Landsat 8 Mission Overview

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by

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Landsat Data Continuity Mission (LDCM) developed through an interagency partnership between NASA and the U.S. Geological Survey (USGS)/Dept. of the Interior

LDCM launched Feb. 11, 2013 from Vandenberg Air Force Base (VAFB), California – ATLAS V 401 launch vehicle

On-orbit commissioning completed May 30, 2013
- USGS assumed lead responsibility for mission operations
- Satellite renamed Landsat 8
• Pushbroom 15° FOV; 6916 detectors per spectral band row; 14 Sensor Chip Assemblies of 494 detectors each
• 9 bands Visible to SWIR (30 meter IFOV spectral with 15 meter IFOV pan)
• 4 mirror anastigmatic telescope
• Solar diffusers (2); Lamps (3) and shutter for calibration
• Designed and built by Ball Aerospace & Technologies, Boulder, CO (photo credit)
- Pushbroom 15° FOV; 1920 detectors/ band row; 3 Sensor Chip Assemblies of 640 detectors each; Quantum Well Infrared Photodetectors (QWIPs)
- Two 100 m IFOV thermal bands plus dark band
  - 10.9 μm (0.6 μm bandwidth) – “band 10”
  - 12.0 μm (1.0 μm bandwidth) – “band 11”
- Refractive optics
- On board blackbody and deep space view for calibration
- Designed and built by NASA/GSFC, Greenbelt, MD
Integrated Satellite Observatory

Orbital Sciences Corp., Gilbert, AZ, built the Landsat 8 spacecraft, integrated the instruments, and performed environmental testing of the integrated observatory.
- OLI & TIRS data are collected simultaneously
- OLI & TIRS collect raw data with a 12-bit radiometric resolution
Landsat 8 Performance Summary

The performance of the Landsat 8 sensors, OLI & TIRS, spacecraft, and ground system exceeds specifications in almost all respects

- Landsat 8 collects, and USGS EROS archives, over 500 scenes per day compared to a 400 scene per day requirement
- By the first anniversary of the launch, USGS EROS distributed 1,332,969 Landsat 8 scenes (Level 1 digital data products)
- Scenes are typically available within 5 hours of data collection compared to a 24 hour latency requirement
- Image geometry and cartographic registration exceed specifications
- The radiometric performance of OLI and TIRS exceeds specifications with one exception
  - The absolute radiometric uncertainty of TIRS data currently exceeds a 2% requirement due to a stray light issue under investigation
- Early analyses are demonstrating backward compatibility with the Landsat archive and more accurate land cover mapping results
OLI pan band confined to visible part of spectrum; provides higher contrast over vegetated areas; Note better radiometry and spatial response as well

Path 38 Row 37 March 29, 2013
New Cirrus Detection Band

OLI natural color (4,3,2)  Cirrus band (9)

Better cloud detection and data filtering possible
OLI Signal-to-Noise Performance at Ltypical
May-2014

- **SNR**
- **Coastal/Aerosol**
- **Blue**
- **Green**
- **Red**
- **NIR**
- **SWIR1**
- **SWIR2**
- **Pan**
- **Cirrus**

**Legend:**
- OLI SNR Requirement (median at Ltyp)
- OLI On-Orbit SNR median (Ltyp)
- Ltyp Requirement * 1.5
Landsat-7 ETM+ Natural Color (3,2,1)

From Pat Scaramuzza, EROS
LDCM OLI Natural Color (4,3,2)

From Pat Scaramuzza, EROS
Improved Thermal Band Noise

TIRS noise exceeds requirements by a factor of ~ 6; ETM+ performance by a factor of ~3

Landsat-7 ETM+ Band 6  
Landsat-8 (TIRS) Band 10
OLI Radiance Calibration Validation Commissioning -- Expected based on Revised Cal
Before Data Reprocessing:

TIRS reported higher temperatures than expected (by ~2 K)

Significant variability in results, particularly in band 11 (12 micron band)

Source appears to be extra signal reaching detectors from outside the field of view – ghosting
TIRS Absolute Calibration

After February, 2014 Data Reprocessing

TIRS10 Calibration Results

$m = 1.04 +/- 0.06$
(not significant)

TIRS11 Calibration Results

$m = 1.16 +/- 0.12$
(significant)
### TIRS Calibration Bias

<table>
<thead>
<tr>
<th>Band</th>
<th>Before Reprocessing CPF Ver. 4 [W/m² sr um]</th>
<th>After Reprocessing CPF Ver. 5 [W/m² sr um]</th>
<th>After Reprocessing Temp RMSE [K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B10</td>
<td>0.29 +/- 0.12</td>
<td>-0.03 +/- 0.04</td>
<td>0.88</td>
</tr>
<tr>
<td>B11</td>
<td>0.51 +/- 0.2</td>
<td>0.02 +/- 0.08</td>
<td>1.88</td>
</tr>
</tbody>
</table>
L8 Radiometric Summary

- OLI and TIRS significantly exceed noise requirements and ETM+ performance
- OLI and TIRS radiometrically stable; much better than requirements
- OLI data well flat fielded (radiometric matching of the ~7000 detectors per band)
- TIRS data well flat fielded on certain Earth scenes yet less so on others
  - Tied into out-of-field ghosting/stray light
- OLI Absolute Radiometric Calibration generally within ±2% of vicarious measurements –
- TIRS Absolute Radiometric Calibration improved by Feb., 2014 data reprocessing
  - Absolute precision remains a concern; worse in Band 11
  - Efforts underway to better understand source of ghosting/stray light and to improve TIRS data processing
OLI Band Registration Accuracy

Band registration accuracy is evaluated using cloud-free scenes of selected test sites

- Mainly desert sites are used
- Data acquired between April 15, 2013 and November 14, 2013 (operational WRS-2 orbit)

Results from 334 OLI registration test scenes:

- 13 high-altitude Earth scenes were used for cirrus band registration assessment
- OLI band registration accuracy (worst band pair)
  - Line Direction: 3.90 meters LE90 (with cirrus)
  - Sample Direction: 3.98 meters LE90 (with cirrus)
  - Specification: 4.50 meters LE90
  - Line Direction: 3.26 meters LE90 (no cirrus) (KPR #7)
  - Sample Direction: 3.33 meters LE90 (no cirrus) (KPR #7)
  - Incentive Threshold: 3.80 meters LE90 (KPR #7)
TIRS Band Registration Accuracy

♦ TIRS 10.8 μm to 12.0 μm band registration
   ▶ Results from 153 TIRS band registration test scenes acquired from April 15, 2013 to November 14, 2013
   ▶ TIRS band registration accuracy
     ❖ Line Direction: 10.5 meters LE90
     ❖ Sample Direction: 8.7 meters LE90
     ❖ Specification: 18.0 meters LE90

♦ TIRS to OLI band registration
   ▶ Results from 143 TIRS-to-OLI registration test scenes acquired from April 15, 2013 to November 14, 2013
   ▶ TIRS-to-OLI band registration accuracy (worst band pair)
     ❖ Line Direction: 22.1 meters LE90
     ❖ Sample Direction: 20.4 meters LE90
     ❖ Specification: 30.0 meters LE90
Geodetic and Geometric Accuracy

Geodetic accuracy (prior to application of ground control) based upon 6595 scenes:
- Absolute Accuracy: 36.9 meters CE90
- Specification: 65.0 meters CE90
- Relative Accuracy: 19.9 meters CE90
- Specification: 25.0 meters CE90
- Reflects L8 absolute pointing knowledge accuracy

Geometric accuracy (using independent validation points after application of ground control) based upon 6231 scenes:
- L1T Accuracy: 11.4 meters CE90
- Specification: 12.0 meters CE90
- Reflects Level 1T product accuracy
Spatial Performance - Edge Slope

OLI On-Orbit Spatial Performance Estimates

Band 8 values are divided by 2 to put them on the same scale.

XT_ES
AT_ES
Edge Slope Spec Limit
Aliasing Limit

Band 1 2 3 4 5 6 7 8
Bahrain and China Bridge Targets

King Fahd Causeway

West Section

Center Section

East Section

Qingdao Bridge

Panchromatic Band Images

Single Span Bridges
L8 Geometric Summary

- Landsat 8 on-orbit geometric performance is excellent and meets all requirements
- The Cal/Val team continues to monitor on-orbit performance, adjusting the calibration when necessary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Measured Value</th>
<th>Required Value</th>
<th>Units</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLI Swath</td>
<td>190.2</td>
<td>&gt;185</td>
<td>kilometers</td>
<td>2.8%</td>
</tr>
<tr>
<td>OLI MS Ground Sample Distance</td>
<td>29.934</td>
<td>&lt;30</td>
<td>meters</td>
<td>0.2%</td>
</tr>
<tr>
<td>OLI Pan Ground Sample Distance</td>
<td>14.932</td>
<td>&lt;15</td>
<td>meters</td>
<td>0.5%</td>
</tr>
<tr>
<td>OLI Band Registration Accuracy (all bands)</td>
<td>3.98</td>
<td>&lt;4.5</td>
<td>meters (LE90)</td>
<td>11.6%</td>
</tr>
<tr>
<td>OLI Band Registration Accuracy (no cirrus)</td>
<td>3.33</td>
<td>&lt;4.5</td>
<td>meters (LE90)</td>
<td>26.1%</td>
</tr>
<tr>
<td>Absolute Geodetic Accuracy</td>
<td>36.9</td>
<td>&lt;65</td>
<td>meters (CE90)</td>
<td>43.2%</td>
</tr>
<tr>
<td>Relative Geodetic Accuracy</td>
<td>19.9</td>
<td>&lt;25</td>
<td>meters (CE90)</td>
<td>20.4%</td>
</tr>
<tr>
<td>Geometric (L1T) Accuracy</td>
<td>11.4</td>
<td>&lt;12</td>
<td>meters (CE90)</td>
<td>5.0%</td>
</tr>
<tr>
<td>OLI Edge Slope</td>
<td>0.03054</td>
<td>&gt;0.027</td>
<td>1/meters</td>
<td>13.1%</td>
</tr>
<tr>
<td>TIRS Swath</td>
<td>186.2</td>
<td>&gt;185</td>
<td>kilometers</td>
<td>0.6%</td>
</tr>
<tr>
<td>TIRS Ground Sample Distance</td>
<td>103.424</td>
<td>&lt;120</td>
<td>meters</td>
<td>13.8%</td>
</tr>
<tr>
<td>TIRS Band Registration Accuracy</td>
<td>10.5</td>
<td>&lt;18</td>
<td>meters (LE90)</td>
<td>41.7%</td>
</tr>
<tr>
<td>TIRS-to-OLI Registration Accuracy</td>
<td>22.1</td>
<td>&lt;30</td>
<td>meters (LE90)</td>
<td>26.2%</td>
</tr>
</tbody>
</table>
Landsat 8 data are free
The performance of the Landsat 8 OLI & TIRS sensors exceeds specifications, as well as TM and ETM+ performance, in all respects with one exception:

- TIRS absolute radiometric correction and precision remains an issue under study

Performance of the ground system is outstanding:

- Greater than 500 scenes captured and archived per day
  - Bumping up to 650 scenes per day
- Level 1 data products typically available for distribution within 5 hours of data collection
- Reprocessing of entire Landsat 8 data set completed in February, 2014
Web Sites

http://landsat.usgs.gov

http://landsat.gsfc.nasa.gov

http://www.nasa.gov/landsat

FaceBook Page
http://www.facebook.com/NASA.Landsat

Twitter Site
http://twitter.com/#!/NASA_Landsat