Landsat Data Continuity Mission On-orbit Calibration and Validation Development

Ron Morfitt†, Esad Micijevic†, Brian Markham

†SGT, U.S. Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS), 47914 252nd Street, Sioux Falls, SD 57198
Work performed under USGS contract 08HQCN0005

NASA GSFC, Greenbelt, MD
Outline

• Overview of Government Calibration and Validation Team
• Overview of Ground System
• Development of Cal/Val tools
• Current Status
Government Calibration and Validation Team (CVT)

- Made up of both NASA GSFC and USGS EROS personnel
- Lead by NASA prior to commissioning
  - Pre-launch calibration
- On-orbit operations turned over to USGS
  - Continued monitoring throughout mission life
Calibration and Validation Functions

• Oversight and coordination of Cal/Val activities
  – Covers portions of ground system, spacecraft, instruments and other external entities

• Algorithm development
  – Review instrument provider algorithms
  – Deliver algorithms to ground system developers
  – Data processing, characterization and calibration
  – OLI and TIRS data simulators
Calibration and Validation Functions

• Instrument performance characterization
  – Pre-launch, on-orbit checkout and on-orbit operations
  – Supports instrument acceptance

• Calibration parameter determination & validation
  – Pre-commissioning validation of vendor provided parameters
  – Validated parameters ensure quality products
  – Determine parameters during operations

• Independent calibration verification and calibration continuity
  – Ensures traceability and continuity with historical products

• Product performance characterization
  – Reports for science and user community

• Anomaly resolution
  – Includes anomalies in product generation and image assessment
  – Supports observatory and other anomaly resolution
Cal/Val Interfaces During Development

- Vendor/Supplier
  - OLI
  - TIRS
  - Spacecraft
- Ground System
  - Data Processing and Archive System
- Landsat Science Team
- Independent Groups
  - Vicarious Calibration


---

August 29—September 1, 2011  CALCON Technical Conference
Ground System Concept from CVT perspective

- **Spacecraft**
  - OLI
  - TIRS

- **Ground System**
  - **Capture**
  - **Ingest**
  - **Product Generation**
  - **Image Assessment**

- **Control**
- **Characterization Data**
- **Image Data**

- **CVT**
  - Cal/Val Toolkit

- **OLI Capture**
  - L0Ra

- **TIRS**
  - L1T
  - L0Rp/L1R/L1G/L1T

- **Characterization Data**
- **Cal/Val Products**

- **Calibration Parameters**

- **Instrument Performance Characterization**
- **Calibration Parameter Determination and Validation**
- **Product Performance Characterization**
- **Anomaly Resolution**
Calibration and Validation Toolkit

• **Description**
  – Mixture of different languages (C, Matlab, IDL, Excel)
  – Configuration controlled by CVT using Subversion
  – Analyst intensive, low efficiency, non-operational code

• **Uses**
  – Validate algorithms and verify ground system implementation
  – Improve algorithm functionality
  – Investigate processing and instrument anomalies
  – Support instrument acceptance

• **Contains working copies of all algorithms**
  – Instrument provider algorithm baseline
  – Ground system algorithm baseline (ingest, product generation, image assessment)
  – Algorithm prototyping/working versions, including algorithms not implemented in the ground system
Cal/Val Tool Development

Instrument Developer
- Algorithms
- Prototype Code (Matlab, C)

Cal/Val Toolkit
- Instrument Developer Algorithms
- CVT Algorithms
- CVT Prototype Code (Matlab, C, IDL)

Ground System
- Ingest Subsystem
- Landsat Product Generation Subsystem
- Image Assessment Subsystem
## Phased Algorithm Development

- Algorithm delivery synchronized with instrument and ground system major reviews
  - **Phase 1**
    - Includes brief descriptions
    - Supports ground system preliminary design
  - **Phase 2**
    - Based on preliminary provider algorithm descriptions
    - Supports ground system detailed design
  - **Phase 3**
    - Based on instrument testing
    - Supports ground system implementation
  - **Phase 4**
    - Based on on-orbit instrument analysis
    - Supports post-launch ground system update

<table>
<thead>
<tr>
<th>Alg. Delivery Phase</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Inputs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Outputs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Maturity</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Prototype</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Test Data</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Verification</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Relational Schedule
Current Status

• Algorithms received from instrument providers
• Algorithms delivered to ground system developers
• Initial release of image assessment subsystem completed
  – Only minor issues remain to be resolved with second release
• One more image assessment release to go
  – Lower priority algorithms
  – Changes found during testing
In-line Characterization Algorithms

- Dropped Frame Characterization
- Impulse Noise Characterization
- Saturated Pixel Characterization
- Histogram Statistics Characterization
- SCA Overlap Statistics Characterization
- Striping Characterization
Off-line Characterization Algorithms

- White Noise Characterization
- 1/f Noise Characterization
- Coherent Noise Characterization
- Relative Gain Characterization
  - Side Slither and Histogram Method
✓ Detector Response Characterization
  - Solar Diffuser and Internal Lamp
✓ Radiometric Stability Characterization
- Nonlinear Response Characterization
- Lunar Irradiance Characterization
Processing Algorithms

✓ Bias Removal
  – Bias Model Calibration
  – Bias Determination
✓ Response Linearization
✓ Gain Application
  • SCA Discontinuity Correction
  • Residual Striping Correction
  • Saturated Pixel Replacement
  • Inoperable Detectors Fill
✓ Reflectance Conversion
Initial Image Assessment Subsystem

Level 0R

Level 1R

Example of radiometric processing to generate floating point Level 1R “product” for band 1, SCA 1