Landsat Data Continuity Mission
Instrument Overview

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….plus a cast of hundreds….

February 13, 2013
LDCM Science Team Meeting
Outline

- Basic Band Requirements
- Several Driving Requirements
- Instrument Overviews:
  - Operational Land Imager (OLI)
  - Thermal Infrared Sensor (TIRS)
### LDCM and ETM+ Spectral Bands

<table>
<thead>
<tr>
<th>L7 ETM+ Bands</th>
<th>LDCM OLI Band Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GSD</strong></td>
<td><strong>“color”</strong></td>
</tr>
<tr>
<td>Band 1</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 2</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 3</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 4</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 5</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 6</td>
<td>60 m</td>
</tr>
<tr>
<td>Band 7</td>
<td>30 m</td>
</tr>
<tr>
<td>Band 8</td>
<td>15 m</td>
</tr>
<tr>
<td>Band 9</td>
<td>30 m</td>
</tr>
</tbody>
</table>
### Signal-to-Noise Ratios (SNR)

<table>
<thead>
<tr>
<th>Band</th>
<th>$L_{\text{typical}}$</th>
<th>SNR</th>
<th>$L_{\text{high}}$</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal/Aerosol</td>
<td>N/A</td>
<td>130</td>
<td>N/A</td>
<td>290</td>
</tr>
<tr>
<td>Blue</td>
<td>40</td>
<td>130</td>
<td>140</td>
<td>360</td>
</tr>
<tr>
<td>Green</td>
<td>40</td>
<td>100</td>
<td>190</td>
<td>390</td>
</tr>
<tr>
<td>Red</td>
<td>30</td>
<td>90</td>
<td>140</td>
<td>340</td>
</tr>
<tr>
<td>NIR</td>
<td>35</td>
<td>90</td>
<td>250</td>
<td>460</td>
</tr>
<tr>
<td>SWIR 1</td>
<td>35</td>
<td>100</td>
<td>190</td>
<td>540</td>
</tr>
<tr>
<td>SWIR 2</td>
<td>30</td>
<td>100</td>
<td>140</td>
<td>510</td>
</tr>
<tr>
<td>Pan</td>
<td>16</td>
<td>80</td>
<td>90</td>
<td>230</td>
</tr>
<tr>
<td>Cirrus</td>
<td>N/A</td>
<td>50</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*ETM+ Performance, OLI Requirements*
### TIRS and ETM+ TIR Spectral Bands

<table>
<thead>
<tr>
<th>L7 ETM+ Thermal Band</th>
<th>LDCM TIRS Band Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GSD</strong></td>
<td><strong>“color”</strong></td>
</tr>
<tr>
<td>Band 6</td>
<td>60 m</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 120 m resolution TIRS requirement deemed sufficient to resolve most center-pivot irrigation fields in U.S. West - typically 400 to 800 m in diameter – TIRS design provides for 100 m resolution
- Landsat 4 & 5 TM’s provided 120 m thermal images for a single thermal band
- Landsat 7 ETM+ provided 60 m thermal images for a single thermal band
- A two band instrument will enable atmospheric correction so that more accurate surface temperatures can be derived.
Several Driving Requirements

- Nadir Swath Width >185 km; 15/30/100 m GSD; @ S/C altitude of 705 km
- Wide spectral coverage (Deep Blue – NIR, SWIR, TIR)
- Geo-registration & Accuracy
  - Band-to-band: 4.5 meters or less
    - in the line and sample directions at the 90% confidence level
  - Geodetic Accuracy: Absolute 65 m / Relative 25 m
  - Geometric Accuracy: 12 m
- Signal to Noise Ratio (SNR) & Dynamic Range (DNR)
- Radiometric Accuracy
  - Calibration stability
  - Stray light (diffused scatter and ghosting)
- Uniformity
  - Spatial (Distortion/GSD, Edge Response)
  - Spectral
    - Radiometric (Coherent noise, pixel-to-pixel stability & non-linearity, spectral uniformity)
OLI represents a generational change in Landsat technology

- Whiskbroom imager
- Obscured telescope
- 1020 cm$^2$ aperture
- 8 bits transmitted to ground (gain switching)
- VIS/SWIR and IR

- Pushbroom Imager
- Unobscured telescope
- 143 cm$^2$ aperture
- 12 bits transmitted to ground
- OLI is VIS/SWIR only (TIRS does IR)
ETM+ Scan Footprint

Landsat Data Continuity Mission Instrument Overview
Operational Land Imager (OLI)

- Collects 400 scenes per day using pushbroom design
  - Coincident with TIRS data collection
- Covers a 185 km swath
- Collects data for nine shortwave spectral bands
  - Provides continuity with seven TM and ETM+ shortwave spectral bands
  - Adds two new bands
- Provides a 30 m spatial resolution
  - 15 m panchromatic band
- Collects calibration data
  - Internal cal lamps, shutter collects, solar panel, lunar views, vicarious field campaigns

Courtesy of BATC
OLI is a fairly simple instrument (slide created and provided by Ed Knight of BATC.)

- Pushbroom VIS/SWIR sensor
- Four-mirror telescope with front aperture stop
- FPA consisting of 14 sensor chip assemblies, passively cooled
- On-board calibration with both lamps and full aperture diffusers
OLI uses 4 large state-of-the-art Silver coated mirrors in the telescope.

- The mirrors project the image onto the detector arrays.
- They are large so they will provide:
  - a 15.1 deg. FOV.
  - 15/30 meter resolution
  - enough light collect for good sensitivity
- They must be ultra-clean and ultra-smooth to reduce scattered light.
OLI Stimulation Lamp Assembly

- Track short/mid-term stability
- Transfer to orbit calibration for the Cirrus band.
- Stimulate the FPA with the shutter closed for testing and signal related noise assessment.
Solar Calibration Subsystem for LDCM's Operational Land Imager

- Solar Diffuser Calibrator Wheel:
  - 2 Spectralon (Teflon) Panels
    - 1 working panel
    - 1 pristine reference
  - Nominally nadir viewing
    - +/-15 degrees for special acquisitions.
  - Sun viewing using spacecraft inertial hold maneuver.

Courtesy of BATC
OLI Glamour shot—pre-blankets and sunshade

Solar Diffuser Calibrator: 2 Spectralon (Teflon) Panels

Courtesy of BATC
Thermal Infrared Sensor (TIRS)

- Collects 400 scenes per day using a pushbroom design
  - Coincident with OLI data collection
- Covers a 185 km (115 mile) swath
- Collects data for two long-wave spectral bands
  - Provides continuity with one TM/ETM+ thermal band
- Provides a 100 m (328 ft) spatial resolution
- Collects calibration data
  - Space view for near absolute zero ref. (On opposite side)
  - Earth viewing port.
  - On-board blackbody (ie. warm/hot plate) (Internal)
Landsat Data Continuity Mission Instrument Overview

TIRS FPA Architecture

- TIRS Sensor Chips use quantum well infrared photodetector (QWIP) detector technology
  - Gallium Arsenide (GaAs) semiconductor detector chip
  - Bump-bonded to a ROIC
The QWIP detectors need to be cooled to a very chilly 43K (-382F) in order to get optimal thermal data.

The cooler was built by Ball Aerospace in Boulder, CO.
TIRS On-board Black Body Calibrator

- Provides a uniform calibration scene of known apparent temperatures close to critical scene temperatures.
- Adjustable Temperature Set-points on orbit. (nominally 295K)
- Allows for frequent calibration and correction of gain and non-linearity changes.
TIRS Scene Select Mirror (SSM)

- Gold coated to reflect infrared radiation (heat) between 10.3 microns and 12.5 microns.
- Selects between:
  - Nadir Earth view
  - Space view (near absolute zero for offset calibration)
  - Warm/hot internal blackbody calibrator view (gain calibration)
LDCM Launches in less than 7 days!
Simulated L0R Detail

Note SCA & detector misalignment

Band, SCA & detector misalignment
Corresponding L1T Detail
Acknowledgements and Credits

The following persons contributed significant expertise, effort, and material towards the preliminary results shown here. Many others unnamed here were also instrumental in the success. Our apologies to anyone inadvertently left off this list.

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….plus many others….