Section 10

Comparison of ALI and Landsat Data Sets
EO-1 and Landsat

Landsat ETM+
Multispectral
Swath Coverage
(185 km @ 30 m)

ALI Multispectral
Swath Coverage
(37 km @ 30 m)

Atmospheric Corrector
Hyperspectral Coverage
(185 km @ 125 / 250 m)

AVIRIS Underflight
(10 km @ 20 m)

Hyperion
Hyperspectral
Swath Coverage
(7.7 km @ 30 m)

705 km
Altitude

Within 1 Minute

Landsat-7

EO-1
EO-1 and Landsat 7

Descending Orbit Ground Tracks

Landsat 7 ETM+

EO-1 Atmospheric Corrector

EO-1 Hyperion (7.7 KM)

(37 KM)

(185 KM)

EO-1 ALI

N
## EO-1 Instrument Overviews

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Landsat 7 ETM+</th>
<th>EO-1 ALI</th>
<th>EO-1 HYPERION</th>
<th>EO-1 AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Range</td>
<td>0.4 - 2.4 µm*</td>
<td>0.4 - 2.4 µm</td>
<td>0.4 - 2.5 µm</td>
<td>0.9 - 1.6 µm</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>30 m</td>
<td>30 m</td>
<td>30 m</td>
<td>250 m</td>
</tr>
<tr>
<td>Swath Width</td>
<td>185 Km</td>
<td>37 Km</td>
<td>7.7 Km</td>
<td>185 Km</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>Variable</td>
<td>Variable</td>
<td>10 nm</td>
<td>3 - 9 nm**</td>
</tr>
<tr>
<td>Spectral Coverage</td>
<td>Discrete</td>
<td>Discrete</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Pan Band Resolution</td>
<td>15 m</td>
<td>10 m</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Total Number of Bands</td>
<td>7</td>
<td>10</td>
<td>220</td>
<td>256</td>
</tr>
</tbody>
</table>

* Excludes thermal channel  
** 35/55 cm⁻¹ constant resolution
Solar Calibration

Signal Level | Cumulative Signal
---|---
1% | 1%
2% | 3%
7% | 10%
20% | 30%
20% | 50%
20% | 70%
20% | 90%

Solar Calibration Profile

Counts

Frame Number

2.5''

Aperture Selector

Diffuser

Solar Beam

Secondary

Cover

Scattered Light
“First Light” image of Alaska

L7 PAN

ALI PAN
Why is the ALI pan band better

† Improved Radiometric resolution
  – Superior signal-to-noise
  – 12-bit versus 8-bit representation of dynamic range

† Inherently higher contrast measurement
  – ALI pan restricted to 480 – 690nm VIS spectral interval
  – ETM+ spans vegetation transition rise (520 – 900nm)

† Smaller pixel size (IFOV)
  – ALI pan IFOV is 10 meters
  – ETM+ is nominally 15 meters (effectively 18 meters)
Mount Etna - July 22, 2001

ALI Pan Enhanced 3-2-1

EO-1 ALI Bands 7-5-5’
You can’t do that with EO-1!
(Views with the EO-1 ALI Pan band)
You can’t do that with EO-1!
(Views with the EO-1 ALI Pan band)

The Pleiades

ALI detections
Skukuza, Kruger National Park
S. Africa

Landsat-7 ETM+

R,G,B = 4,3,2
Skukuza, Kruger National Park
S. Africa

EO-1
ALI

R,G,B = 4,3,2
Kruger National Park, SA  \((R,G,B = 4,2)\)

Landsat-7 ETM+  

EO-1 ALI
Comparison of ALI and Landsat 7 ETM+

† Physical Specifications
† Spectral Bands
† Radiometric Performance
† Geometric Performance
Physical Specifications

**EO-1/Landsat Instrument Comparison**

<table>
<thead>
<tr>
<th>ALI Based Concept for Future Landsat Instrument</th>
<th>Enhanced Thematic Mapper (ETM+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Mass (kg)</td>
</tr>
<tr>
<td>100</td>
<td>Power (W)</td>
</tr>
<tr>
<td>0.2</td>
<td>Size (m²)</td>
</tr>
<tr>
<td>10</td>
<td>VNIR/SWIR Bands</td>
</tr>
<tr>
<td>6200</td>
<td>Detectors Per Band</td>
</tr>
<tr>
<td>None</td>
<td>Thermal Bands</td>
</tr>
<tr>
<td>300</td>
<td>Data Rate (Mbps)</td>
</tr>
<tr>
<td>10</td>
<td>Pan Resolution (m)</td>
</tr>
<tr>
<td>4x</td>
<td>Relative SNR</td>
</tr>
</tbody>
</table>
Spectral Bands

**EO-1 ALI Spectral Coverage**

<table>
<thead>
<tr>
<th>Band</th>
<th>Wavelength (μm)</th>
<th>Ground Sample Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pan</td>
<td>0.48 - 0.69</td>
<td>10</td>
</tr>
<tr>
<td>MS-1'</td>
<td>0.433 - 0.453</td>
<td>30</td>
</tr>
<tr>
<td>MS-1</td>
<td>0.45 - 0.515</td>
<td>30</td>
</tr>
<tr>
<td>MS-2</td>
<td>0.525 - 0.605</td>
<td>30</td>
</tr>
<tr>
<td>MS-3</td>
<td>0.63 - 0.69</td>
<td>30</td>
</tr>
<tr>
<td>MS-4</td>
<td>0.775 - 0.805</td>
<td>30</td>
</tr>
<tr>
<td>MS-4'</td>
<td>0.845 - 0.89</td>
<td>30</td>
</tr>
<tr>
<td>MS-5'</td>
<td>1.2 - 1.3</td>
<td>30</td>
</tr>
<tr>
<td>MS-5</td>
<td>1.55 - 1.75</td>
<td>30</td>
</tr>
<tr>
<td>MS-7</td>
<td>2.08 - 2.35</td>
<td>30</td>
</tr>
</tbody>
</table>
Spectral Bands (con’t)

† **ETM+ Heritage Bands**
  - ETM+ panchromatic band extends into the NIR
  - ALI panchromatic band cuts off in the red
  - ETM+ NIR band 4 split into ALI bands 4 and 4’

† **ALI “Prime” Bands**
  - 1’ - “deep” blue (atmospheric correction, oceanography)
  - 4/4’ - modified NIR (less sensitive to water vapor)
  - 5’ - SWIR 1 - vegetation mapping applications
NIR spectral response

NIR channels: ALI vs. ETM+

ALI:4
ALI:4P
TM7:Band 4

Wavelength (micronmeters)
Pan band spectral response

![Graph showing ALI vs. ETM+ Panchromatic Spectral Response](image)
Pan band spectral response

California Test Site (day 206)

ETM+  ETM+ bands 5,4,3  ALI
Radiometric Performance

† **ALI: high signal-to-noise**
  - *Improved sensitivity range w/o saturation*
  - *Improved low-light response*

† **On-board calibration**
  - *L7: FASC, PASC*
  - *ALI: solar diffuser*

† **Ground-based calibration (U. Az.)**
Radiometric Performance
Pre-launch SNR

@ 5% Earth Surface Reflectance

SNR

Band

ALI
ETM+

PAN 1' 1 2 3 4 4' 5' 5 7
Radiometric Performance

RR Valley Calibration Site

RR Valley

wavelength (nm)

Courtesy S. Biggar U. of Az
Radiometric Performance
On-Orbit SNR

Multispectral "SNR" at Railroad Valley
2001 June 14

SNR

0 50 100 150 200 250 300 350

0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4

Wavelength (micrometers)

ALI
ETM+

Courtesy S. Biggar U. of Az
Radiometric Performance
ALI vs. Ground

ALI Image Radiance/Predicted Radiance

 Courtesy S. Biggar U. of Az
Radiometric Performance
ETM+ vs. Ground

ETM+ Image Radiance/Predicted Radiance

Wavelength (micrometers)

Ratio

22 Jan BB
13 May RRV
30 Jun RRV

Courtesy S. Biggar U. of Az
ALI spatial response (U. AZ)

- **Image based evaluation**
- **Linear targets**
- **Sensor intercomparison**
  - ALI to ETM+
  - ALI to high spatial resolution sensors
    - IKONOS (MS and pan)
    - ADAR (aircraft sensor)
LSF extraction

- extract multiple profiles across field berms
- shift profiles to align maxima and average
- average profile = subpixel-sampled Line Spread Function (LSF) in orthogonal direction
- in-track and cross-track

- subpixel interval = \( \tan(13.08^\circ) \) inclination angle = 0.23 ALI pixels
- berm width about 7-8m = 0.25 ALI pixels (measured from Ikonos image)

- Fourier transform of LSF = Modulation Transfer Function (MTF)

Courtesy S. Biggar U. of Az
ALI LSFs (bands 1 - 6)

Line Spread Function (in-track)

Line Spread Function (cross-track)

Courtesy S. Biggar U. of Az
ETM+ LSF (Bands 1-4)

ETM+ LSF (In-Track)

ETM+ LSF (Cross-Track)
ALI Radiometric Artifacts

- Leaky Pixel: correctable
- Residual Striping: relative gain correction under development
- Stray light: quantifiable, but not correctable
Geometric performance

- **ALI**: no moving parts to degrade over time (e.g., ETM+ “bumper wear”)
- Small inter-SCA misalignment correctable
- Phased array X-band antenna affords stable imaging platform (unlike gimbaled antenna)
- Terrain effects on band registration and SCA-to-SCA registration
ALI versus ETM local geometry

Maricopa July 27, 2001 (DOY208)

ETM
L1G
band 1

ALI
L1R
band 2

Courtesy S. Biggar U. of Az
Geometry: effects of Landsat 7 gimbaled antennae

**Uncorrected L0 Data**

**Corrected L1 Data**
ALI interband registration

Band Average RMS (Net) Registration

![Bar chart showing band average RMS registration for SoCal2 Pre, SoCal2 Post, and SoCal1 Post. The x-axis represents bands 1 to 7, and the y-axis represents pixels ranging from 0.00 to 0.50. The bars for each band show the registration error for each dataset.](chart.png)
ETM+ interband registration

Band Average RMS Registration
Operational Period Calibration

Offset (IFOVs)

Band

1 2 3 4 5 6 7 Pan Spec

Net