Summary of the Landsat Science Team Meeting

Thomas R. Loveland, U.S. Geological Survey Center for Earth Resources Observation and Science, Loveland@usgs.gov
James R. Irons, NASA Goddard Space Flight Center, James.R.Irons@nasa.gov

Meeting Overview

The first meeting of the United States Geological Survey (USGS) and the NASA Landsat Science Team was held January 9-11, 2007, at the USGS Center for Earth Resources Observation and Science (EROS) near Sioux Falls, SD. The Landsat Science Team, funded by the USGS, was established to advance the objectives of the NASA-USGS Landsat Data Continuity Mission (LDCM), and to contribute to the complete integration of LDCM data with past, present, and future Landsat and other remotely sensed data for the purpose of observing and monitoring global environmental systems. The Landsat record, beginning in July 1972, is already the longest and most comprehensive unbroken collection of global land observations in existence. With LDCM, the Landsat legacy will become a nearly 45-year global land record. The uniqueness and value of this record places additional responsibilities on the LDCM design. The Landsat Science Team will provide the science support needed by the USGS and NASA on issues critical to the success of the mission, including data acquisition, product access and format, and science opportunities for new- and past-generation Landsat data.

The Landsat Science Team consists of 18 members selected through a competitive process. The Principal Investigators (PI's), their affiliation, and research focus are listed in **Table 1**.

Technical Presentations Summary

Meeting objectives, offered by **Tom Loveland** [USGS—*Landsat Project Scientist*], included:

- a review of LDCM and Landsats 5 and 7 status and plans;
- a review of related activities relevant to Landsat data continuity and Earth observation and monitoring;
- an introduction to the science activities of the Landsat Science Team members; and
- identification of team priorities and working strategies.

The meeting agenda and presentations are available at *ldcm.usgs.gov/intro.html*.

R. J. Thompson [USGS—*EROS Director*], **Bruce Quirk** [USGS—*Acting Land Remote Sensing Program Coordinator*], and **Ed Grigsby** [NASA Headquarters—*Landsat Program Executive*] each provided their perspectives on the importance of the Landsat Science Team in meeting the goals of the LDCM mission. They emphasized that the key to the initial meeting was to establish a dialog between the Landsat Science Team and NASA and USGS developers. They surmised that the USGS, NASA, and the Landsat Science Team together are essential to mission success.

Bill Ochs [NASA Goddard Space Flight Center (GSFC)—*LDCM Project Manager*] provided a status report on where the project has been, where it is today, and where it is going. In 1999, plans were initiated for a commercial data buy as the mechanism to ensure Landsat data continuity. Unfortunately, in 2003, the solicitation was canceled due to unresolvable problems with the proposed government-industry partnership. In 2004, the Office of Science and Technology Policy (OSTP) issued a memorandum that called for placement of a Landsat-class instrument on the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) platform. By late-2005, it was clear that this configuration was not appropriate and OSTP issued a new memorandum calling for a free-flying LDCM. An LDCM operations concept has been established in which NASA will develop the launch and space segments and the USGS will develop the flight operations and data processing and archive segments.

Ochs informed the team that the Request for Proposals for the Operational Land Imager (OLI), the next generation sensor, was released on January 9, 2007 with responses due to NASA on February 23, 2007. An instrument award is expected in early summer. The OLI is a multispectral, moderate resolution (30 m) sensor capable of providing an average of 400 scenes (185 km x 180 km) per day to the archive—see **Table 2**. The OLI will not have thermal capabilities but discussions are still ongoing about adding two thermal channels via a stand-alone instrument.

Ochs also explained plans to use the Rapid Spacecraft Development Office Rapid II Catalog for acquiring the LDCM spacecraft. The spacecraft component of the mission is to be contracted by late-2007. The targeted launch readiness date is July 2011.

Mike Headley [USGS—*LDCM Project Manager*] gave an overview of EROS, Landsat support, and LDCM development activities. The USGS is responsible for acquiring and operating the LDCM ground network, data archive, processing and distribution systems, and the data collection scheduling capabilities. The USGS will operate the LDCM observatory following on-orbit

Table 1. Landsat Science Team PI's, affiliation, and research interests.

Principal Investigator	Organization	Research Topic
Richard Allen	University of Idaho	Operational Evapotranspiration Algorithms for LDCM as a Member of the Landsat Data Continuity Mission Science Team
Martha Anderson	USDA Agricultural Research Service	Mapping Drought and Evapotranspiration at High Spatial Resolution Using Landsat Thermal and Surface Reflectance Band Imagery
Alan Belward	European Commission Joint Research Centre	Natural Resources Management—Meeting Millennium Development Goals
Robert Bindschadler	NASA Goddard	Advancing Ice Sheet Research with the Next Generation Landsat Sensor
Warren Cohen	USDA Forest Service	Landsat and Vegetation Change: Towards 50 Years of Observation and Characterization
Feng Gao	Earth Resources Technology	Developing a Consistent Landsat Data Set from MSS, TM/ETM+ and International Sources for Land Cover Change Detection
Sam Goward	University of Maryland	The LDCM Long Term Acquisition Plan: Extending and Enhancing the Landsat 7 LTAP Approach
Dennis Helder	South Dakota State University	A Systematic Radiometric Calibration Approach for LDCM and the Landsat Archive
Eileen Helmer	USDA Forest Service	Cloud-Free Landsat Image Mosaics for Monitoring Tropical Forest Ecosystems
Rama Nemani	NASA Ames	Developing Biophysical Products for Landsat
Lazaros Oraiopoulos	University of Maryland Baltimore County	Cloud Detection and Avoidance for the Landsat Data Continuity Mission
John Schott	Rochester Institute of Technology	The Impact of Land Processes on Fresh and Coastal Waters
Prasad Thenkabail	International Water Management Institute	Global Irrigated Area Mapping using Landsat 30-m for the Years 2000 and 1975
Eric Vermote	University of Maryland	A Surface Reflectance Standard Product for LDCM and Supporting Activities
Jim Vogelmann	USGS EROS/SAIC	Monitoring Forest and Rangeland Change Using Landsat Continuity and Alternative Sources of Satellite Data
Curtis Woodcock	Boston University	Toward Operational Global Monitoring of Landcover Change
Mike Wulder	Canadian Forest Service	Large-Area Land Cover Mapping and Dynamics: Landsat Imagery to Information
Randy Wynne	Virginia Tech	Commercial Forestry Applications of Landsat and LDCM Data

acceptance and for the life of the mission. Headley also explained the major requirements of the LDCM ground system, including:

- perform mission operations including data collection scheduling;
- ingesting and archiving 400 World Reference System-2 (WRS-2) scenes per day;
- making data available for search and ordering within 24 hours following acquisition;
- providing standard orthorectified data products within 24 hours of collection and making the standard products accessible via the web at no cost;
- providing "user specified" data products; and
- ensuring that LDCM data are calibrated consistently with data from previous Landsat missions.

Table 2. OLI spectral and ground resolution specifications

#	Band	Minimum Lower Band Edge (nm)	Minimum Lower Band Edge (nm)	Center Wavelength (nm)	Maximum Spatial Resolution at Nadir (m)
1	Coastal/Aerosol	433	453	443	30
2	Blue	450	515	482	30
3	Green	525	600	562	30
4	Red	630	680	655	30
5	NIR	845	885	865	30
6	SWIR 1	1560	1660	1610	30
7	SWIR 2	2100	2300	2200	30
8	Panchromatic	500	680	590	15
9	Cirrus	1360	1390	1375	30
10*	Thermal 1	10300	11300	10800	120
11*	Thermal 2	11500	12500	12000	120

* Provision of thermal capabilities is contingent upon requirement trades between program elements, technical requirements, and mission risk as part of the LDCM procurement.

Jim Irons [GSFC—*LDCM Project Scientist*] provided additional history on the evolution of LDCM, outlined the LDCM Programmatic and Level 1 Requirements, and emphasized the importance of Landsat data continuity, and the significance of Landsat 7 as a benchmark with respect to instrument data characterization and calibration. Irons also reviewed the needs and issues facing the addition of a thermal imaging system on the LDCM platform. Finally, Irons and **Jason Williams** [USGS/Scientific Applications International Corporation (SAIC) walked the team through the technical details of the mission operations concept.

In the final LDCM presentation, **John Dwyer** [USGS/SAIC—*LDCM Principal Scientist*] shared the current plans for standard and user-specified data products. Standard product specifications include: (1) Level 1 Systematic Terrain Corrected Landsat Data (L1Gt) product generated routinely and based on a fixed recipe; (2) geolocation accuracy achieved using definitive ephemeris; (3) relief displacement corrected using best available digital elevation models; and (4) web-enabled access for electronic retrieval. User-specified products are defined as products generated on-demand by user request. Dwyer said that input is needed from the user community on the levels of processing and service that are required.

Kristi Kline [USGS—*Landsat Project Manager*] provided an overview of the status and plans for Landsat 5 and 7 operations. Launched in 1984, Landsat 5 continues to acquire data. Engineering solutions to solar array drive malfunctions and X-band transmission problems have enabled continued operation. Other than the scan line corrector (SLC) failure in May 2003, Landsat 7 is fully functional and acquiring global data.

Rachel Kurtz [USGS—*Acting Landsat Acquisitions Manager*] presented an overview of upcoming Landsat 7 SLC-off, gap-filling products that are based on new segmentation methods. In addition, she described USGS plans to make contemporary terrain corrected conterminous U.S. Landsat 7 SLC-off data available via the web at no cost starting in March 2007.

Ron Hayes [USGS/SAIC] and **Brian Markham** [GSFC] presented efforts to maintain current and consistent Landsat 5 and 7 calibration documentation, and plans to establish consistent calibration between all Landsat instruments.

Following the presentations on LDCM and Landsat status, discussions turned to related Earth observation topics. **Ray Byrnes** and **John Cullen** [USGS], and **Ed Grigsby** presented an overview of the Future of Land Imaging (FLI) activities. They reported that the following statement is the outcome of the OSTP-led FLI planning process:

> *"It is proposed that the U.S. establish a National Land Imaging Program led by the U.S. Department of the Interior to ensure U.S. leadership in all areas of civil land imaging and land science, including the development and operation of all U.S.-owned operational space assets dedicated to civil land imaging purposes, and that the U.S. pursue a strategy of collaborating with its international partners and other U.S. and foreign commercial entities to augment U.S. capabilities to the level required to meet U.S. operational needs."*

Because the forthcoming FLI report will have considerable influence on the future of moderate resolution

Earth observation, the Landsat Science Team plans to become active in the next stage of FLI planning.

Jeff Masek [GSFC] presented an overview and status of the Mid-Decadal Global Land Survey activities. This project will provide a consistently processed 2004-2006 moderate resolution global image database comprised primarily of Landsats 5 and 7 scenes. This effort adds to the 1990 and 2000 Geocover Landsat global coverage and is designed to meet Climate Change Science Program science objectives as well as the many other needs for regional to global environmental assessments. Masek also presented an overview of the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) developed in support of forest disturbance mapping as part of North America Carbon Program investigations. LEDAPS provides a testbed for testing product characteristics in the LDCM era.

It seems likely that Landsats 5 and 7 will both cease operations prior to the launch of LDCM. **Gregg Stensaas** [USGS] and **Gyanesh Chander** [USGS/SAIC] presented an overview of the NASA-USGS Landsat Data Gap data characterization studies that are underway. Data gap planning is designed to identify those moderate resolution missions—e.g., **China/Brazil**—China-Brazil Earth Resource Satellite (CBERS-2); **India**—Indian Remote Sensing Satellite (IRS) Advanced Wide Field Sensor (AWifs), Low Imaging Sensing Satellite (LISS III and IV)—that can be combined to provide continued global coverage until LDCM is operational. The formulation and implementation of a data gap strategy is still pending until a number of policy issues are resolved.

Finally, each Landsat Science Team PI gave a brief presentation on their research plans that relate to LDCM and Landsat. The presentations (*ldcm.usgs.gov/scienceP-resentation.html*) addressed product, calibration/validation, and applications topics.

Meeting Conclusions

On the final day of the meeting, the Landsat Science Team members focused on organizational issues and laid plans for future team activities. The topics included team leadership, working groups, and study issues that must be addressed at the next meeting.

The Landsat Science Team leadership structure was clarified and the broad duties of the leadership team were defined. The team is led by two co-chairs, **Tom Loveland (**USGS) and **Jim Irons** (NASA). Their responsibilities include facilitating the functions of the team and recommending the team's agenda and priorities. The third member of the science team leadership group is the Landsat Science Team Leader. The Team Leader is elected from the ranks of the team members, with responsibilities including serving as the lead representative of the Landsat Science Team, acting as a spokesperson for the team, and communicating team needs to the USGS and NASA. **Curtis Woodcock** [Boston University] was elected by the other 17 science team members to serve as the Team Leader.

The team established four working groups that will work with USGS and NASA staff to address a set of Landsat and LDCM mission topics. The working groups, working group coordinators, and example topics are:

- *Operations Acquisition Strategy* (Darrel Williams, GSFC) – Long-term acquisition program; international cooperators; and off-nadir acquisition issues
- *Products, including archive data* (John Dwyer, USGS/SAIC; Jeff Masek, GSFC) - Data gap, mid-decadal studies; quality assurance and validation; monitoring sciences and applications development; user models; data and measurement continuity (i.e., Climate Data Records); surface reflectance, atmospheric corrections; and thermal data needs.
- *Future Missions, Outreach and Advocacy* (Sam Goward, University of Maryland College Park) – FLI and long-term observation needs; international cooperation; thermal data advocacy.
- *Instrument Engineering* (Dennis Helder, South Dakota State University) – calibration; observation technologies; and surface reflectance, atmospheric corrections, etc.

The first action taken by the working groups was the preparation of a letter to NASA, USGS, and other organizations from the Landsat Science Team advocating for a LDCM thermal infrared imaging system.

The Landsat Science Team identified a set of specific topics for study prior to the next meeting. The study results will be reviewed at the next meeting. The questions that are to be investigated and the study lead for each topic include:

- *Mission operations* – What are the key operations issues affecting the acquisition strategy, such as the role of international cooperators, impacts of off-nadir acquisition, Long-Term Acquisition Plan (LTAP), etc.?
- *Future of Land Imaging* – How can the science team express their support of FLI while emphasizing the necessity to include science, applications, and other end-user perspectives into the planning process?
- *USGS Landsat data distribution* – What is the USGS vision and what are the policy plans for distribution of past, present, and future Landsat data?

- *Data gap mitigation implementation* – With a data gap possible any time, what are the specific implementation plans and how will the implementation plans be expedited if a data gap begins sooner than expected?
- *International cooperator historical holdings* – While the international ground stations hold significant amounts of historical Landsat data, the long-term viability of those data could, in some cases, be in jeopardy. In addition, the international holdings represent an invaluable collection needed by the science and applications user community. What is the possibility for expanding the National Satellite Land Remote Sensing Data Archive (NSLRSDA) archive with Landsat data from international cooperator holdings?

The next meeting will be held this coming summer in Corvallis, OR and will be hosted by Warren Cohen of the U.S. Forest Service.

Shown here is a Landsat image of Tianjin, China obtained March 6, 2000. This image is one of 77 such images of cities around the world that have been published as part of a new website—*sedac.ciesin.org/ulandsat/*—created by the Socioeconomic Data and Application Center (SEDAC). SEDAC has established criteria to help distinguish urban and land surfaces from other land cover types—by studying reflectance (visible and infrared) and surface temperature differences between urban and non-urban areas. These spatial characterizations of urban land cover extent can be fed into climate, hydrology, and ecology models helping to make the models more accurate. As described on the Urban Landsat web page, Landsat data provide "objective physically-based metrics for comparative analyses of urban dynamics that cannot generally be obtained from administrative definitions of urban extent." SEDAC is a NASA Distributed Active Archive Center (DAAC) that focuses on data about human interactions with the environment. The center is housed at Columbia University's Lamont-Doherty Earth Observatory in New York. **Image Credit:** NASA/SEDAC