Landsat Science Team

Landsat Operations Report

7 July 2015

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USGS EROS
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Agenda

- Mission Status (L7,L8)
- L7/L8 Acquisition Status
- Archive Status
- LGAC Status
- Product Distribution
Spacecraft Status: L7 Summary

≈ 15 years of on-orbit operations

Attitude Control System
- 05/05/2004 Gyro 3 Shut Off
- 1-gyro control system in development

Enhanced Thematic Mapper +
- 05/31/2003 SLC Failure
- 04/01/2007 Bumper mode

Remote Tlm Cmd (RTC) Box
- 09/27/2014 RTC A Failover

X-band System
- Performance nominal

S-band System
- Performance nominal

Power Subsystem

Batteries
- Performance nominal

Power Control Unit
- 10/18/2014 BVR failover

Solar Array
- 05/14/2002 Circuit #14 Failure
- 05/16/2005 Circuit # 6 Failure
- 08/13/2008 Circuit #14 partial recovery
- 14 circuits remain operating
- no impact to ops

Reaction Control System
- 1/07/04 Fuel line #4 thermostat #1a failure
- 02/24/05 Fuel line #4 thermostat failure; Primary heater circuit disabled
- 04/25/13 Fuel line #2 thermostat failure; Redundant heater circuit disabled

Solid State Recorder
- 11/15/1999 SSR PWA #23 Loss
- 02/11/2001 SSR PWA #12 Loss
- 12/07/2005 SSR PWA #02 Loss
- 08/02/2006 SSR PWA #13 Loss
- 03/28/2008 SSR PWA #22 Loss
- 09/03/2008 SSR PWA #23 Recovered
- 10/12/2013 SSR PWA #11 Loss
- Each PWA is 4% loss of launch capacity
- Boards are likely recoverable

** No new spacecraft issues to discuss.**
Mission-Limiting Factors

- **Component Anomalies**: Mission status that invokes consideration of decommissioning
  - End of Science Mission: A critical failure of either the ETM+ or supporting bus subsystem
  - Imminent failure of critical sub-system component capability considered necessary to execute the decommission plan
    - Loss of critical subsystem redundancy may not be an exit trigger and would be evaluated on a case-by-case basis
    - Examples include ACS gyro or C&DH S-band transponder

- **Fuel Reserves**
  - Sufficient fuel must be maintained to meet mission decommissioning requirements
    - The satellite is lowered below the operational orbit of the 705km constellation
L7 Fuel Estimates

Landsat 7 Fuel Usage (past and future)

Estimated Fuel Mass (kg)
Predicted Fuel Mass (kg)

Fuel Mass (kg)
Year
MLT-9:30
Last Delta-i

USGS

Landsat Science Team – July 2015
L7 MLT Long-Term Prediction

- Peak MLT 10:14:58 AM ~Sep 2016
- (Plan) Sep 2015: 810 sec X2
- June 2019
- January 2020
- July 2020

Date:
1/1/2013, 1/1/2015, 1/1/2017, 1/1/2019, 1/1/2021

L7 MLT (hrs)
9, 9.25, 9.5, 9.75, 10, 10.25, 10.5

Inclination (deg)
98.21, 98.22, 98.225, 98.23, 98.235, 98.24

Historical MLT
Predicted MLT
Inclination
L8 Spacecraft Status

All spacecraft subsystems are nominal

- ACS
- FSW
- CDH
- EPS
- TCS
- PROP
- TTC

A-side anomaly swap to B-side 2 Mar
Ground System Activities Related to TIRS

- **TIRS Anomaly**
  - 19 Dec 2014 – Mechanical Control Electronics (MCE) reached a yellow over-current limit. Scene Select Mirror (SSM) encoder was switched to ‘Mode-0’ which basically disables the encoder
    - TIRS bands in products were set to 0 (until we reprocess to handle mirror drift)
  - 2 Mar 2015 – TIRS switched to Side-B ‘Mode-4’. Commission and calibration period followed
    - Develop new parameters for CPF, BPF, RLUT
  - 30 Apr 2015 – Reprocessing of TIRS data started
    - Mode-0 data (19 Dec 2014 – 2 Mar 2015)
  - 14 May 2015 – Reprocessing completed

- **TIRS Stray Light**
  - Discussion forthcoming (Ron Morfitt)
  - Tentatively planned for LPGS 2.6 (~October)
  - Plan to reprocess OLI_TIRS data once stray light algorithm is validated
Landsat 8 Mean Local Time (MLT)
1 November 2014 through 17 May 2015

MLT = 10:11:20 a.m.
as of 17 May 2015

INC3 (DOY 134)
Data not acquired is lost forever!

-- Eugene A Fosnight, PHD
Signature Block
Landsat 7 Current Status

- Acquire only continental land masses
  - Minimize revisit time
  - Maximize interval lengths
  - Exclude many islands, Antarctica, Greenland, and row 9 and above

- Most rejects due to
  - Duty cycle
  - Onboard memory

- No daily limits

- Map of % acquired in 2014

Currently acquiring ~470 scenes/day!
Landsat 7 Current Investigations

- Tune Landsat 7 Continental Model
  - Acquire as many images as possible
  - Acquire the best possible images
  - Do nothing to shorten the mission

- Reduce duty cycle rejections by relaxing constraints
  - Propose gradual increase in duty cycle to 105% of current
  - Careful monitoring of telemetry
  - Acceptable risk given near end-of-mission?
  - Duty cycle rejections tend to shift to memory rejections

- Increase download opportunities
  - Add International cooperators as “bent-pipe” LGN stations
  - Adds operational margin in anticipation of future memory board losses and loss of download opportunities
Landsat 8 Acquisition Status (1/1/2015 – 5/19/2015)

- Daily limit at ~725 images/day
  - Acquiring 421 mid-latitude day-lit land scenes (99.4% of candidates)
    - Beyond 57° Latitude (rows 20 and 105) there is more than 50% sidelap yielding an 8-day revisit period
    - Only reject due to maneuvers
  - Acquiring 249 high-latitude day-lit land scenes (89.7%)
  - Acquiring 11 descending day-lit water scenes/day (98.6%)
  - Acquiring ~25 special request scenes day
    - Cloud threshold set on night and ocean requests
Landsat 8 Acquisitions
2014-06-01 – 2015-05-31

- Percent acquisitions
- Average Cloud Cover Prediction for rejected scenes
An Evolving Scheduling Paradigm

- **Landsat 7**
  - Maximize repeat coverage of continental land masses
  - Maximize health and safety of mission
  - Coordinate acquisitions with Landsat 8
  - Increase ground station contacts and relax duty cycle constraints to maximize acquisitions between now and end-of-mission

- **Landsat 8**
  - Continue with 725 limit
    - All encompassing - includes special requests
    - Consider further reducing day-lit scene restriction
U.S. Landsat Archive Overview
(1 May 2015)

- **OLI-TIRS: Landsat 8**
  - 469,493 scenes
  - ~ 1,623 TB Raw and L0Ra Data
    - average scene size 1,813 MB

- **ETM+: Landsat 7**
  - 1,936,956 scenes
  - ~ 1,799 TB Raw and L0Ra Data
    - average scene size 487 MB

- **TM: Landsat 4 & Landsat 5**
  - 2,078,853 scenes
  - ~ 1,042 TB Raw and L0Ra Data
    - average scene size 263 MB

- **MSS: Landsat 1 through 5**
  - 1,300,091 scenes
  - ~ 79 TB Raw and L0Ra Data
    - average scene size 32 MB

- **Total:**
  - 5,785,393 scenes
  - ~ 4,543 TB Raw and L0Ra Data

All average scenes sizes are for uncompressed data
How much data are we talking about (L1T)?

For High-level Estimation Only

** Rough Estimates **

<table>
<thead>
<tr>
<th>Sensor</th>
<th>% Stackable</th>
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<tr>
<td>OLI-TIRS</td>
<td>100.00%</td>
</tr>
<tr>
<td>ETM+</td>
<td>76.00%</td>
</tr>
<tr>
<td>TM</td>
<td>56.00%</td>
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<tr>
<td>MSS</td>
<td>0.00%</td>
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L1 Archive Storage Requirement
Existing (CY14) and Predicted (CY15+)

Level-1 (L1) Product Size

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<thead>
<tr>
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<th>MB</th>
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<tr>
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<td>ETM+</td>
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<td>MSS</td>
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<tr>
<td>L1 (MB)</td>
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<td>L1 (MB) (compressed)</td>
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<td>L1 (MB)</td>
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<tr>
<td>L1 (MB)</td>
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LGAC

HDDT drives coming from Thailand

Pakistan data (1,257 HDDTs completed out of 2,540)

HDDTs being sent from Thailand
Previous “Woodcock Metric” (1/2/2015): 3,164,701


~ 6M total (~ 53% complete)

~ 69% of scenes are unique to the archive
LGAC Status

- **Argentina – LTOs**
  - TM and ETM+ data delivery continues

- **Brazil – HDDTs**
  - USGS to set up Wideband Video Drive to read tapes
    - ~875 tapes to be sent by Brazil upon sample tape success
    - Primarily consist of MSS data, with very small number of TM intervals also included

<table>
<thead>
<tr>
<th>Country (Organization)</th>
<th>Ground Station</th>
<th>% LGAC Delivered</th>
<th>% LGAC Ingested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina (CONAE)</td>
<td>COA</td>
<td>TM</td>
<td>TM</td>
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<td></td>
<td></td>
<td>ETM+</td>
<td>ETM+</td>
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<tr>
<td>Australia (GA-NEO)</td>
<td>ASA</td>
<td>MSS</td>
<td>MSS</td>
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<td>TM</td>
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<td>HOA</td>
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<td>ETM+</td>
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<td>Brazil (INPE)</td>
<td>CUB</td>
<td>MSS</td>
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<td></td>
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<td>ETM+</td>
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<td>Canada (CCMEO)</td>
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<td>Canada (CCMEO)</td>
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## LGAC Status

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<th>Country (Organization)</th>
<th>Ground Station</th>
<th>% LGAC Delivered</th>
<th>% LGAC Ingested</th>
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<tbody>
<tr>
<td>China (RADI)</td>
<td>BJC</td>
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<td>ETM+</td>
<td>ETM+</td>
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<td>China (RADI)</td>
<td>KHC</td>
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<td>TM</td>
<td>TM</td>
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<tr>
<td>Europe (ESA)</td>
<td>FUI</td>
<td>MSS</td>
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<td>ETM+</td>
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<td>Europe (ESA)</td>
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<td>Europe (ESA)</td>
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<td>TM</td>
<td>TM</td>
</tr>
</tbody>
</table>

- **China** – Electronic data delivery
  - TM data delivered in FRED format

- **Ecuador** – All data has been received
  - Addressing several problematic tapes
  - Partial data redelivery on hard drives being investigated

- **Europe** – NAS HDs
  - Phase I LGAC support consisted of Kiruna (KIS) TM data
    - Issues with missing PCD for ~500,000 TM scenes
    - **USGS** analysis currently in progress
  - Phase II LGAC data to consist of all outstanding TM and ETM+ data
    - First shipment consisted of KIS and MPS ETM+ data
    - Additional shipments of TM and ETM+ data in 2015

- **India** – Letter of Cooperation (LOC) has been signed between ISRO and USGS
  - LGAC data to be delivered to USGS within the upcoming weeks
**LGAC Status**

<table>
<thead>
<tr>
<th>Country (Organization)</th>
<th>Ground Station</th>
<th>% LGAC Delivered</th>
<th>% LGAC Ingested</th>
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</thead>
<tbody>
<tr>
<td>Indonesia (LAPAN)</td>
<td>DKI</td>
<td>TM</td>
<td>TM</td>
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<td></td>
<td></td>
<td>ETM+</td>
<td>ETM+</td>
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<tr>
<td>Japan (HIT/HEEIC)</td>
<td>HIJ</td>
<td>ETM+</td>
<td>ETM+</td>
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<tr>
<td>Japan (JAXA/RESTEC)</td>
<td>HAJ</td>
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<td>MSS</td>
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<td>TM</td>
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<td>ETM+</td>
<td>ETM+</td>
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<tr>
<td>Kyrgyzstan (DLR)</td>
<td>BIK</td>
<td>TM</td>
<td>TM</td>
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<tr>
<td>Mongolia (DLR)</td>
<td>ULM</td>
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<td>Pakistan (SUPARCO)</td>
<td>ISP</td>
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<td>TM</td>
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<td>Saudi Arabia (KACST)</td>
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<td>TM</td>
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<tr>
<td>South Africa (SANSA)</td>
<td>JSA</td>
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<td>TM</td>
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<tr>
<td></td>
<td></td>
<td>ETM+</td>
<td>ETM+</td>
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<tr>
<td>Taiwan (CSRSR-NCU)</td>
<td>CLT</td>
<td>TM</td>
<td>TM</td>
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<td>Thailand (GISTDA)</td>
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<td>MSS</td>
<td>MSS</td>
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<td></td>
<td></td>
<td>TM</td>
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<td></td>
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<td>ETM+</td>
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<tr>
<td>US (U of Puerto Rico)</td>
<td>UPR</td>
<td>ETM+</td>
<td>ETM+</td>
</tr>
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</table>

- **Indonesia** – All data has been received
  - DCRSi drive parts needed for remaining tapes
- **Pakistan** – All HDDTs have been delivered
  - Tape reading in process
  - Delivery of additional TM data on LTOs pending
- **Saudi Arabia** – Initial sample set of HDDTs successfully received, read, and ingested
  - Delivery of additional TM and MSS data on DLTs and HDDTs pending
- **South Africa** – Electronic data delivery continues
- **Thailand** – TM and ETM+ data received on LTOs and DLTs and data ingest currently in process
  - Delivery of additional TM and MSS data on HDDTs, as well as three tape drives, in process
# LGAC Status Summary

<table>
<thead>
<tr>
<th>GSID</th>
<th>Country</th>
<th>Location</th>
<th>MSS Actual</th>
<th>MSS Estimated</th>
<th>MSS Comp</th>
<th>MSS Unique</th>
<th>TM Actual</th>
<th>TM Estimated</th>
<th>TM Comp</th>
<th>TM Unique</th>
<th>ETM+ Actual</th>
<th>ETM+ Estimated</th>
<th>ETM+ Comp</th>
<th>ETM+ Unique</th>
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<td>166,582</td>
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<td>66</td>
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<td>190,000</td>
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<td>96,185</td>
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<td>Cuiaba</td>
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<td>20,767</td>
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<td>FUI</td>
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<td>53,000</td>
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<td>14,681</td>
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<td>9,988</td>
<td>26%</td>
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<td>HAOA</td>
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<td>9,988</td>
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<tr>
<td>JSA</td>
<td>South Africa</td>
<td>Hartebeesthoek</td>
<td>73,759</td>
<td>119,000</td>
<td>62%</td>
<td>61,914</td>
<td>25,531</td>
<td>25,000</td>
<td>100%</td>
<td>8,329</td>
<td>33%</td>
<td></td>
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<tr>
<td>KHC</td>
<td>China</td>
<td>KaShi</td>
<td>14,597</td>
<td>23,000</td>
<td>63%</td>
<td>13,542</td>
<td>28,592</td>
<td>43,000</td>
<td>66%</td>
<td>17,764</td>
<td>62%</td>
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<tr>
<td>KIS</td>
<td>Sweden</td>
<td>Kiruna</td>
<td>183,508</td>
<td>300,000</td>
<td>61%</td>
<td>180,755</td>
<td>7,480</td>
<td>32,000</td>
<td>24%</td>
<td>4,099</td>
<td>55%</td>
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</tr>
<tr>
<td>MPS</td>
<td>Spain</td>
<td>Maspalomas</td>
<td>0</td>
<td>50,000</td>
<td>0%</td>
<td>0</td>
<td>7,480</td>
<td>32,000</td>
<td>24%</td>
<td>4,099</td>
<td>55%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTI</td>
<td>Italy</td>
<td>Matera</td>
<td>2,928</td>
<td>234,000</td>
<td>1%</td>
<td>2,907</td>
<td>20</td>
<td>48,000</td>
<td>0%</td>
<td>3</td>
<td>15%</td>
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<tr>
<td>NSG</td>
<td>Germany</td>
<td>Neustrelitz</td>
<td>5,132</td>
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<td>5,102</td>
<td>2,112</td>
<td>89,000</td>
<td>2%</td>
<td>147</td>
<td>7%</td>
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<tr>
<td>PAC</td>
<td>Canada</td>
<td>Prince Albert</td>
<td>413,758</td>
<td>414,000</td>
<td>100%</td>
<td>201,692</td>
<td>100,374</td>
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<td>100%</td>
<td>28,671</td>
<td>29%</td>
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<tr>
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<td>Riyadh</td>
<td>0</td>
<td>5,000</td>
<td>0%</td>
<td>0</td>
<td>1,092</td>
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<td>100%</td>
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<tr>
<td>SGI</td>
<td>India</td>
<td>Shadnagar</td>
<td>0</td>
<td>12,000</td>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
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<tr>
<td>ULM</td>
<td>Mongolia</td>
<td>Ulan Bator</td>
<td>556</td>
<td>500</td>
<td>11%</td>
<td>554</td>
<td>315</td>
<td>500</td>
<td>63%</td>
<td>118</td>
<td>37%</td>
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<tr>
<td>UPR</td>
<td>Puerto Rico</td>
<td>Mayaguez</td>
<td>315</td>
<td>500</td>
<td>63%</td>
<td>118</td>
<td>315</td>
<td>500</td>
<td>63%</td>
<td>118</td>
<td>37%</td>
<td></td>
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</tr>
</tbody>
</table>

Totals: 801,033, 1,562,000, 51%, 468,584, 58%, 1,834,734, 3,726,500, 49%, 1,512,471, 82%, 727,667, 1,092,500, 67%, 324,864, 45%

- Over 3.3 million scenes ingested!
- Approximately 53% complete
- Approximately 69% of scenes are new to the archive!

![USGS Logo](https://example.com/usgs-logo)

Landsat Science Team – July 2015
# LGAC Notional Timeline

<table>
<thead>
<tr>
<th>International Cooperator</th>
<th>TM</th>
<th>Notes / Notional Timeline (highlights are changes from Winter 2015 LST meeting)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GSID</strong></td>
<td><strong>Country</strong></td>
<td><strong>Location</strong></td>
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<tr>
<td><strong>BJC</strong></td>
<td>China</td>
<td>Beijing</td>
</tr>
<tr>
<td><strong>BKT</strong></td>
<td>Thailand</td>
<td>Bangkok</td>
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<td><strong>COA</strong></td>
<td>Argentina</td>
<td>Cordoba</td>
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<tr>
<td><strong>CPE</strong></td>
<td>Ecuador</td>
<td>Cotapaxi</td>
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<td><strong>DKI</strong></td>
<td>Indonesia</td>
<td>Parepare</td>
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<tr>
<td><strong>FUI</strong></td>
<td>Italy</td>
<td>Fucino</td>
</tr>
<tr>
<td><strong>ISP</strong></td>
<td>Pakistan</td>
<td>Islamabad</td>
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<tr>
<td><strong>JSA</strong></td>
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<td>Saudi Arabia</td>
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</tr>
<tr>
<td><strong>SGI</strong></td>
<td>India</td>
<td>Shadnagar</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- Anticipate completion of TM by end of 2015 - 2016
- Anticipate completion of TM and data (not on HDDTs) by mid-end of 2015; Completion of TM data on HDDTs could take multiple years
- Anticipate completion of TM and ETM+ by mid-2016
- Completion of TM data on DCRSi tapes could take some time due to mold problems on the tapes
- Anticipate delivery by end of 2015
- Anticipate completion of TM and ETM+ data by early end of 2015
- Completion of TM data on HDDTs could take multiple years
- Ingest of TM data by end of 2015
- Outstanding TM data contains poor PCD (~40% of TM data holdings) – decision on how to handle this data is pending (~1991 – 1996; some good data)
Monthly Downloads/Processed

Landsat Web-Enabled Monthly Statistics

FY10
Delivered: 2.45M
Processed: 567K

FY11
Delivered: 2.92M
Processed: 1.27M

FY12
Delivered: 2.73M
Processed: 1.82M

FY13
Delivered: 4.32M
Processed: 3.28M

FY14
Delivered: 6.76M
Processed: 4.19M

FY15 (thru March)
Delivered: 3.72M
Processed: 1.36M
Monthly Full Resolution Browse Downloads

FY11
Delivered: 112K

FY12
Delivered: 301K

FY13
Delivered: 823K

FY14
Delivered: 2,696K

FY15 (thru March)
Delivered: 2,596K
LGAC WRS-2

LGAC WRS2 Scenes
Status as of February 28, 2015
Acquisition Date Range: August 22, 1982 through February 28, 2015
3,262,749 Cumulative Scenes Delivered
3,097,736 Total WRS2 Scenes Acquired
13,162 Unique WRS2 Path/Rows

USGS
LGAC WRS-1

LGAC WRS1 Scenes
Status as of February 28, 2016
Acquisition Date Range: July 26, 1972 through March 31, 1983
3,262,749 Cumulative Scenes Delivered
165,013 Total WRS1 Scenes Acquired
3,521 Unique WRS1 Path/Rows

- 1 - 20
- 21 - 44
- 45 - 67
- 68 - 94
- 95 - 135

USGS

Landsat Science Team – July 2015
OLI/TIRS Downloads

OLI & TIRS Standard Product Downloads via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
1,376,180 Total OLI & TIRS Scenes Delivered
14,483 Unique OLI & TIRS Locations

USGS

Landsat Science Team – July 2015
ETM+ Downloads

ETM+ Standard Product Downloads via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
958,955 Total ETM+ Scenes Delivered
11,419 Unique ETM+ Locations

USGS

Landsat Science Team – July 2015
TM Downloads

TM Standard Product Downloads via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
885,551 Total TM Scenes Delivered
9,230 Unique TM Locations

USGS

Landsat Science Team – July 2015
Landsat 4-5 MSS Downloads

L4-5 MSS Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
255,032 Total L4-5 MSS Scenes Delivered
5,468 Unique L4-5 MSS Locations

- 1 - 40
- 41 - 102
- 103 - 226
- 227 - 489
- 490 - 1226

USGS
Landsat 1-3 MSS Downloads

L1-3 MSS Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
211,735 Total L1-3 MSS Scenes Delivered
11,236 Unique L1-3 MSS Locations

USGS
Long-Term Acquisition Plan Controls

- Cloud predictions better than cloud climatology increases probability of acquisition
- Sun elevation constraints
  - Landsat 7 (15° N & 5° S)
  - Landsat 8 (5° N & 5° S)
- Automatic cloud cover assessments of acquired images identify successful acquisitions
- Missed opportunity boost
- Reduced need
  - Vegetation phenology quantified by discrete seasonality records or continuous NDVI probabilities
  - Thematic Campaigns – requirements not well represented by seasonality (reefs, agriculture, volcanoes, glaciers, night, ocean, emergency)