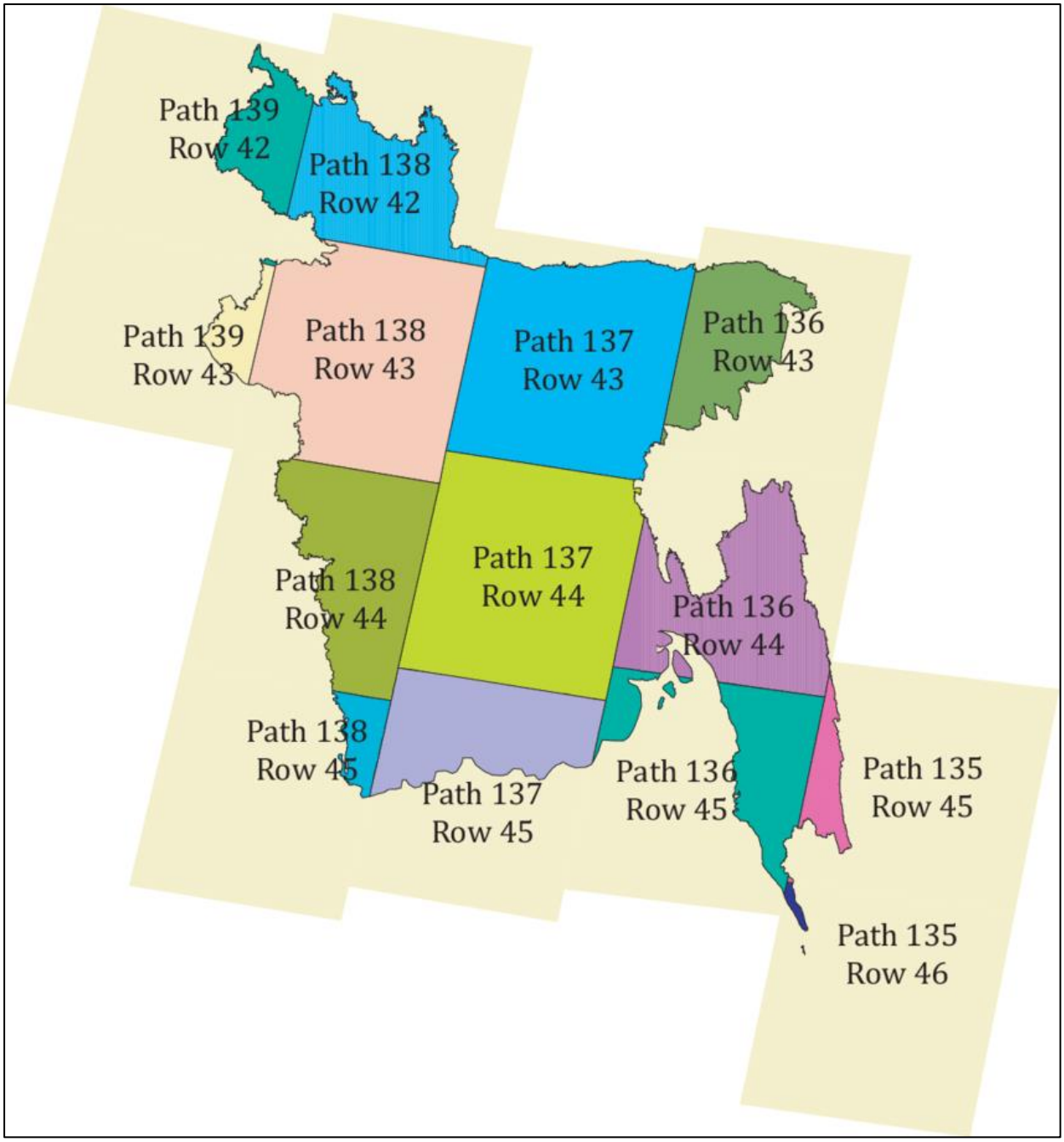

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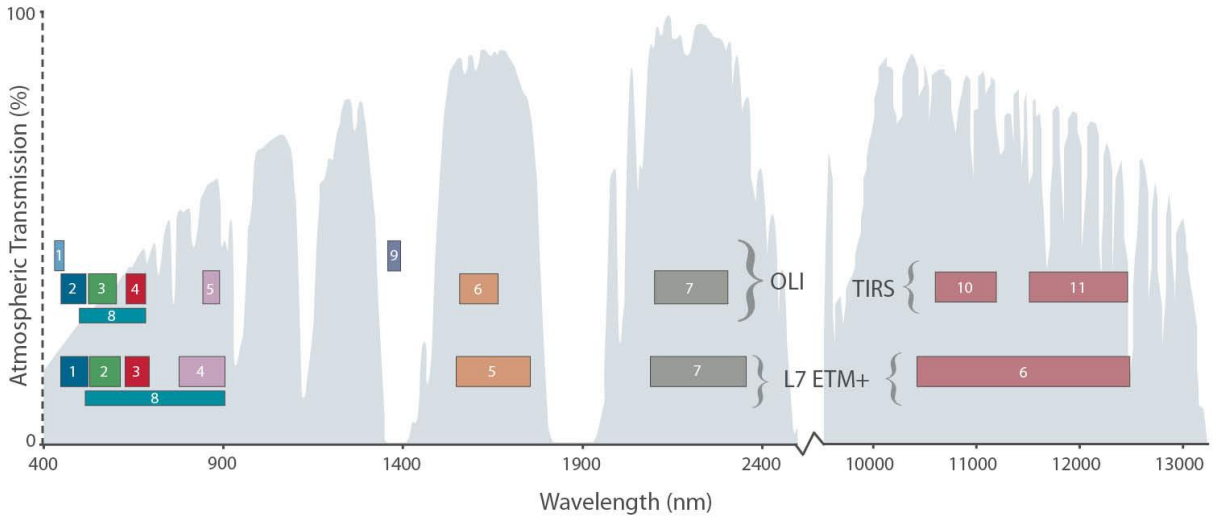
Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS)

The Landsat 8 satellite payload consists of two science instruments—the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). These two sensors provide seasonal coverage of the global landmass at a spatial resolution of 30 meters (visible, NIR, SWIR); 100 meters (thermal); and 15 meters (panchromatic). Landsat 8 was developed as a collaboration between NASA and the U.S. Geological Survey (USGS).

OLI improves on past Landsat sensors using a technical approach demonstrated by a sensor flown on NASA's experimental EO-1 satellite. OLI is a push-broom sensor with a four-mirror telescope and 12-bit quantization. OLI collects data for visible, near infrared, and short wave infrared spectral bands as well as a panchromatic band. It has a five-year design life. The graphic below compares the OLI spectral bands to Landsat 7′s ETM+ bands. OLI provides two new spectral bands, one tailored especially for detecting cirrus clouds and the other for coastal zone observations.



The OLI collects data for two new bands, a coastal/aerosol band (band 1) and a cirrus band (band 9), as well as the heritage Landsat multispectral bands. Additionally, the bandwidth has been refined for six of the heritage bands. The Thermal Instrument (TIRS) carries two additional thermal infrared bands. Note: atmospheric transmission values for this graphic were calculated using

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MODTRAN for a summertime mid-latitude hazy atmosphere (circa 5 km visibility).Graphic created by L.Rocchio & J.Barsi.

Landsat-7 ETM+ Bands (µm)			Landsat-8 OLI and *TIRS* Bands (µm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

TIRS collects data for two more narrow spectral bands in the thermal region formerly covered by one wide spectral band on Landsats 4–7. The 100 m TIRS data is registered to the OLI data to create radiometrically, geometrically, and terrain-corrected 12-bit data products. Landsat 8 is required to return 400 scenes per day to the USGS data archive (150 more than Landsat 7 is required to capture). Landsat 8 has been regularly acquiring 725 scenes per day (and Landsat 7 is acquiring 438 scenes per day). This increases the probability of capturing cloud-free scenes for the global landmass. The Landsat 8 scene size is 185-km-cross-track-by-180-km-along-track. The nominal spacecraft altitude is 705 km. Cartographic accuracy of 12 m or better (including compensation for terrain effects) is required of Landsat 8 data products.

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The Enhanced Thematic Mapper Plus (ETM+)

The **Enhanced Thematic Mapper Plus (ETM+)** instrument is a fixed "whisk-broom", eight-band, multispectral scanning radiometer capable of providing high-resolution imaging information of the Earth's surface. It detects spectrally-filtered radiation in VNIR, SWIR, LWIR and panchromatic bands from the sun-lit Earth in a 183 km wide swath when orbiting at an altitude of 705 km.

The primary new features on Landsat 7 are a panchromatic band with 15 m spatial resolution, an on-board full aperture solar calibrator, 5% absolute radiometric calibration and a thermal IR channel with a four-fold improvement in spatial resolution over TM.

Landsat 7 collects data in accordance with the World Wide Reference System 2, which has catalogued the world's land mass into 57,784 scenes, each 183 km wide by 170 km long. The ETM+ produces approximately 3.8 gigabits of data for each scene. An ETM+ scene has an Instantaneous Field Of View (IFOV) of 30 meters x 30 meters in bands 1-5 and 7 while band 6 has an IFOV of 60 meters x 60 meters on the ground and the band 8 an IFOV of 15 meters. Please visit the L7 Science Data Users Handbook for a detailed description of ETM+ spatial characteristics.

ETM+ Technical Specifications

- Sensor type: opto-mechanical
- Spatial Resolution: 30 m (60 m – thermal, 15-m pan)
- Spectral Range: 0.45 – 12.5 µm
- Number of Bands: 8
- Temporal Resolution: 16 days
- Image Size: 183 km X 170 km
- Swath: 183 km
- Programmable: yes

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Band # (L1-L2)	µm	Resolution*
1	0.45-0.515	30m
2	0.525-0.605	30m
3	0.63-0.69	30m
4	0.775-0.90	30m
5	1.55-1.75	30m
6	10.4-12.5	60m
7	2.08-2.35	30m
8	0.52-0.9	15m

Thematic Mapper (TM)

The **Thematic Mapper (TM)** is an advanced, multispectral scanning, Earth resources sensor designed to achieve higher image resolution, sharper spectral separation, improved geometric fidelity and greater radiometric accuracy and resolution than the MSS sensor. TM data are sensed in seven spectral bands simultaneously. Band 6 senses thermal (heat) infrared radiation. Landsat can only acquire night scenes in band 6. A TM scene has an Instantaneous Field Of View (IFOV) of 30m x 30m in bands 1-5 and 7 while band 6 has an IFOV of 120m x 120m on the ground

- Sensor type: opto-mechanical
- Spatial Resolution: 30 m (120 m – thermal)
- Spectral Range: 0.45 – 12.5 µm
- Number of Bands: 7
- Temporal Resolution: 16 days

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- Image Size: 185 km X 172 km
- Swath: 185 km
- Programmable: yes

Band Number	µm	Resolution
1	0.45-0.52	30 m
2	0.52-0.60	30 m
3	0.63-0.69	30 m
4	0.76-0.90	30 m
5	1.55-1.75	30 m
6	10.41-12.5	120 m
7	2.08-2.35	30 m

The Multispectral Scanner System (MSS)

The **Multispectral Scanner System (MSS)** sensors were line scanning devices observing the Earth perpendicular to the orbital track. The cross-track scanning was accomplished by an oscillating mirror; six lines were scanned simultaneously in each of the four spectral bands for each mirror sweep. The forward motion of the satellite provided the along-track scan line progression.

The first five Landsats carried the MSS sensor which responded to Earth-reflected sunlight in four spectral bands. Landsat 3 carried an MSS sensor with an additional band, designated band 8, that responded to thermal (heat) infrared radiation.

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An MSS scene had an Instantaneous Field Of View (IFOV) of 68 meters in the cross-track direction by 83 meters in the along-track direction (223.0 by 272.3 feet respectively). To understand this concept consider a ground scene composed of a single 83 by 83 meter area. The scan monitor sensor ensures that the cross-track optical scan is 185 km at nominal altitude regardless of mirror scan nonlinearity or other perturbations of mirror velocity.

Cross- track image velocity was nominally 6.82 meters per microsecond. After 9.958 microseconds, the 83 by 83 meter image has moved 67.9 meters. The sample taken at this instant represented 15 meters of previous information and 68 meters of new information.

Therefore, the effective IFOV of the MSS detector in the cross-track direction was considered to be 68 meters which corresponds to a nominal picture element (pixel) ground area of 68 by 83 meters at the satellite nadir point. Using the effective IFOV in area calculation eliminates the overlap in area between adjacent pixels.

- Sensor type: opto-mechanical
- *Spatial Resolution: 68 m X 83 m (commonly resampled to 57 m, or 60 m)
- Spectral Range: 0.5 – 1.1 µm
- Number of Bands: 4, 5 (Landsat 3 only)
- Temporal Resolution: 18 days (L1-L3), 16 days (L4 & L5)
- Image Size: 185 km X 185 km
- Swath: 185 km
- Programmable: no

Band # (L1-L2)	**Band # (L3)**	**Band # (L4-L5)**	**µm**	**Resolution***	**L4/L5 TM Band Equivalent**
4	4	1	0.5-0.6	68 m X 83 m	~ 2 (0.52–0.60 µm)
5	5	2	0.6-0.7	68 m X 83 m	~ 3 (0.63–0.69 µm)

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Band # (L1-L2)	Band # (L3)	Band # (L4-L5)	µm	Resolution*	L4/L5 TM Band Equivalent
6	6	3	0.7-0.8	68 m X 83 m	~ 4 (0.76–0.90 µm)
7	7	4	0.8-1.1	68 m X 83 m	~ 4 (0.76–0.90 µm)
N/A	8	N/A	10.4-12.6	68 m X 83 m	~ 6 (10.41-12.5 µm)