Landsat 8 Status and Landsat/Sentinel-2 Synergy

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presented at the
Sentinel-2 for Science Workshop, ESRIN
May 20, 2014
1. Landsat-8 Status and Performance

2. Sustainable Land Imaging

3. NASA & USGS Preparation for Sentinel-2
Landsat-8 launched Feb. 11, 2013 from Vandenberg Air Force Base (VAFB), California – ATLAS V 401 launch vehicle

Partnership between NASA (space segment) and USGS (ground system, operations)

On-orbit commissioning completed May 30, 2013
- USGS assumed lead responsibility for mission operations
- Satellite renamed Landsat 8
Landsat-8 Instrumentation

Operational Land Imager (OLI, Ball Aerospace)
- Push-broom VNIR/SWIR sensor
- 8 spectral bands @ 30m + pan band @ 15m
- new bands for cirrus (1.38 μm) and coastal (0.44 μm)
- 4 mirror anastigmatic telescope
- Solar diffusers (2); Lamps and shutter for calibration
- Improved SNR & Dynamic Range compared to ETM+

Thermal Infrared Sensor (TIRS, GSFC)
- 2 channel (10.8 and 12 μm) thermal imager
- Quantum Well Infrared Photodiodes (QWIP)
- <120 m Ground Sample Distance (100 m nominal)

Spacecraft built by Orbital Sciences Corp.

5-year Mission Life (2018); 10-years of consumables
LDCM First Light Image (Ft Collins, CO, March 18, 2013)

TIRS 12.0 μm brightness temperature, Saudi Arabia Irrigated Crops
Landsat-8 Status

- Landsat-8 continues to perform well
  - OLI performance meets or exceeds all radiometric & geometric performance requirements
  - TIRS meeting almost all requirements
    - TIRS Band 11 stray light issue
    - Users discouraged from using Band 11 for now

- Landsat-8 currently acquiring ~550 scenes/day (out of possible ~850 land scenes/day)
Landsat 8 Data Acquisitions

- Landsat 8 acquires over 500 scenes per day
  - exceeds requirements of 400 scenes/day
  - By Feb 2014, USGS EROS distributed 1,332,969 Landsat 8 scenes
  - Scenes are typically available within 5 hours of data collection compared to a 24 hour latency requirement

Landsat 8 data are free
New Cirrus Detection Band

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

Better cloud detection and data filtering possible
OLI Signal to Noise Ratio

OLI Signal-to-Noise Performance at Ltypical

- Coastal/Aerosol
- Blue
- Green
- Red
- NIR
- SWIR 1
- SWIR 2
- PAN
- CIRRUS

Legend:
- ETM+ SNR Performance (Ltyp)
- OLI SNR Requirement (median at Ltyp)
- OLI SNR Performance (12-bit median at Ltyp)
- OLI On-Orbit SNR median (Ltyp)
LDCM OLI Natural Color (4,3,2)

From Pat Scaramuzza, EROS
Offshore Application: Environmental Impacts

Environmental Impacts Assessment
legal obligation for offshore wind farm construction

LANDSA T-8 and S-2high spatial resolution => new Environmental Impacts visible

OLI Absolute Calibration

OLI radiance calibration well within 5% specification

5% requirement
Users advised to not use TIRS band 11 for quantitative applications for the present time.
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>
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</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>
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<tr>
<td>OLI Pan Ground Sample Distance</td>
<td>14.932</td>
<td>&lt;15</td>
<td>meters</td>
<td>0.5%</td>
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<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>
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<tr>
<td>Absolute Geodetic Accuracy</td>
<td>36.9</td>
<td>&lt;65</td>
<td>meters (CE90)</td>
<td>43.2%</td>
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<tr>
<td>Relative Geodetic Accuracy</td>
<td>19.9</td>
<td>&lt;25</td>
<td>meters (CE90)</td>
<td>20.4%</td>
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<tr>
<td>Geometric (L1T) Accuracy</td>
<td>11.4</td>
<td>&lt;12</td>
<td>meters (CE90)</td>
<td>5.0%</td>
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<tr>
<td>OLI Edge Slope</td>
<td>0.03054</td>
<td>&gt;0.027</td>
<td>1/meters</td>
<td>13.1%</td>
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<tr>
<td>TIRS Swath</td>
<td>186.2</td>
<td>&gt;185</td>
<td>kilometers</td>
<td>0.6%</td>
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<tr>
<td>TIRS Ground Sample Distance</td>
<td>103.424</td>
<td>&lt;120</td>
<td>meters</td>
<td>13.8%</td>
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<tr>
<td>TIRS Band Registration Accuracy</td>
<td>10.5</td>
<td>&lt;18</td>
<td>meters (LE90)</td>
<td>41.7%</td>
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<tr>
<td>TIRS-to-OLI Registration Accuracy</td>
<td>22.1</td>
<td>&lt;30</td>
<td>meters (LE90)</td>
<td>26.2%</td>
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</table>
After Lansdat-8… where to next?
Landsat Program History

- **Landsat 1**: 1972–1978
- **Landsat 2**: 1975–1982
- **Landsat 3**: 1978–1983
- **Landsat 4**: 1982–1993
- **Landsat 5**: 1984–
- **Landsat 6**:
- **Landsat 7**: 1999–

Timeline:
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

- **Gov’t Operations**
- **Commercial Operations**
- **Gov’t Operations**
Sustainable Land Imaging

- President’s FY14 budget called for a NASA/USGS **Sustainable Land Imaging (SLI)** program to secure Landsat continuity for 2018-2038
  - NASA responsible for system design, implementation, and launch
  - USGS responsible for ground system and operations

- Initial study phase by Architecture Study Team (AST)
  - Recommend one or more 20-year architectures for US Land Imaging
    - Develop representative mission configurations, apply cost models
    - Assess configurations based on availability, performance, risk
  - Report due to Office of the President (OSTP) Aug 2014

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**The President’s FY 2014 Budget Submittal for NASA’s Sustainable Land Imaging activities**

<table>
<thead>
<tr>
<th>$K</th>
<th>FY 14</th>
<th>FY 15</th>
<th>FY 16</th>
<th>FY 17</th>
<th>FY 18</th>
<th>FY 19</th>
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<tr>
<td>Land Imaging</td>
<td>30,000</td>
<td>84,000</td>
<td>94,800</td>
<td>117,900</td>
<td>117,900</td>
<td>-</td>
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Per ESD direction assume for planning purposes: $120M in FY19 as the base year and inflation adjust in FY20 and beyond
3. NASA and USGS Preparations for Sentinel-2
Merging Sentinel-2 and Landsat data streams could provide 2-3 day coverage globally – transformational for land science

- vegetation phenology at patch scale
- ecological change & land management

The large number of blue colored bands (>41 accesses) indicate that the revisit interval over the majority of the region is on the order of 2 days.

Number of times Landsat-8 and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.

- 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
- 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

Courtesy Brian Killough, LARC
US Preparations for Sentinel-2

1. OLI/MSI Cross-calibration and Sensor Characterization
   - Pre-launch comparison of integrating spheres w/ ESA
   - Characterization of MSI diffuser in SWIR (U Az/ESA)
   - Post-launch planning for joint calibration activities (e.g. vicarious campaigns)

2. US Access to Sentinel-2 Data

3. Higher-level Data Products
USGS Plans for Data Archive

- Sentinel-2 MSI L1c data will be made available via FTP through USGS GLOVIS & EarthExplorer sites
  - **USGS is in discussions with ESA on obtaining a copy of the L1c archive**
  - No specific latency requirements; data to be pulled as available from PACs
  - **USGS will track distribution and report metrics to ESA and Copernicus**
  - L1c reprocessed data will be replaced – no concurrent versions

- Level-2 products developed by NASA will be distributed via USGS

- Total data archive of 6.4 TB per day (assumes 2 satellites, L1c and reflectance products)
NASA Activities: Higher Level Products

- **Object 1**: Harmonized surface reflectance product from S2 and Landsat
  - Calibration/radiometric normalization
  - Atmospheric correction
  - BRDF (solar, view angle) and band pass adjustments
  - Cloud/shadow screening & cirrus masking
  - Common gridding, compositing approach

- **Object 2**: Higher-Level Land Cover and Biophysical products from merged moderate-resolution record
  - Planning and prioritization of products (eg. GTOS ECV’s)
  - QA & Validation components
  - Implementation using ARC NEX processing system (bring algorithms to the data)

NASA solicitation for Land Imaging Science team in 2015, with focus on Landsat/Sentinel integration
SPOT-4 “Take 5”

- NASA participated in Take 5 Experiment with CESBIO
- Focus on atmospheric correction and BRDF adjustment (Vermote/Claverie)
Conclusions

- Landsat-8 has achieved considerable mission success during its first year
  - Excellent data quality
  - Nearing “always on” data acquisition
  - Extends 42-year Landsat legacy

- NASA and USGS collaborating on a plan for a 20+ year program to ensure Landsat continuity

- The potential synergies between Landsat and Sentinel-2 are enormous
  - Near-daily, 10-30m resolution data on vegetation condition, phenology, and land use… a transformational advance
  - Harmonized 42+ year view of how Earth’s land areas are changing through natural and human activities
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