Update on Landsat Program and Landsat Data Continuity Mission

Dr. Jeffrey Masek
LDCM Deputy Project Scientist

NASA GSFC, Code 923

November 21, 2002
Celebrate!

-1 July 23, 1972
-2, January 22, 1975
-3, March 5, 1978

-4, July 16, 1982
-5, March 1, 1984

-7, April 15, 1999

Landsat is 30 years old!
And Thematic Mapper is 20!
Landsat-7 Mission Status

- Landsat-7 Spacecraft and ETM+ Instrument continue to perform well - no significant anomalies.
- Since 1999, 270,000+ full scenes ingested into the US archive
- 47,000 scenes sold from the US archive
- ETM+ calibration stable to ~1% per year
- Absolute calibration accurate to ±5% at-sensor radiance
- Geodetic precision continues better than 50 meters RMS
Landsat-7 ETM+ Band 5 Radiometric Calibration Results
Scaled to High Gain

\[ y = -9.5 \times 10^{-5} + 7.880 \pm 1.4 \times 10^{-5} \pm 0.009 \]

\[ y = -6 \times 10^{-5}x + 7.409 \pm 0.070 \]

Time Since Launch (Days)
Landsat-5 Status

• Landsat-5 TM (18+ years old!) continues acquiring imagery

• 29,700 TM scenes added to US archive since July, 2001

• Landsat-5 now successfully operating in “Bumper Mode”...
L5 TM Bumper Mode

• L5 TM lost synchronization between scan mirror and calibration shutter in early 2002 - “caterpillar tracks” on imagery

• USGS switched the TM to backup bumper mirror mode to extend TM useful life

• Bumper mode geometric algorithms successfully developed, tested, and documented Mar–Jun 2002
  – Requires frequent scan mirror calibration update to track scan mirror behavior changes due to bumper wear
Loss of Mirror/Shutter Synch in SAM Mode

• Scan mirror period grows until cal shutter can’t slow down enough to maintain synch
  – Caused by scan mirror bumper wear

• Cal shutter obscures Earth-view scan
  – “Caterpillar Tracks” anomaly
Bumper Mode Geometric Correction

- Algorithms developed to geometrically calibrate and correct TM bumper mode data

Uncorrected TM Bumper Mode Data
Corrected TM Bumper Mode Data
Corresponding ETM+ Data
Landsat Data Continuity Mission
Background

- LDCM is the follow-on mission to Landsat 7

- NASA and the Dept. of Interior (DOI) / U.S. Geological Survey (USGS) are interagency partners in the LDCM
  - By virtue of an October, 2000 revision to a 1994 Presidential Decision Directive

- NASA and the DOI/USGS plan to implement the LDCM by procuring data from a *privately owned and privately operated* remote sensing system
Mission Objectives

• Provide continuity in the multi-decadal land use/land cover change measurements of the Landsat Program for scientific research

• Facilitate expansion of the commercial remote sensing marketplace and commercialization of Landsat data
Data Procurement Strategy

• A two-step data procurement strategy has been implemented

• The first step is formulation with multiple contractors
  – An RFP for formulation studies was released in Nov., 2001
    • Called for the formulation of preliminary system designs
  – Two firm fixed-price contracts ($5M each) were awarded in March, 2002
    • Resource 21 of Englewood, CO
    • DigitalGlobe of Longmont, CO
  – Formulation culminates with preliminary design reviews in Nov., 2002

• The second step is implementation
  – A single contract will be awarded for the acquisition and delivery of LDCM data for a five-year period (with a costed option for an additional five years)
  – A draft implementation RFP was released Oct. 07, 2002 for comment
  – Release of final RFP expected in Jan., 2003
    • Open to third-party “responsible” bidders as well as formulation contractors
  – Operational delivery of LDCM data to begin no later than 45 months after contract award; March, 2007 assuming June, 2003 award
Early Formulation Results

Preliminary Design Concepts

- Both formulation contractors have publicly announced plans to develop remote sensing systems capable of acquiring multispectral image data having finer spatial resolutions (that is, smaller ground sample distances) than required for the LDCM
  - Both contractors plan to sell the finer resolution data commercially
  - The DOI/USGS EROS Data Center would only distribute Level 1 products where the data had been aggregated and resampled to the maximum ground sampling distances specified for the LDCM (that is, 30m for multispectral data with a 15m sharpening band and a 120m cirrus cloud detection band)
DigitalGlobe System Overview

**Business Approach**

- Complements existing QuickBird hi-res business
  - Wide-area coverage, frequent revisits & additional spectral bands
- Augment QuickBird and SPOT in supporting world-wide agricultural market
  - Also supports environmental monitoring, disaster relief, etc.

**Team**

[DigitalGlobe logo]

[Ball logo]

[ITT Industries logo]

**Space Segment Overview**

- “M5” system
  - 4 satellite constellation
- Multi-spectral
  - 5m nadir GSD
    - Off-nadir capability
  - 185km swath width
- Constellation operational Q3 2007

**Space Segment Concept**

[Diagram of satellite]
Resource21 Overview

Team

BOEING

Ball

Farmland

BAE SYSTEMS

Institute for Technology Development

Space Segment Overview

- 1 or more satellites
- Multi-spectral
  - 5+ bands
  - 10m/20m GSD
- International Cooperator support

Business Approach

Central Processing Facility

DEALER

GROWER

Information Products to Customers

Complementary Markets (Government and other Customers)

Multi-spectral Satellites

Data Collection

Data Download

Blue

Green

Red

NIR

SWIR

Other

Data

Information

Products

to

Customers

Space Segment Concept
RFP Elements

• Key RFP Elements for the User Community:

  – LDCM Data Specification- defines quality and quantity of multispectral data required for delivery to the US Government

  – LDCM Data Policy - defines rights for access to data and data products
Data Specification

• Seasonal coverage of global land mass is the goal:
  – 16 day repeat coverage required for U.S.,
  – 250 global scenes per day (average) to an active archive,
  – March 2007 beginning of delivery for 5 years with 5 year option.

• Sensor or aggregated data delivered to the USGS/EDC.

• Spectral bands include both heritage-based and new bands:
  – 6 reflective bands with 30 m resolution (heritage-based)
  – 1 sharpening band with 15 m resolution (heritage-based)
  – 2 new reflective bands – coastal/aerosol (443 nm, 30-m resolution) and cirrus detection band (1375 or 1875 nm, 120-m resolution)
  – No thermal band

• Radiometric enhancements (SNR, dynamic range) based on newer technologies, e.g. EO-1 (pushbroom instrument technology).
Landsat 7 vs. LDCM Band Comparison

Visible Light

SWIR 2 (2.1 - 2.3)
SWIR 1 (1.56 - 1.66)
Cirrus (1.36 - 1.39)
NIR (0.845 - 0.885)
Red (0.63 - 0.68)
Green (0.525 - 0.6)
Blue 2 (0.45 - 0.515)
Blue 1 (0.433 - 0.453)
Sharpening (0.5 - 0.68)

L7 Band 6 (10.4 – 12.5)
L7 Band 7 (2.09 - 2.35)
L7 Band 5 (1.55 - 1.75)
L7 Band 4 (0.75 - 0.9)
L7 Band 3 (0.63 - 0.69)
L7 Band 2 (0.525 - 0.605)
L7 Band 1 (0.45 - 0.515)
L7 Pan Band (0.52 - 0.9)

NOTE: Underlined/Italicized are optional bands
LDCM Data Policy

• The LDCM Data Policy maintains Landsat 7 Data Policy tenants:
  – Ensures non-discriminatory access to Level 1 data products derived from Government-procured LDCM data
  – Precludes restrictions on sharing and secondary distribution of LDCM Level 1 data products

• The LDCM Data Policy protects the LDCM contractor’s commercial rights to data exceeding quantity or specifications of LDCM data procured by NASA / USGS

• No special provision for International Ground Stations
Procurement Strategy – Envisioned Results

Sensor Data

LDCM Data (~250 Scenes/day)

Daily 250 scenes (package deliveries)

NASA DOI/USGS

NSLRSDA DATA (Rights Reserved)

LDCM Contractor

All Data

LDCM L1 Data Products (Public Domain Data, No Rights Reserved)

Customers: End Users, VARs, IC’s

Commercial L0/L1, and Value Added Products (All Rights Reserved)
Roles & Responsibilities

• NASA will:
  – Procure data from an LDCM Contractor
  – Require the Contractor to deliver the procured data to the DOI/USGS EROS Data Center in Sioux Falls, SD
    • The average daily delivery shall provide coverage of 250 Landsat scenes
  – Validate that the data quality and quantity meet LDCM specifications

• DOI/USGS will:
  – Receive and archive the LDCM data at the EROS Data Center
  – Allow the general public to search the LDCM data archive on a nondiscriminatory basis and to order Level 1 data products (that is, radiometrically corrected data registered to cartographic projections)
  – Produce and distribute ordered data products in accordance with an LDCM Data Policy
  – Charge no more than $50 per scene for a Level 1 data product
Invitation to Comment

• Final RFP to be released in early January, 2003
• LDCM Award expected by June, 2003

• The RFP can be found at the following web site:
  http://prod.nais.nasa.gov/cgi-bin/eps/sol.cgi?acqid=102577
  – A link to the web site providing the RFP can be found at the LDCM Home Pages: http://ldcm.nasa.gov or http://ldcm.usgs.gov

• Please send comments in writing to Jim Becker, Contracting Officer either by:
  – Facsimile at: 301-286-7434
  Or
  – Email at: jbecker@pop200.gsfc.nasa.gov