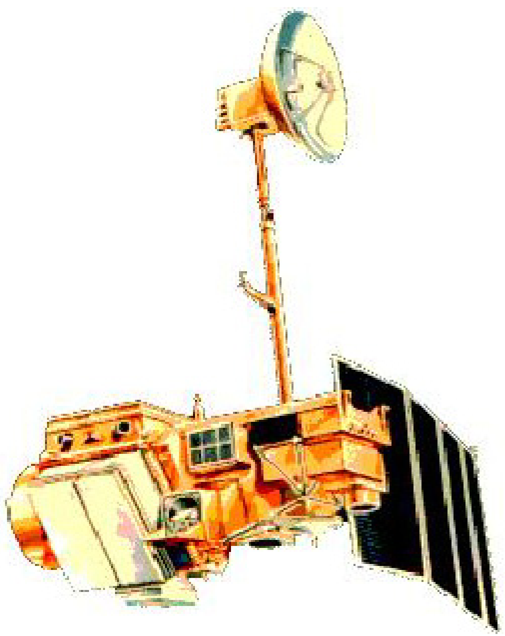
A new 7 spectral band scanner, called the Thematic Mapper, was/is the prime instrument on Landsats 4, 5, and 6. This improved sensor system includes a blue band so that quasi-natural color images can be made, two bands in the mid-IR, and a thermal band. System resolution is increased to 30 meters. Landsat 7 carried a single sensor, the ETM+, which, besides the 7 bands, also has a panchromatic band that achieves 15 m resolution. The ability of the TM to better identify materials and classes is demonstrated.

History of Remote Sensing: Landsat's Thematic Mapper (TM)

A more sophistical multispectral imaging sensor, named the Thematic Mapper (TM) has been added to Landsats 4 (1982), 5 (1984), and 6 (this last failed to attain orbit during launch and thus has never returned data) and a modified version to Landsat-7 (1999). These TMs flew on redesigned, more advanced platforms, the first of which, Landsat-4, is pictured below:



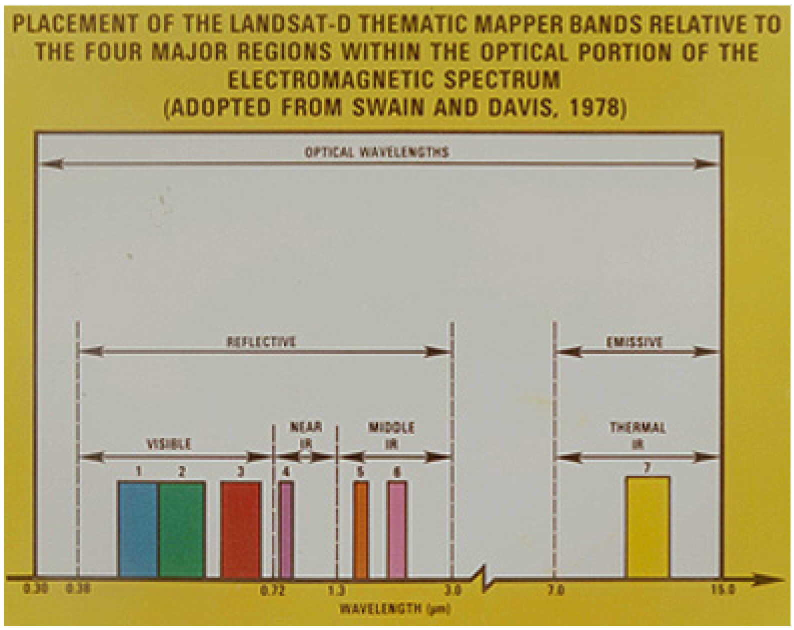
Although similar in operational modes to the MSS (which was also part of the Landsat 4 and 5 payloads, to maintain continuity), the TM consists of 7 bands that have these characteristics:

Band No.	Wavelength Interval (µm)	Spectral Response	Resolution (m)
1	0.45 - 0.52	Blue-Green	30
2	0.52 - 0.60	Green	30

3	0.63 - 0.69	Red	30
4	0.76 - 0.90	Near IR	30
5	1.55 - 1.75	Mid-IR	30
6	10.40 - 12.50	Thermal IR	120
7	2.08 - 2.35	Mid-IR	30

Six reflectance bands obtain their effective resolution at a nominal orbital altitude of 705 km (438 miles) through an IFOV of 0.043 mrad. The seventh band (but designated as Band 6) is the thermal channel, which has an IFOV of 0.172 mrad, which reduces resolution.

This diagram shows the placement of each band on a wavelength base:



The TM spacecraft differs from the earlier MSS Landsats in the orbital repeat cycles, as shown in this diagram:

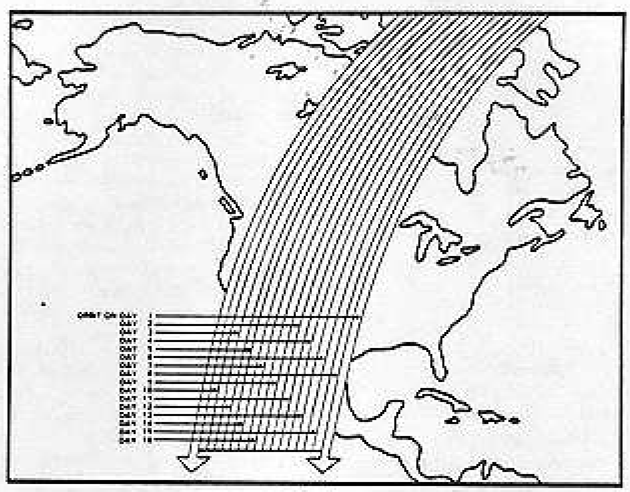


Figure 2.
LANDSAT 4/5 SWATHING PATTERN

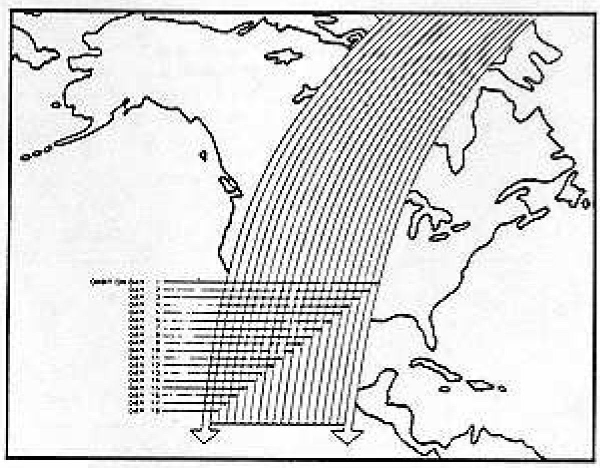
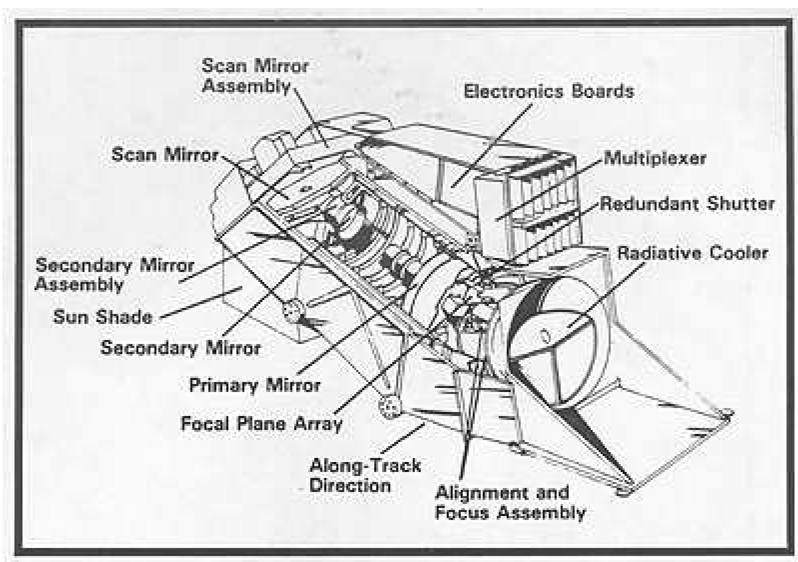


Figure 3.
LANDSATS 1, 2, AND 3 SWATHING PATTERN

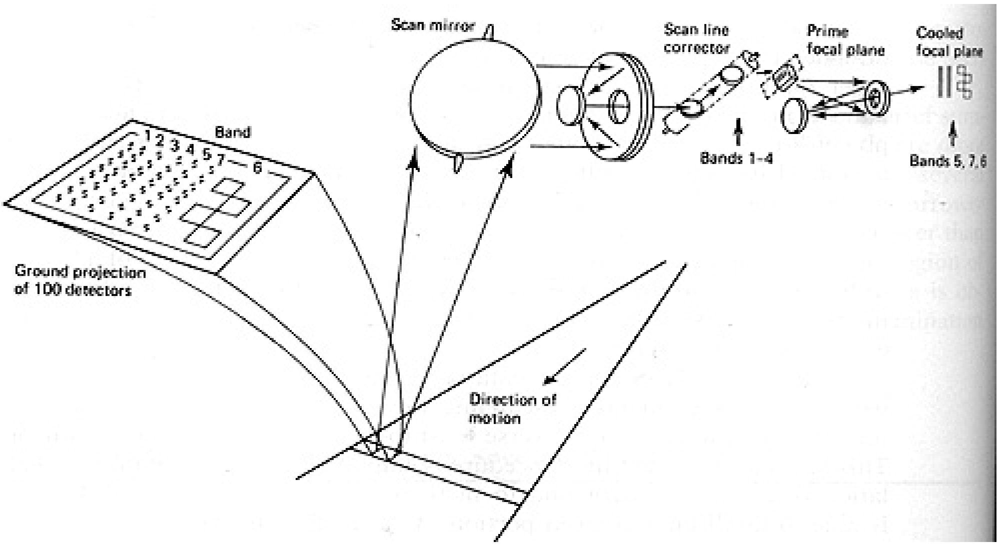
Note that for the first three Landsats there is an 18 day swath cycle in which the shift to the west (left) is systematic in that Path 1 is reoccupied after the 251 orbits have been occupied over an 18 day period. But keep in mind that for each day there are 14 circumglobal orbits (each orbit taking 103 minutes) such that as the Earth turns below each next path will have shifted less (160 km) than one frame (full size = 185 km) width to the west, allowing for some (variable) overlap between successive frames. During the 14 cycle single day history the total western shift produces a continuous combined swath width of 14 x 160 = 2240 km (1400 miles). In the full 18 day cycle this leads to a total composite coverage of (40900 km) 25200 miles. Landsats 4 and 5, at a lower altitude (which helps in improving resolution), accomplish 233 orbits in 16 days. The repeat pattern is notably different, as shown by the variable offset lines in the upper map.

Here is a photograph of the Thematic Mapper on the ground before it was mated to the spacecraft. Note the gold leaf that is used to shield the inner workings.

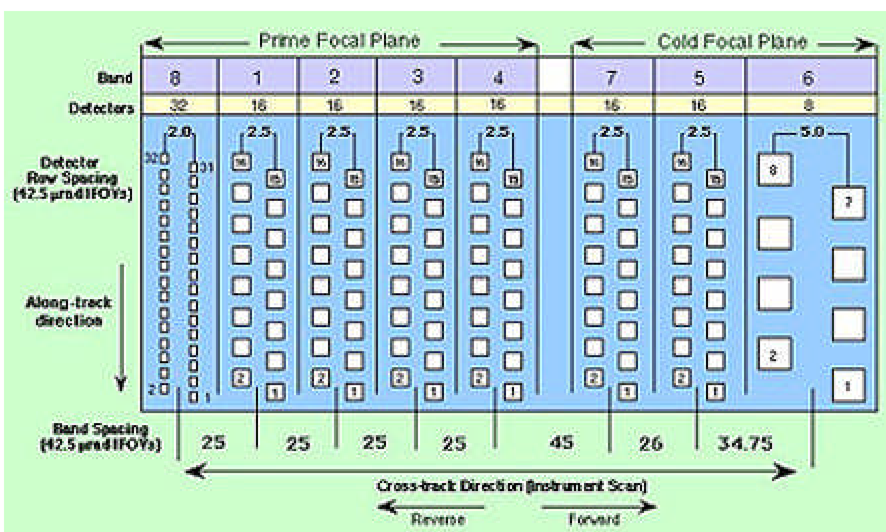
This cutaway diagram shows the major components of the TM system. Not shown are the interference filters used to separate the radiation into spectral bands:



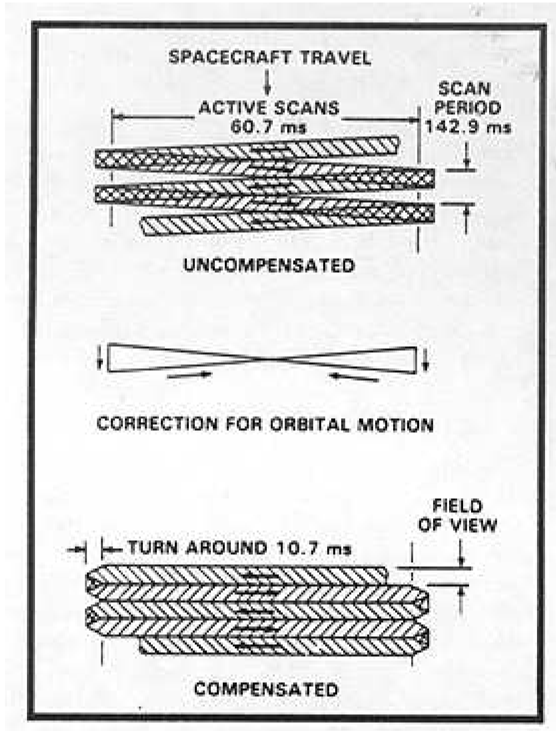
The sketch below shows some of the components in the optical train and detector layout of the TM.



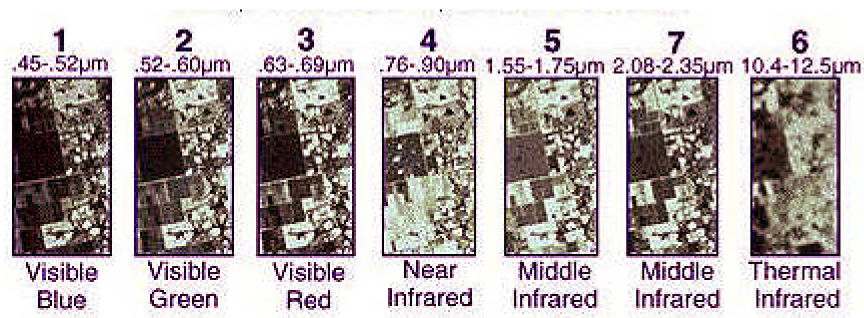
Instead of the 24 detectors on the MSS, the TM has a total of 96 for the reflective bands (16 each for a band; the mirror scan produces 16 lines at once) and 4 for the thermal band. For Bands 1-4, silicon metal is the photoelectric detector; for 5 and 7 an indium antimony (InSb) alloy is used; for Band 6, the detector is a mercury cadmium telluride alloy (HgCdTe). At any given IFOV, each detector views a slightly different part of the ground that will be represented in the pixel being activated by radiation at any instant. The radiation collected for each band passes through a scan line corrector which compensates for the forward motion of the spacecraft. Radiation comprising Bands 1 through 4 is sensed by silicon detectors located in one focal plane; Bands 5 and 7, in the Mid IR (SWIR) use InSb detectors and Band 6 used a HgCdTe detector. Radiation from all three band sets are focused on a second focal plane at the detectors; the spectral filters are just before the detector plane. Bands 5, 6, and 7 are subjected to a radiative cooling system to improve sensitivity. This figure summarizes the detector array layout for the Landsat ETM+:



The TM's primary scan mirror takes imagery during both its left and its right swings (a full cycle; swing rate: there are 7 cycles/second). This results in a zig-zag pattern, in part because of the small but steady rotation of the Earth's surface below, as shown in the next figure. When the scan data are processed to produce an image, the lines are made to be parallel by using data acquired by two secondary mirrors (in parallel to one another; each rotating completely):



To introduce you to the differences in a TM image shown in all seven bands, we take a quick look at a scene in Florida:



This table indicates the principal identification tasks that each band is especially adept at doing:

TABLE 4. TM SPECTRAL BAND APPLICATONS

BAND	SPECTRAL RANGE	PRINCIPAL APPLICATIONS
1	0.45-0.52 μm	COASTAL WATER MAPPING SOIL VEGETATION DIFFERENTIATION DECIDUOUS/CONIFEROUS DIFFERENTIATION
2	0.52-0.60 μm	GREEN REFLECTANCE BY HEALTHY VEGETATION
3	0.63-0.69 μm	CHLOROPHYL ABSORPTION FOR PLANT SPECIFIES DIFFERENTIATION
4	0.76-0.90 μm	BIOMASS SURVEYS WATER BODY DELINEATION
5	1.55-1.72 μm	VEGETATION MOISTURE MEASUREMENT SNOW CLOUD DIFFERENTIATION
6	10.4-12.5 μm	PLANT HEAT STRESS MEASUREMENT OTHER THERMAL MAPPING
7	2.08-2.35 μm	HYDROTHERMAL MAPPING

In more detail: Band 1 is superior to the MSS band 4 in detecting some features in water. It also allows us to form quasi-natural color composites. Band 5 is sensitive to variations in water content, both in leafy vegetation and as soil moisture. It also distinguishes between clouds (appearing dark) and bright snow (light). This band also responds to variations in ferric iron (Fe_2O_3) content in rocks and soils, which show higher reflectances as the iron content increases. Band 7 likewise reacts to moisture contents and is especially suited to detecting hydrous minerals (such as clays or certain alteration products) in geologic settings. Band 6 can distinguish a radiant temperature difference of about 0.6° C and is helpful in discriminating rock types whose thermal properties show differences in temperatures near their surface. It often can pick out changes in ground temperatures due to moisture variation and can single out vegetation due to its evaporative cooling effect. The higher resolution achieved in the reflective bands is a significant aid in picking out features and classes whose minimum dimension is usually on the order of 30 m (98 ft) . Thus, it can often discern houses and smaller buildings, which were unresolvable in MSS images.

The size and shape of full TM images from Landsats 4 and 5 are identical to the MSS images. At first glance, the quality and characteristics of these full scene TM images seem similar to those made by the MSS after optimal computer-based processing, but on closer inspection they do appear sharper. This apparent similarity is due to the need to resample the TM images for TV monitor displays (which are not high resolution systems capable of reproducing all TM pixels) by dropping some pixels. The influence of the better TM resolution (when un-resampled) becomes apparent whenever photographs of full scenes are enlarged (pictures more than a meter on a side can be produced with exceptional clarity) or subscenes are extracted and enlarged. Also, higher resolution improves scene feature classification since many objects on the Earth's surface are smaller than 30 meters; thus computer-based classification should result in higher accuracies for individual class identification and location.

PREVIOUS NEXT

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