

SEPTEMBER 2, 2009

AUDIT REPORT

OFFICE OF AUDITS

THE LANDSAT PROGRAM IS NOT MEETING THE GOALS
AND INTENT OF THE LAND REMOTE SENSING POLICY
ACT OF 1992

OFFICE OF INSPECTOR GENERAL



National Aeronautics and
Space Administration

Final report released by:

signed
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Acting Assistant Inspector General for Auditing

Acronyms

DoD	Department of Defense
DOI	Department of the Interior
FY	Fiscal Year
GOES	Geostationary Operational Environmental Satellite
LDCM	Landsat Data Continuity Mission
LRD	Launch Readiness Date
LRSP	Landsat Remote Sensing Policy
MOU	Memorandum of Understanding
NLIP	National Land Imaging Program
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-Orbiting Operational Environmental Satellite System
NSTC	National Science and Technology Council
NPR	NASA Procedural Requirements
OLI	Operational Land Imager
OSTP	Office of Science and Technology Policy
RSDO	Rapid Spacecraft Development Office
SLC	Scan Line Corrector
SMD	Science Mission Directorate
SRB	Standing Review Board
TIRS	Thermal Infrared Sensor
TM	Thematic Mapper
USGS	U.S. Geological Survey

OVERVIEW

THE LANDSAT PROGRAM IS NOT MEETING THE GOALS AND INTENT OF THE LAND REMOTE SENSING POLICY ACT OF 1992

The Issue

The Landsat Program comprises a series of Earth-observing satellite missions of, thus far, six satellites. The Program is jointly managed by NASA's Science Mission Directorate (SMD) and the Department of the Interior's U.S. Geological Survey (USGS) on the basis of a memorandum of understanding. The Program has used remote sensing instruments since 1972 to gather wide-swath images of Earth's surface. Landsat images have provided over 3 decades of continuous data on changes in land cover, land use, water resources, and climate, worldwide, that researchers rely on to establish trends and prediction models. The Landsat Data Continuity Mission (LDCM) is the next satellite mission NASA is developing for USGS's Land Remote Sensing Program.¹ The primary purpose of LDCM is to extend the land surface record by collecting data that can be compared to data collected by the previous Landsat satellites, including data collected via infrared imaging capability.

The overall objective of our audit was to determine whether NASA's project management of LDCM has adequately addressed risks associated with the acquisition strategy and a potential data gap between Landsats 5 and 7 and LDCM. In addition, we addressed the LDCM Project and the Landsat Program management's efforts to meet the goals and intent of the Land Remote Sensing Policy (LRSP) Act of 1992 and also addressed the impact late changes to LDCM requirements have had on mission costs and launch schedule. (Details of the audit's scope and methodology are in Appendix A.)

Results

We found that LDCM Project management had ensured that the acquisition plan and subsidiary documents prepared for LDCM followed applicable interagency agreements, policies, regulations, and best practices. In addition, we found that LDCM Project management effectively identified, reported, and mitigated LDCM acquisition risks and had implemented an effective Earned Value Management System to improve management of cost and schedule risks. However, NASA's efforts to comply with the goals outlined in the LRSP Act of 1992 needed improvement. Specifically, NASA and the Nation's efforts to develop, launch, and operate a land remote sensing system to maintain long-term data continuity is in jeopardy because no Federal agency has been

¹ USGS's Land Remote Sensing Program includes the satellites developed under the Landsat Program and alternative data sources.

given overall responsibility for the Landsat Program and LDCM baseline requirements changed after the contract award for the spacecraft, resulting in increased Project costs and possible launch schedule delays.

Because no single Federal agency has overall responsibility for the Landsat Program, decisions about acquisition strategies were delayed, causing significant schedule delays, and thus challenging the goals and intent of the Act, which were to serve the user community's interests and maintain data continuity with the Landsat system. Over the course of more than 6 years, several alternatives for satisfying the LDCM mission objectives were considered, pursued, and rejected, resulting in LDCM and the Landsat Program not fully meeting the goals or intent of the LRSP Act of 1992. Specifically, Landsats 5 and 7 have surpassed their life spans, are operating in a degraded state, and therefore not producing a full set of data, yet LDCM is not scheduled to launch until December 2012. Establishing operational program responsibility and accountability for the Landsat Program within a single Federal agency could help ensure Landsat data continuity.

NASA removed, and now must reinstate, Landsat's legacy thermal imaging capability. Congress directed NASA to reinstate the thermal imaging capability to satisfy the user community's needs, congressional concerns, and the goals and intent of the LRSP Act of 1992. The reinstatement of the capability late in LDCM Project development has resulted in increased Project costs estimated between \$11 million and \$20 million and the risk of a full data gap if LDCM's launch is further delayed. Historically, NASA has made changes to Project requirements, resulting in cost and schedule impacts.

Management Action

In our July 7, 2009, draft we made five recommendations to the Associate Administrator for SMD. He concurred with the five recommendations.

Recommendation 1 was that the Associate Administrator coordinate with USGS to assist in developing a plan for continuous provision of Landsat-type data, should Landsat 7 and Landsat 5 become inoperable before LDCM is operational. In response, the Associate Administrator noted that a USGS analysis of fuel usage suggests that Landsat 7 has sufficient fuel to operate through 2012 or longer, that assessments of the viability of alternative data sources continue, and that NASA will coordinate with USGS to document a plan to mitigate the potential data gap by August 31, 2010.

Our Recommendation 2 suggested that the Associate Administrator coordinate with USGS to assist in establishing the National Land Imaging Program, to include developing detailed plans for future Landsat acquisitions and agency funding responsibility for the program. In response, the Associate Administrator noted that NASA meets monthly with USGS to discuss implementation of the National Land Imaging Program and that NASA intends to work with OSTP and USGS to plan for a follow-on mission.

We suggested in Recommendation 3 that the Associate Administrator request an independent analysis of the impact on the spacecraft's development cost and schedule due to the late change of LDCM requirements. In response, the Associate Administrator stated that an independent analysis of LDCM's development cost and schedule will be conducted in preparation for Key Decision Point-C, scheduled for October 2009.

Recommendation 4 was that the Associate Administrator issue guidance affirming the need for Space Flight Programs and Projects to quantify technical and programmatic risks associated with undefined system-level requirements, which can impact cost and schedule, prior to contract award for any major mission element. The Associate Administrator concurred and noted, in response, that the requirement to quantify technical and programmatic risks is codified in NASA Procedural Requirements (NPR) 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007, and stated that SMD's Management Handbook, released in February 2008, affirms the need for all programs and projects to follow that NPR through all mission phases. In addition, the Associate Administrator stated that the thermal infrared sensor (TIRS) requirements issue was mitigated by structuring the LDCM spacecraft request for proposal so as not to preclude its late introduction.

Recommendation 5 was that the Associate Administrator re-emphasize the provisions of NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," March 26, 2007, which require that NASA programs and projects adequately consider stakeholder expectations and user community interests prior to contract award for development of any major mission element, revisiting these expectations and interests whenever fundamental changes are made to the mission implementation approach. In concurring with Recommendation 5, the Associate Administrator noted that SMD is committed to working with the stakeholder community, as detailed in the SMD Management Handbook, published in 2008, and consistent with NPR 7123.1A.

We consider management's proposed actions to be responsive. On the basis of actions already taken and procedures in place, the recommendations are resolved. Recommendations with corrective actions forthcoming will be closed upon completion and verification of management's corrective action. (See Appendix B for the full text of management's comments.)

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INTRODUCTION

Background

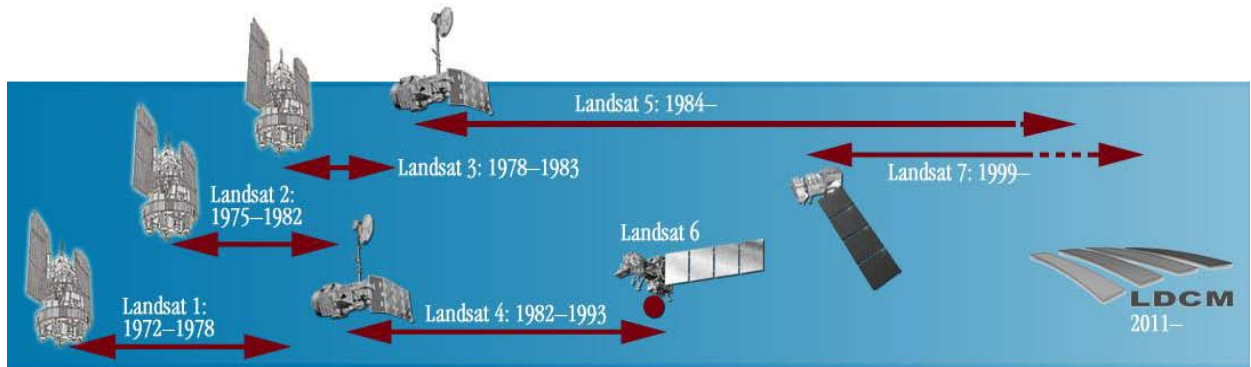
The Landsat Program, at Goddard Space Flight Center (Goddard), constitutes missions to launch Earth orbiting satellites that record land surface changes on a global scale and is the only program, worldwide, committed to preserving a consistent, long-term record of Earth's land surface at moderate resolution. The Landsat satellites constitute the only satellite system designed and operated to observe the global land surface continuously at a moderate resolution;² and the data provided by the Landsat spacecraft constitute the longest record of Earth's continental surfaces as seen from space.

Landsat's land images serve hundreds of users annually who observe and study the Earth, manage and utilize its natural resources, and monitor the changes brought on by natural processes and human activities. The instruments on the Landsat satellites have recorded millions of images used to monitor timber loss, estimate soil moisture and snow water equivalence, monitor population changes, and estimate community growth. The images provide information that meets the needs of a broad and diverse user community that includes business, science, education, government, and national security. For example, Federal agencies and programs that use Landsat data include the Department of Defense (DoD) National Geospatial-Intelligence Agency; the Department of the Interior's U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service, and Bureau of Land Management; USDA's Forest Service, and the U.S. Climate Change Science Program as well as NASA's Biodiversity and Applied Science Applications and Land-Cover and Land-Use Change Program.

History of Landsat. The first Landsat satellite was launched in 1972 by NASA. NASA launched Landsats 2 and 3 in 1975 and 1978, respectively. NASA managed these three satellites as experimental missions. A second generation of Landsat satellites was developed and launched as Landsats 4 and 5 in 1982 and 1984, respectively. From 1979 until 1984, the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) managed all Landsat satellite operations (Landsats 2 through 5). Public Law 98-365, the "Land Remote Sensing Commercialization Act of 1984," directed Commerce/NOAA to delegate management of Landsats 4 and 5 and their data distribution to the private sector. As a result, the Earth Observation Satellite Company, a consortium of private companies, was chosen to operate those satellites as well as build and launch Landsats 6 and 7. Landsat 6, the only satellite not built and launched under NASA management, failed at launch.

² Remotely sensed images are numeric representations of the sampled land surface made up of individual picture elements, or pixels. Each pixel represents a square area on an image that is a measure of the sensor's resolution. The finer the spatial resolution, the smaller the objects that are detectable. Moderate resolution sensors are useful in seasonal and time series applications at regional or global scales, whereas fine resolution studies are more useful in local environmental applications.

Figure 1. Illustrative Timeline of Landsat Satellites 1 through 7.



Source: NASA Landsat Program Web site.

Landsat 7 was mandated in 1992 by Public Law 102-555, “The Land Remote Sensing Policy Act” (LRSP Act of 1992). The Act identified three goals for the Landsat Program:

- (1) encourage the development, launch, and operation of a land remote sensing system that adequately serves the civilian, national security, commercial, and foreign policy interests of the United States;
- (2) encourage the development, launch, and operation of a land remote sensing system that maintains data continuity with the Landsat system; and
- (3) incorporate system enhancements, including any such enhancements developed under the technology demonstration program under section 303, which may potentially yield a system that is less expensive to build and operate, and more responsive to data users, than is the Landsat system projected to be in operation through the year 2000

In 1999, the initial acquisition planning began for Landsat 7’s successor, the Landsat Data Continuity Mission (LDCM).

Program Responsibilities and Accountabilities for LDCM. LDCM is being jointly developed by NASA’s Science Mission Directorate (SMD) and USGS for USGS’s Land Remote Sensing Program. NASA and USGS established a memorandum of understanding (MOU) for collaborative programs in January 2000. The MOU sets forth the general terms and conditions under which NASA and USGS will coordinate and cooperate in implementing research and technology development activities. The MOU states that there shall be a separate Implementing Agreement for each project to define the specific interagency relationships and responsibilities with regard to the activity. For the LDCM Project, NASA is responsible for developing and launching the satellite, and USGS is responsible for mission operations, data collection and processing, and distributing land surface data to users.

However, neither NASA nor USGS has program-level responsibility for the Landsat Program. The agencies receive LDCM acquisition strategy directions through the Office of Science and Technology Policy³ (OSTP) and congressional mandates.

The Project's pre-formulation phase of the acquisition life cycle began in 1999. By 2009, the LDCM Project had progressed to the formulation phase. LDCM's original acquisition schedule was driven by an aggressive launch readiness date (LRD) of July 2011 because time constraints were imposed to have the Project develop and launch a successor before Landsats 5 and 7 failed. However, after independent reviews identified high levels of risk as a result of the aggressiveness of LDCM's acquisition schedule, NASA rescheduled the LRD to December 2012 to reduce development risks. In fiscal years (FYs) 2007 and 2008, NASA awarded contracts for the Operational Land Imager (OLI), spacecraft, and Mission Operations Element (in coordination with USGS), and conducted the Mission Confirmation Review.

The total NASA New Obligation Authority for development and operations of LDCM was \$624 million. For FY 2008, Congress appropriated \$160.2 million for NASA's portion of work on LDCM. In NASA's FY 2009 budget request, NASA projected future budget needs of \$139.4 million and \$127.1 million for LDCM for FYs 2009 and 2010, respectively.

Objectives

Our overall objective was to determine whether NASA's project management of LDCM had adequately addressed the risks associated with the acquisition strategy and the potential data gap between Landsats 5 and 7 and LDCM. Specifically, we determined whether

- the acquisition plan and subsidiary documents follow applicable interagency agreements, policies, regulations, and best practices;
- management has effectively identified, reported, and mitigated LDCM acquisition risks, to include implementation of an effective Earned Value Management System to improve management of cost and schedule risks; and
- LDCM will meet Congress's goals, as set forth in the Land Remote Sensing Policy Act of 1992, and the NASA Authorization Act of 2008.

See Appendix A for details of the review's scope and methodology, our review of internal controls, and a list of prior coverage.

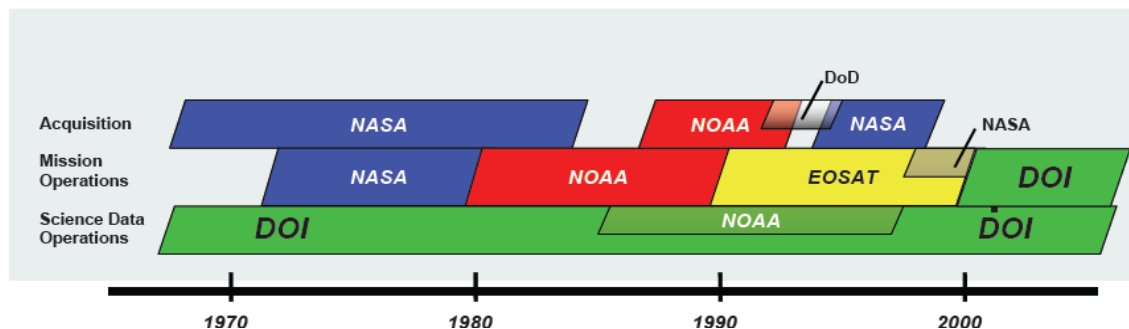
³ Congress established OSTP in 1976 with a broad mandate to advise the President and the Executive Office of the President on the effects of science and technology on domestic and international affairs and to lead interagency efforts to develop and implement sound science and technology policies and budgets.

FINDING A: LANDSAT'S ABILITY TO MEET CONGRESSIONAL GOALS IS HAMPERED BY A LACK OF ACCOUNTABILITY

The Land Remote Sensing Policy (LRSP) Act of 1992 mandates expedited procurement procedures to ensure Landsat data continuity. However, NASA spent more than 6 years in LDCM's pre-formulation phase (concept studies and acquisition planning). The delays in acquiring and launching the next Landsat satellite resulted primarily because no single Federal agency had operational program responsibility or accountability for the Landsat Program or for Landsat data continuity. As a result, the Landsat Program is not meeting the goals or intent of the LRSP Act of 1992. Specifically, Landsat 7—the only operational on-orbit source of complete global Landsat imagery—is operating in a degraded state and is likely to fail prior to LDCM reaching orbit, ending over 3 decades of Landsat data continuity.

Landsat Management Responsibility and Acquisition Process Changed Periodically

Since the Program's inception, responsibility for acquisition, launch, and operations of Landsat satellites has been divided and moved among several Federal agencies and private industry (see Figure 2). The LRSP Act of 1992, section 401, directed NASA and DoD to develop and USGS and NOAA to operate Landsat 7. In addition to Landsat 7, the Act directed the agencies to assess various system development and management options for a satellite system to succeed Landsat 7. The 1992 Act also expressed a preference for "private-sector funding and management." In 1993, the National Science and Technology Council (NSTC) reassessed the joint NASA/DoD Landsat 7 development strategy in an attempt to minimize the potential for a data gap if Landsats 4 and 5 ceased to operate and to reduce costs and development risks. In May 1994, NSTC mandated the transfer of all Landsat 7 development responsibilities to NASA via Presidential Decision Directive NSTC-3, "Landsat Remote Sensing Strategy." The Directive also mandated that USGS and NOAA were responsible for satellite operations and data management. Landsat 7 launched in April 1999. In that same year, the initial acquisition planning began for Landsat 7's successor, LDCM.

Figure 2: Generalized Timeline Schematic of Landsat Responsibility

Source: USGS Report to the Committee on Earth Observation Satellites' Working Group on Collaboration & Validation (February 26, 2008).

On October 16, 2000, an amendment to the May 1994 Presidential Decision Directive transferred responsibility for Landsat operations and data management from NOAA solely to USGS. Thus, jointly, NASA, with development responsibilities, and USGS, with operations and data management responsibilities, began exploring various data acquisition strategies for Landsat 7's successor. However, neither NASA nor USGS was assigned Landsat Program-level responsibility. The agencies received LDCM acquisition strategy directions through OSTP and congressional mandates. The original LDCM acquisition plans called for NASA to purchase, from a commercially owned and operated satellite system, data that met LDCM specifications.

LDCM Formulation Phase Delayed by Acquisition Strategy Indecision

LDCM Project management spent more than 6 years (FYs 2000-2006) and \$54.2 million in the pre-formulation phase (concept studies and acquisition planning) of development. Given the 5-year projected life span of Landsat 7 and equivalent development time for LDCM, in order to prevent a potential gap in data continuity, the acquisition process should have commenced immediately after the launch of Landsat 7 in 1999. However, delays resulted as several alternatives for satisfying the LDCM mission objectives were considered, pursued, and rejected.

In FY 2000, NASA, in cooperation with USGS, began formulating LDCM as a commercial data buy from a vendor who would build, launch, and operate the satellites and charge users for the data. Within that context, the Government acquisition strategy of partnering with private industry was characterized by having both partners provide consideration for and receive benefit from the system once data was acquired. During formulation of the data buy procurement, NASA awarded two study contracts to develop preliminary designs for a system that would provide continuity of Landsat data. Following the delivery of the two preliminary designs, NASA requested proposals for implementation of the system and completion of the data buy procurement. Ultimately, however, NASA received only one proposal. After the proposal evaluation process was completed, the selection official, NASA's Associate Administrator for Earth Science,

determined that acceptance of the proposal was not in the best interests of the Government, due to a lack of competition, and decided not to complete the data buy procurement.

Following the non-completion of the data buy procurement, in 2003, OSTP chartered an Interagency Working Group, chaired by the National Security Council and NASA, to study an implementation strategy for the Landsat Program. After a 9-month study, the Interagency Working Group recommended that land surface data be obtained by developing instruments for use aboard the National Polar-Orbiting Operational Environmental Satellite System (NPOESS). However, further technical evaluation determined that Landsat's instrumentation was not compatible with the NPOESS satellite configuration, and in December 2005, consideration of incorporating Landsat capabilities on NPOESS was discontinued. OSTP then directed NASA to pursue an independent satellite mission approach for Landsat. In early 2006, NASA began re-formulation of LDCM and notified industry that mission development would be openly competed. Following an extensive re-formulation of the mission during 2006 and early 2007, NASA initiated open competitions for the separate elements (spacecraft, instrumentation, launch vehicle, ground system) of LDCM.

In 2007, after more than 6 years of exploring and evaluating various strategies to meet Landsat data continuity requirements, OSTP directed NASA and USGS to use the same acquisition strategy for LDCM that was successfully used to develop and launch Landsat 7, wherein NASA builds and launches the satellite and USGS operates it, and mandated that the Final Implementation Agreement be commensurate with that strategy. Thus, the NASA/USGS Final Implementation Agreement for LDCM was not established until April 2007, more than 8 years after the launch of Landsat 7. In July 2007, in compliance with the OSTP mandate, NASA commenced the acquisition process with the procurement of LDCM's primary instrument, the Operational Land Imager (OLI).

Initial Acquisition Schedule Driven by Aggressive Launch Readiness Date. LDCM's original acquisition schedule was driven by an aggressive LRD of July 2011 with the goal of developing and launching a successor before Landsats 5 and 7 failed. During the Key Decision Point reviews to transition into Phase B of the Project Life Cycle,⁴ LDCM's Standing Review Board (SRB)⁵ determined that the LRD requirement of July 2011 drove the Project to baseline an extremely aggressive, high-risk schedule with no schedule reserve at the mission level. At the outcome of the Key Decision Point review, NASA estimated a more likely development schedule to launch, and delayed the LRD to December 2012. In September 2008, the results of the SRB's Independent Cost Review indicated that delaying the LRD from July 2011 to December 2012 increases the

⁴ During Phase B, the project team completes its preliminary design and technology development, to include baselining the system-level requirements and developing the subsystem and lower-level technical requirements.

⁵ The SRB's role is advisory to the program/project and the convening authorities and does not have authority over any program/project content. Its review provides expert assessment of the technical and programmatic approach, risk posture, and progress against the program/project baseline. When appropriate, it may offer recommendations to improve performance and/or reduce risk.

Project's life cycle cost estimate by \$90.5 million (from \$614.7 million to \$705.2 million), but this LRD correlates with a 70 percent confidence level for achieving the launch date as the Project enters Phase B of the life cycle.

However, the Landsat Science Team,⁶ in January 2008 had concluded that LDCM must be operational by March 2012 to observe the Northern Hemisphere growing season. The LRD of December 2012 conflicts with this user requirement and is far beyond the expected life span of Landsat 7. The latest technical assessment of Landsat 7's projected life expectancy approximates a 50 percent to 70 percent chance of the satellite experiencing a full system failure by December 2012. In the "NASA Report to Congress Regarding Landsat Data Continuity Mission (LDCM) Data Continuity," April 2008, NASA management states, "[b]oth Landsat 7 and Landsat 5 are presently experiencing technical problems and are expected to run out of fuel in late 2010.⁷ Combine this with the most expedient development for LDCM and the outcome is that a Landsat data gap is inevitable."

No Mandated Responsibility or Accountability for Landsat Data Continuity

The LRSP Act of 1992 mandates continuity in Landsat data collection—maintaining consistency with earlier Landsat systems in terms of spectral and spatial coverage. The Act states that continuous collection and utilization of land remote sensing data from space are of major benefit in studying and understanding human impacts on the global environment, in managing Earth's natural resources, in carrying out national security functions, and in planning and conducting many other activities of scientific, economic, and social importance. The Act further states that given the importance of the Landsat program to the United States, urgent actions, including expedited procurement procedures, are required to ensure data continuity.

The Act specifically directs NASA and USGS to assess various system development and management options for a satellite system to succeed Landsat 7. In addition to maintaining data continuity, the LRSP Act of 1992 mandates that the Landsat system should serve the civilian, national security, commercial, and foreign policy interests of the United States and incorporate system enhancements that may potentially yield a system that is less expensive to build and operates more responsively to user requests. One of the key objectives of LDCM is to make all Landsat-type data available at an affordable cost to ensure that the different sectors of the user community can utilize the data for high-quality research applications. However, in the 35-year history of the

⁶ The Landsat Science Team comprises scientists and engineers selected to investigate and advise USGS and NASA on issues critical to the success of LDCM. The team combines USGS-based leadership, USGS and NASA agency scientists, and a group of external scientists and application specialists. The external members consist of principle investigators representing the larger Landsat science and applications community. The most common application appears to be estimating annual agricultural production and national and international forest area.

⁷ In a subsequent report to Congress, "Report on Landsat Thermal Infrared Data Continuity," June 2009, NASA management states that because of fuel limitations, Landsat 7 may cease operating in 2013.

Landsat Program, no Federal agency has been directed or has chosen to adopt the operational program responsibility for Landsat data continuity and, thus, serve the Nation's land imaging needs.

The delays in acquiring and launching LDCM were primarily the result of no single Federal agency taking responsibility for Landsat data continuity. The indecision about LDCM's acquisition strategy was ultimately caused by a lack of ownership of, and dedication to, the continuation of Landsat missions. Although NSTC provided guidance for the continuance of Landsat 7 operations in its 1994 Presidential Decision Directive, NSTC divides responsibilities between NASA and USGS and does not clearly assign the program and associated funding to either agency. While the LRSP Act of 1992 states in its introduction that the purpose of the Act is "[t]o enable the United States to maintain its leadership in land remote sensing by providing data continuity for the Landsat program, to establish a new national land remote sensing policy, and for other purposes," no single Agency has been mandated responsibility or accountability for ensuring that the United States maintains that leadership role or that the Nation's future land imaging needs are met.

Landsat Spacecraft Degradation and Ensuing Data Gap Ends Three Decades of Data Continuity

The Landsat Program is not meeting the goals or intent of the LRSP Act of 1992, as Landsat 7, the only present on-orbit source of complete global Landsat imagery, is operating in a degraded state. Specifically, on May 31, 2003, Landsat 7's scan line corrector (SLC), a subsystem of Landsat 7's primary instrument, the enhanced thematic mapper plus (ETM+), underwent a permanent failure, which caused a 22 percent loss of data on all future images from this system. May 2003 marked the end of more than 30 years of complete Landsat global coverage. Now, to create a full image, older data has to be overlapped onto newer imagery. Many users find this data unacceptable and have pursued other data sources, to include India's ResourceSat and China-Brazil Earth Resources Satellite; however, these sources are not capable of meeting all user needs. Landsat 5, which is more than 20 years beyond its design life and limited by subsystem degradation, has not been capable of providing complete global coverage since 1985 and cannot fill the data gap caused by the SLC failure. Further, Landsat 7 is likely to fail prior to LDCM reaching orbit.

NASA and USGS recognized the likelihood that both Landsat 5 and Landsat 7 will become inoperable before LDCM reaches orbit, resulting in a 100 percent data gap. Consequently, they formed the Landsat Data Gap Study Team to evaluate potential sources of data to fill the ensuing full data gap. The results of their evaluation indicate there is no replacement for all of the data that Landsat satellites provide. Other sources do not provide the inventory of global land surface over time at a resolution allowing human versus natural causes of change to be differentiated or global land observations on a seasonal basis. The Landsat Program is the only national or international program committed to preserving a consistent, long-term record of Earth's land surface at this

resolution. Specifically, no other satellite or combination of satellites can provide the same baseline specifications (spectral bands, radiometry, spatial resolution, geographic registration, band-band registration, and geographic coverage) that Landsat provides. Our interviews with NASA users of Landsat data confirmed that, while several systems could meet special regional acquisition needs during some or all of the potential data gap period, no other satellite system is capable of providing annual global coverage. Thus, the use of other systems will only minimize the impact of the data gap, not close it.

Although the Landsat Data Gap Study Team has determined that at present “there is no substitute for Landsat,” the team continues to conduct assessments of the viability of alternative data sources should Landsat 7 or Landsat 5 fail before LDCM is operational.

Establishing a Long-Term Program to Meet Land Imaging Needs

The FY 2009 Omnibus Appropriations Act directed NASA “to develop, in cooperation with OSTP and USGS, a plan for a follow-on mission to LDCM consistent with the recommendations of the [NSTC] report, *A Plan for a U.S. National Land Imaging Program*.”⁸ This report calls for a continued U.S. commitment to moderate-resolution land imagery, recommends that the United States maintain a core operational capability for land imagery while supplementing its data with similar data from partners, and designates the Department of the Interior (DOI) as the host of the program. NSTC concluded that establishing the National Land Imaging Program (NLIP) would ensure a consistent planning and budgeting process for future land imaging missions and would “transition the Landsat program from a series of independently planned missions to a sustained operational program.” The report also stated that NLIP would provide a mechanism to assess the land imagery needs of Federal agencies, state and local land management officials, scientists, and geographic researchers, and to translate those needs into the technical capabilities of future satellites.

In the judgment of NSTC and the stakeholder agencies it represents, Landsat operational program responsibility most appropriately fits within the mandate and objectives of USGS/DOI; and NASA, which has historically maintained a research, development, and applied science role in land remote sensing, should maintain that role. For example, a similar cross-agency cooperative agreement exists between NASA and the Department of Commerce for the execution of the Geostationary Operational Environmental Satellite (GOES) Program.⁹ GOES operational program responsibility and funding authority falls under the Department of Commerce’s NOAA. On June 15, 2007, NOAA and NASA signed a memorandum of understanding such that NOAA’s GOES-R Program Office is fully responsible for all aspects of program management: acquisition strategy, funding, program-level systems engineering and integration, and scientific,

⁸ Future of Land Imaging Interagency Working Group, Executive Office of the President, NSTC, *A Plan for a U.S. National Land Imaging Program* (Washington, D.C.: August 2007).

⁹ The GOES Program develops and provides satellites that operate at a fixed position above the Earth’s surface to collect and transmit environmental data used to forecast the weather. GOES-R is the next satellite in the series and scheduled for launch in FY 2015.

technical, and administrative support, while NASA's primary responsibility is to manage the development of the Flight Project, which includes spacecraft, launch services, instruments, and satellite integration. NOAA fully reimburses NASA for all resources used to support the GOES program. In its report, "Geostationary Operational Environmental Satellites: Acquisition Is Under Way, but Improvements Needed in Management and Oversight," April 2, 2009, the Government Accountability Office (GAO) noted that NASA and NOAA have made progress on the Program. DOI and NASA could benefit from the lessons learned in developing and executing the GOES Program and apply those lessons to NLIP implementation.

Recommendations, Management's Response, and Evaluation of Management's Response

Recommendation 1. The Associate Administrator for SMD should develop a plan for continuous provision of Landsat-type data, should Landsat 7 and Landsat 5 become inoperable before LDCM is operational.

Management's Response. The Associate Administrator for SMD concurred with the recommendation, noting that, on the basis of USGS's further analysis of fuel usage for both Landsats 5 and 7, NASA officials believe that Landsat 7 has sufficient fuel to operate through 2012 and perhaps longer. He also noted that the Landsat Data Gap Study Team continues to conduct assessments of the viability of alternative data sources should Landsat 5 or 7 fail before LDCM data is available, and that NASA will coordinate with USGS to document a formal plan for the partial mitigation of the potential data gap by August 31, 2010.

Evaluation of Management's Response. We consider management's proposed action to be responsive. The recommendation is resolved and will be closed upon completion and verification of management's corrective action.

Recommendation 2. The Associate Administrator for SMD should assist in establishing the National Land Imaging Program, to include developing detailed plans for future Landsat acquisitions and agency funding responsibility for the program.

Management's Response. The Associate Administrator for SMD concurred with this recommendation. He added that NASA meets monthly with USGS to discuss implementation of the National Land Imaging Program, although full implementation by USGS is on hold pending legislation authorizing the program and appropriation of funds. Also, NASA intends to work with OSTP and USGS to plan for a follow-on mission to LDCM in time to inform the President's FY 2012 Budget Request, which is due to the Office of Management and Budget by September 1, 2010.

Evaluation of Management's Response. Management's proposed action is responsive. Based on actions taken and procedures in place, we have closed the recommendation.

FINDING B: REINSTATEMENT OF THERMAL IMAGING INCREASED COSTS AND MAY FURTHER DELAY LAUNCH

On March 11, 2009, Congress directed NASA to reinstate Landsat’s legacy thermal infrared imaging capability. In 2002, NASA management removed the thermal infrared imaging capability from the LDCM requirements baseline, disregarding the Landsat data continuity goals of the LRSP Act of 1992 and not adequately considering the user community’s growing reliance on thermal imaging. LDCM Project management estimates that reinstating the capability this late in the Project’s life cycle will result in spacecraft modification costs of \$11 million to \$20 million, and could cause further delays to an already significantly delayed mission.

Importance of Thermal Imaging Increased for the Landsat Data User Community

The Land Remote Sensing Policy Act of 1992 directs Landsat Program management to “maintain data continuity.” The Act defines “data continuity” as “the continued acquisition and availability of unenhanced data which are, from the point of view of the user, sufficiently consistent (in terms of acquisition geometry, coverage characteristics, and spectral characteristics) with previous Landsat data to allow comparisons for global and regional change detection and characterization.” Spectral characteristics that are sufficiently consistent with previous Landsat data would include thermal spectral band imaging.

Since 1972, Landsat satellites have carried sensors that collect wide field-of-view images of the Earth’s surface. Landsats 1 through 3 each carried both a Remote Beam Vidicon camera and a multispectral scanner subsystem instrument. Landsat 3, launched in 1978, marked the beginning of thermal image acquisitions on Landsat missions, and thermal imaging has been a function of Landsat satellites since then. One of the technical advancements made in 1982, for Landsat 4 and follow-on Landsat satellites, was the addition of the Thematic Mapper (TM) sensor. Analysts found that TM data significantly improved capabilities for recognizing and mapping land cover types and for detecting land cover change relative to multispectral scanner subsystem data. The TM sensor collected data for seven spectral bands, compared to the four multispectral scanner subsystem bands of Landsats 1 through 3. In addition, the TM sensor provided an improved spatial resolution relative to the multispectral scanner subsystem instruments, to include image data for a thermal spectral band sensitive to emitted radiation. The user community used images from the TM sensor thermal band to map and monitor the variation of surface temperatures across landscapes.

The user community's growing preference for TM data resulted in the next two Landsat satellites—Landsat 6 and Landsat 7—being built to carry single sensors that were close derivatives of the TM design. The Landsat 6 sensor, the Enhanced Thematic Mapper (ETM), was enhanced by the addition of a panchromatic band sensitive to all or most light in the visible spectrum and improved spatial resolution. Landsat 7 carries the Enhanced Thematic Mapper – Plus (ETM+) sensor; the “plus” refers to an improvement in the ground resolution of the thermal spectral band.

During FYs 2000 through 2007, while the implementation strategy for Landsat data continuity was being formulated, the Landsat 5 TM and Landsat 7 ETM+ sensors continued to provide users thermal spectral images, along with the data from the other spectral bands, and user community interest in thermal data increased. The increased use of thermal imagery was driven by multiple factors; specifically, the lowering of costs for Landsat images, removal of copyright restrictions on Landsat data, successful research in developing dependable processes for computing “evapotranspiration”¹⁰ from satellite images, and the need for evapotranspiration data by state water resources entities such as the Idaho Department of Water Resources.

Western state and local governments found the high-resolution thermal imagery provided by Landsat 7 to be particularly useful in the early detection of water stress in crops and in tracking sediment and chemical transport in lakes and coastal waters. As coverage and estimates of water consumption became more reliable, local governments in many arid regions came to rely heavily on the thermal images and began to use thermal image data to improve their management of over-subscribed water resources.

The importance of thermal imaging to the user community was established and had been addressed in earlier Landsat satellites. NASA Procedural Requirements (NPR) 7123.1A, “NASA Systems Engineering Processes and Requirements,” March 26, 2007, requires that NASA programs and projects analyze stakeholders (which includes relevant user communities) expectations using a process to establish a set of measures by which overall system or product effectiveness will be judged and customer satisfaction will be determined. Once established, the project is required to obtain commitments from stakeholders that the resultant set measures is acceptable. The process is then used to transform the baselined stakeholder expectations into unique, quantitative, and measurable technical requirements.

NASA Removed Thermal Imaging Capability from LDCM Requirements

In 2002, NASA management removed the thermal imaging capability from the LDCM requirements baseline on the basis of contractors' recommendations even though Project management recommended retaining the capability. However, in removing the thermal

¹⁰ USGS defines *evapotranspiration* as the water lost to the atmosphere from the ground surface, evaporation from the capillary fringe of the groundwater table, and the transpiration of groundwater by plants whose roots tap the capillary fringe of the groundwater table.

imaging capability, NASA management disregarded the Landsat data continuity goals of the LRSP Act of 1992 and the increasing reliance on the data by the user community. The thermal infrared spectral band is a legacy capability present on the last four successfully launched Landsat missions (Landsats 3, 4, 5, and 7), providing data dating back to 1978. Sufficient consistency with the data archive provided by previous Landsats allows effective monitoring of land and water usage and consumption trends, tracking of sediment and chemical transport, and research in “global and regional change detection.”

Contractors Recommend Exclusion of Thermal Capability. In FY 2000, a year after the launch of Landsat 7, NASA, in cooperation with USGS/DOI, began formulation of LDCM as a commercial data buy. Early in the formulation process, NASA, in an attempt to commercialize Landsat development, awarded two study contracts to develop preliminary designs for a system that would provide data continuity. The contractors, as potential commercial partners with NASA, considered and analyzed various designs and took different approaches to a thermal instrument.

The first contractor proposed a cryo-cooler system, citing excellent performance but significant impact to the spacecraft’s mass, power, propulsion, and possibly reflective instrument performance. The second contractor proposed a microbolometer-based system, citing anticipated adequate performance but with newer technology that was not flight proven in Earth remote sensing in a system whose 5-year reliability was unproven, and recommended that the capability only be included as a technology demonstration. Both contractors recommended that NASA not include the thermal capability unless classified as experimental (technology demonstration) with the admonition of “best performance within cost constraints.”

The contractors were concerned with levying firm requirements on a microbolometer-based instrument because of its technological immaturity. However, reverting to mature technologies (active cryo-cooling) would have required significant re-baselining of the spacecraft architecture. Both study contractors indicated that the thermal imaging capability was not “commercially viable” and that the return on investment for thermal image data, based on their assessment of the limited number of users, was far too low for consideration. Because neither contractor had determined a customer base supporting commercial applications, both recommended NASA not include the thermal capability with current LDCM requirements.

LDCM Project Management Recommends Inclusion of Thermal Capability. In August 2002, LDCM Project management reported the results of these studies to the Associate Administrator for Earth Science¹¹ and recommended inclusion of the thermal capability on LDCM “as a technology demonstration with relaxed lifetime requirements.” Project management stated that the “microbolometer-based instrument is the only viable LDCM approach” and “should be flight proven for Earth remote sensing missions.” Project management also determined that the microbolometer approach had some flight

¹¹ The Science Mission Directorate was established in 2004 from the merger of the former Office of Space Science and Office of Earth Science.

heritage within NASA's Thermal Emission System aboard the Mars Odyssey mission spacecraft and reasoned that it was technically feasible with the current technology. LDCM Project management reported that the mass, power, schedule, and cost of the cryo-cooled instrument would result in significant impacts to mission and architectures. These findings were validated in a study by Goddard's Instrument Synthesis and Analysis Laboratory.

Despite LDCM Project management's analyses and recommendations, the Associate Administrator for Earth Science removed the thermal imaging capability from the LDCM requirements baseline on the basis of the assessments provided by the potential commercial partners. As Project formulation continued, further implementation approaches were explored for LDCM, including incorporating Landsat capabilities on NPOESS. The thermal imaging capability remained unsupported and unfunded. Since the development of NASA's FY 2002 budget, neither budget requests nor its appropriated budgets included funding for a thermal capability for LDCM. It was not again addressed until the FY 2007 budget, but "due to the expected high cost and low priority of the thermal capability relative to the other Landsat instrument spectral requirements,"¹² it was not included. Development of the FY 2008 budget also did not include funding for the thermal capability "due to the magnitude of the likely schedule impact that was indicated by the 2007 thermal development studies."¹³

System-Level Requirements Change to Reinstate Thermal Capability Late in Acquisition Life Cycle

In 2007, congressional concerns "that the LDCM mission does not include a thermal infrared sensor to provide important data for surface and ground water information"¹⁴ prompted NASA to initiate technical and programmatic studies on developing a thermal imaging capability. NASA's analyses indicated that the schedule for development of a thermal instrument would drive the overall LDCM mission schedule, delay the launch date significantly, and increase the potential Landsat data gap. Development of a thermal capability was estimated to take 48 months, plus an additional 9 months for satellite integration and testing.

In July 2007, NASA awarded the contract for LDCM's primary instrument, the Operational Land Imager (OLI), to Ball Aerospace and Technologies Corporation. During the preliminary phase of the OLI design, the LDCM Project office began procurement of the LDCM launch vehicle through the NASA Kennedy Space Center's Launch Services Program.

¹² "NASA Report to Congress Regarding LDCM Continuity," April 2008.

¹³ "NASA Report to Congress Regarding LDCM Continuity," April 2008.

¹⁴ FY 2008 Departments of Commerce and Justice, Science, and Related Agencies Appropriations Bill; Calendar No. 259, 110th Congress Report to Senate (June 29, 2007).

In May 2008, during the LDCM Project's life cycle reviews to transition into Phase B, the LDCM SRB expressed concerns with the possibility that, because the Project did not have system-level Spacecraft and Mission Operations requirements fully defined or signed by NASA and USGS, system-level requirements could change, resulting in technical, cost, and schedule impacts to mission execution. In addition, the SRB expressed concerns that the Project had a lingering requirement for the spacecraft to accommodate TIRS and continued to conduct feasibility studies to include the instrument on LDCM. The SRB stated, "continued requests for technical, cost, and schedule plans and estimates for adding the TIRS instrument distracts the Project leadership and engineering personnel from focusing on implementing the current baseline mission, which adds risk."

LDCM Project management had recognized the requirement for spectral data continuity and included it in the LDCM Technical, Schedule, and Cost Control Plan (May 5, 2008), mission requirements for LDCM. Specifically, both the Plan and the LRSP Act of 1992 state that the data acquired by LDCM shall be sufficiently consistent with that provided by Landsat 7 to allow comparisons for global and regional change detection and characterization. The NASA Authorization Act of 2008 (dated May 15, 2008) directed NASA to incorporate the thermal imaging capability on LDCM and provide the plan to Congress not later than 60 days after the date of enactment of the Act. Specifically, Section 205, "Landsat Thermal Infrared Data Continuity," states:

In view of the importance of Landsat thermal infrared data for both scientific research and water management applications, the Administrator shall prepare a plan for ensuring the continuity of Landsat thermal infrared data or its equivalent, including allocation of costs and responsibility for the collection and distribution of the data, and a budget plan. As part of the plan, the Administrator shall provide an option for developing a thermal infrared sensor at minimum cost to be flown on the Landsat Data Continuity Mission with minimum delay to the schedule of the Landsat Data Continuity Mission.

Though TIRS development was under way, as of June 1, 2009, NASA had not provided a formal plan to Congress in response to the Act. However, the FY 2009 Omnibus Appropriations (PL 111-8) provided NASA \$10 million to initiate development of TIRS and directed NASA to identify the earliest and least expensive development approach and flight opportunity for TIRS. In addition, NASA's American Recovery and Reinvestment Act program final plans (dated May 15, 2009) include funding for a Critical Design Review¹⁵ of TIRS. As of June 10, 2009, a specific dollar amount had not been identified because the Agency is awaiting Congress' approval of its Operating Plan.

¹⁵ The Critical Design Review demonstrates that the maturity of the TIRS design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test.

Spacecraft Costs Increased as a Result of Late Changes to Requirements

In testimony before the Subcommittee on Space and Aeronautics on April 3, 2008, GAO highlighted cost and schedule risks resulting from requirement changes in NASA's Ares I Crew Launch Vehicle and the Orion Crew Exploration Vehicle Projects.¹⁶ Likewise, the LDCM Project has incurred cost increases and may experience schedule delays associated with spacecraft modifications needed to accommodate a change in baseline, system-level requirements after NASA awarded the spacecraft contract. NASA awarded the firm-fixed price contract for the spacecraft in April 2008 through the Agency's Rapid Spacecraft Development Office (RSDO). At the time of award, LDCM Project management designed or "scarred" the spacecraft to account for the possible late addition of a microbolometer-based—not a cryo-cooled—thermal instrument. Yet, in August 2008, 4 months after award, NASA management made the decision to use the cryo-cooled TIRS instrument, which required a substantial redesign of the spacecraft in development. Consequently, spacecraft costs increased as a result of NASA-directed design changes.

Project management estimated that the addition of cryo-cooled thermal imaging capability to LDCM would cause spacecraft modification costs, which do not include any costs associated with the development of the TIRS instrument, of \$11 million to \$20 million and possible delays to an already delayed mission. However, historically, NASA has made changes to Project requirements, resulting in cost and schedule impacts. The following table illustrates NASA's RSDO spacecraft cost growth and launch readiness date (LRD) delays for similar projects with the respective reason or cause for each. Each projects' initial projection of cost and schedule was significantly less than the actual.

¹⁶ Government Accountability Office. "NASA: Ares I and Orion Project Risks and Key Indicators to Measure Progress" (GAO-08-186T, April 3, 2008). Ares I and Orion Projects are being developed by NASA's Exploration Systems Mission Directorate under the Constellation Program.

Table. Rapid Spacecraft Development Office Spacecraft Development History							
Spacecraft	Spacecraft Development Cost (\$ Millions)			Launch Readiness Date Delay (Months from Project Inception)			Reason/Cause of Cost and Delay
	Estimate	Actual	Difference	Planned ATP	Actual ATP	Delay	
ICESat (Ice, Cloud, and Land Elevation Satellite)	\$39.40	\$68.20	\$28.80	41.0	60.0	19	Technical changes/ adding mission operations scope, and GFE instrument delays
GLAST (Gamma-Ray Large Area Space Telescope)	\$55.60	\$102.60	\$47.00	48.5	70.0	21.5	Immature spacecraft requirements definition when delivery order awarded
Swift (Gamma-Ray Burst Detecting Satellite)	\$36.30	\$46.40	\$10.10	46.7	58.3	11.6	GFE instrument delays
NPOESS Preparatory Project	\$75.35	\$153.87	\$78.52	50.0	96.0	46	Changes in capabilities and lateness of instruments
LDCM	\$116.30	TBD	TBD	38.0	TBD	TBD	Change/adding instrument requirements after delivery order awarded

ATP - Authority to Proceed; GFE - Government furnished equipment.

Throughout the formulation phase of the acquisition, LDCM Project management briefed NASA management on the implementation risks of changing baselined system-level requirements and integrating a cryo-cooled thermal instrument after contract award. Specifically, Project management reported the following to Goddard and Agency Program Management Councils:

- Given that the cryo-cooled TIRS instrument design is too immature to enable detailed definition of the spacecraft interface in time to support the spacecraft development schedule, there is a possibility that there may be substantial spacecraft or TIRS redesign if the LDCM is directed to fly TIRS. The scarring of the spacecraft as defined in the contract is based on micro-bolometer technology, which did not involve cryo-cooler or larger than expected radiators.
- Latest TIRS design exceeds project-required volume and intrudes into the OLI field of view. Given that a TIRS instrument may be located within thermal line-of-sight of the OLI, there is a possibility of a significant redesign to the OLI thermal control system.

The Project's preliminary integrated master schedule indicates that the late manifestation of this requirement has resulted in TIRS having the latest delivery time of all mission

elements and could therefore cause the entire LDCM Project schedule and launch to be delayed. Accordingly, on February 12, 2009, an independent review team was convened by the Earth Systematic Missions Program Manager. Their Assessment Summary, March 6, 2009, states that the TIRS development schedule is “very aggressive.” However, the review team also reported that “[t]he plan presented showed that risk, cost and schedule are already being actively managed.” The independent review team made several recommendations, to include the implementation of Earned Value Management for TIRS development and a plan to address funding for the instrument, to “increase the probability of a successful development effort meeting schedule and cost constraints.”

Recommendations, Management’s Response, and Evaluation of Management’s Response

Recommendation 3. The Associate Administrator for SMD should request an independent analysis of the impact on the spacecraft’s development cost and schedule due to the late change of LDCM requirements.

Management’s Response. The Associate Administrator for SMD concurred, stating that an independent analysis of LDCM’s development cost and schedule will be conducted in preparation for Key Decision Point-C, scheduled for October 2009.

Evaluation of Management’s Response. We consider management’s proposed action to be responsive. The recommendation is resolved and will be closed upon completion and verification of management’s corrective action.

Recommendation 4. The Associate Administrator for SMD should issue guidance affirming the need for Space Flight Programs and Projects to finalize system-level requirements prior to contract award.

Management’s Response. The Associate Administrator for SMD concurred with our recommendation. He noted that the requirement to quantify technical and programmatic risks is codified in NPR 7120.5D, “NASA Space Flight Program and Project Management Requirements,” March 6, 2007, and stated that SMD’s Management Handbook, released in February 2008, affirms the need for all programs and projects to follow that NPR through all mission phases and further noted that risk management approach, risk identification, and risk mitigations will be critically evaluated at all major program/project reviews and key decision points. In addition, he stated that the thermal infrared sensor (TIRS) requirements issue was identified and purposely mitigated by structuring the LDCM spacecraft request for proposal so as not to preclude its late introduction.

Evaluation of Management’s Response. We consider management’s actions, specifically, issuance of the Management Handbook affirming the provisions of NPR 7120.5D, to be responsive, and the recommendation is closed.

Recommendation 5. The Associate Administrator for SMD should re-emphasize the provisions of NPR 7123.1A, “NASA Systems Engineering Processes and Requirements,” which require that NASA programs and projects adequately consider stakeholder expectations and user community interests prior to contract award for development of any major mission element.

Management’s Response. The Associate Administrator for SMD concurred with the recommendation, noting that SMD is committed to working with the stakeholder community to develop missions that are responsive to scientific and other needs, as detailed in the SMD Management Handbook, published in 2008, and consistent with NPR 7123.1A. He further noted that the decision to make fundamental changes to a mission (e.g., descopes, launch slips, or cancellations) resides with SMD management, not the program or project, taking into consideration all stakeholder expectations, including congressional direction, and community interest. For LDCM, the Landsat Science Team was specifically tasked to prioritize a thermal imaging capability vis-à-vis a launch readiness date and the higher priority was placed on an earlier launch readiness date.

Evaluation of Management’s Response. The 2008 issuance of SMD’s Management Handbook includes numerous mechanisms for working with stakeholders. In 2002, despite LDCM Project management’s analyses and recommendations and stakeholder interest, the then-Associate Administrator for Earth Science removed the thermal imaging capability from the LDCM requirements baseline on the basis of assessments provided by potential commercial partners. Issuance of the SMD Management Handbook is consistent with NPR 7123.1A and adequately emphasizes SMD’s commitment to working with the stakeholder community. We consider management’s actions to be responsive, and the recommendation is closed.

Scope and Methodology

We performed this audit from August 2008 through August 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We gathered data and information from NASA Project personnel, NASA users of Landsat data, and external users to determine whether the Project was meeting, and would continue to meet, the intent, goals, and other provisions of the LRSP Act of 1992. We reviewed the NASA acquisition strategy used to acquire prior Landsats and compared it to the acquisition strategy for LDCM to determine whether there were any risks associated with the established acquisition and management processes. The acquisition strategy detailed in the acquisition plan was consistent with the memorandum of understanding between NASA and U.S. Geological Survey (USGS) for LDCM. The acquisition strategy also addressed the possibility that a thermal infrared sensor (TIRS) instrument might be incorporated onto the LDCM mission during the development phase, even though NASA initially decided to forego including the legacy thermal capability, contrary to the data continuity goals of the LRSP Act of 1992.

We obtained, reviewed, and summarized the applicable provisions of the Land Remote Sensing Policy (LRSP) Act of 1992, NASA Authorization Acts of 2008 and 2009, LDCM Project plan, and pertinent policy documents. We evaluated and compared the mission, objectives, and goals of the LDCM Project, as stated in the Project plan with the goals set forth in the LRSP Act of 1992 and the NASA Authorization Act of 2008. We interviewed Project personnel to determine whether the Project was meeting, and would continue to meet, the intent, goals, and other provisions of the Acts. We reviewed documentation of Landsat 7 Life Projections, the impact of the scan line corrector failure, and Landsat Data Gap Study Team analyses. We obtained Landsat data use information from external users' Web sites to determine how they are using Landsat data, the uniqueness of Landsat, and the importance of thermal imaging to their operations. We interviewed NASA users of Landsat data to determine if they could use sources other than Landsat for their needs and what sources they would use if Landsat 5 and Landsat 7 failed before LDCM's launch readiness date. We evaluated current projected milestones for LDCM and most likely time of failure for Landsat 5 and Landsat 7 to determine potential gap in image coverage. We interviewed Landsat Data Gap Study Team personnel and obtained supporting documentation to determine whether the team is adequately evaluating the feasibility of acquiring data from alternate data sources in the likely event of a gap in Landsat satellite coverage.

We obtained and reviewed the LDCM Project acquisition plan and related acquisition documentation. We compared the roles and responsibilities of management documented in the acquisition plan to those of the Interagency Agreement and NASA policies. We reviewed the NASA-USGS Interagency Agreement for LDCM to determine what changes have occurred in NASA's roles and responsibilities. We attempted to identify NASA and other agency projects that used the selected acquisition strategy and contract type. We reviewed the acquisition cost and development schedule for all elements of the LDCM Project. We reviewed the Earned Value Management System and data as it pertains to the OLI contract. We reviewed the results and recommendations of the LDCM Standing Review Board for the System Requirements Review, Mission Definition Review, and Preliminary Non-Advocate Review.

We obtained and reviewed the National Science and Technology Council (NSTC), an Executive Office of the President, "A Plan for a U.S. National Land Imaging Program," August 2007 report; "NASA Report to Congress Regarding Landsat Data Continuity Mission (LDCM) data Continuity," April 2008; and Presidential Decision Directive/NSTC-3 "Landsat Remote Sensing Strategy," May 1994; and other documentation to determine NASA's role regarding the various Landsat satellites. We interviewed NASA users of Landsat data to determine if NASA would be adversely impacted if Landsat became an operational program with DOI as the lead agency. We interviewed the USGS/DOI representative to determine the status of National Land Imaging Program (NLIP).

Earned Value Management. We found that management had implemented an effective Earned Value Management System to improve management of cost and schedule risks. LDCM Project management's Earned Value Management System, managed through the Defense Contract Management Agency, formally complied with the standards of the American National Standards Institute/Electronic Industries Alliance - 748 (ANSI/EIA-748), "Standard for Earned Value Management Systems," June 1998,¹⁷ as required by NPR 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007. Project management also implemented Earned Value Management in accordance with the, "LDCM Project Plan," May 2008,¹⁸ as required by NPR 7120.5D.

Use of Computer-Processed Data. We used computer-processed data for historical Rapid Spacecraft Development Office Spacecraft cost growth and LRD delays, which we verified to records maintained by the LDCM Deputy Resource Manager. We also used computer-processed data from Review Item Discrepancies (RIDs) tracked by Center management. We tracked each of the 28 RIDs and issues through the risk identification, reporting, and mitigation process. We believe the data to be reliable based upon our confirmation of spacecraft costs and tracked RIDs and issues.

¹⁷ ANSI/EIA-748-B was published in June 2007.

¹⁸ The Project also implemented the Earned Value Management System in accordance with the "Technical, Schedule and Cost Control Plan," May 5, 2008, a document referenced in the "LDCM Project Plan."

Review of Internal Controls

We identified and tested LDCM acquisition processes for compliance with NASA's policies and procedures. We reviewed Goddard Space Flight Center (Goddard) procedures for controlling LDCM risks and for conducting critical milestone reviews of contractor performance. We found that LDCM Project management effectively identified, reported, and mitigated LDCM acquisition risks. Our review of the Project's internal controls found that Project management established a risk assessment process that complied with NASA Procedural Requirements (NPR) 8000.4, "Risk Management Procedural Requirements," April 25, 2002. As of February 5, 2008, Project management managed 19 unique review item discrepancies and 9 issues (a total of 28 unique risks), which they reported to Goddard management. We tracked the 28 risks through the risk identification, reporting, and mitigation process. The Project's Risk Management Board unanimously closed 8 of the 28 items, leaving 20 open or ongoing items to be addressed in Phase B of the Project's life cycle reviews. We did not identify any NASA internal control weaknesses

Prior Coverage

During the last 5 years, the Government Accountability Office (GAO) and the NASA Office of Inspector General (OIG) have issued four reports of particular relevance to the subject of this report. Unrestricted reports can be accessed over the Internet at <http://www.gao.gov> (GAO) and <http://oig.nasa.gov/audits/reports/FY09> (NASA).

Government Accountability Office

"Military Space Operations: Common Problems and Their Effects on Satellite and Related Acquisitions" (GAO-03-825R, June 2, 2003)

"NASA: Ares I and Orion Project Risks and Key Indicators to Measure Progress" (GAO-08-186T, April 3, 2008)

"Geostationary Operational Environmental Satellites: Acquisition Is Under Way, but Improvements Needed in Management and Oversight" (GAO-09-323, April 2, 2009)

National Aeronautics and Space Administration

Our office issued "More Stringent Entrance Criteria Needed for Project Life-Cycle Reviews" (Report No. IG-09-004, October 31, 2008). We determined that the Orion Project Office (Project Office) conducted a Phase A life-cycle review with a vehicle configuration (606 vehicle) that was not at the proper maturity level to proceed to Phase B. Specifically, a required engineering design analysis conducted prior to the life-cycle review disclosed that the vehicle configuration required a reduction in weight, power, and instrumentation. However, instead of delaying the Phase A life-cycle review until the correct vehicle configuration (607 vehicle) could be reviewed, the Project Office proceeded with a nonconforming vehicle. As a result, a significant portion of the vehicle

configuration that eventually did proceed to Phase B did not receive the benefit of a Phase A life-cycle review, nor was it completely evaluated for compliance with requirements.

Our office also issued “Final Memorandum of NASA’s Management of the Flight Project for the Geostationary Operational Environment Satellite Series-R Program” (Report No. IG-08-006, December 19, 2007). We determined that the responsible NASA Program Management Councils for the GOES-R Program was effectively reviewing project issues and progress and that NASA’s GOES-R Flight Project Office had procedures and processes in place to adequately identify, mitigate, and report technical risks in accordance with NASA policy. However, we found that NASA’s ability to effectively procure, manage, and execute the GOES-R Flight Project was impeded by the level of oversight provided by NOAA and Commerce. Specifically, increased management oversight by NOAA and Commerce delayed the release of requests for proposals for the GOES-R spacecraft. The delays were caused by Commerce implementing processes that were in conflict with the current memorandum of understanding (MOU) between Commerce and NASA, dated June 15, 2007. The MOU states that guidance for GOES-R Program processes will be derived from NASA Procedural Requirements (NPR) 7120.5D, “NASA Space Flight Program and Project Management Requirements,” March 6, 2007. The process followed for the spacecraft request for proposal conflicted with NPR guidance and the resultant delays increased the risks to GOES-R Program development and the GOES-R launch schedule.

MANAGEMENT COMMENTS

National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001



AUG 06 2009

Reply to Attn of: SMD/Strategic Integration and Management Division

TO: Assistant Inspector General for Auditing
FROM: Associate Administrator for Science Mission Directorate
SUBJECT: Response to the Draft Audit Report, "The Landsat Program is not Meeting the Goals and Intent of the Land Remote Sensing Policy Act of 1992"

I appreciate the opportunity to comment on your draft audit report entitled "The Landsat Program is not Meeting the Goals and Intent of the Land Remote Sensing Policy Act of 1992." (Assignment No. A-08-019-00).

The Enclosure contains our comments on the draft report, including the recommendations in the draft report. We welcome and encourage further dialog with the Office of the Inspector General to provide further explanation of our response to this draft.

A handwritten signature in black ink, appearing to read "E. Weiler".

Edward J. Weiler

Enclosure

**Agency Program Management Response to the Draft Audit Report
“The Landsat Program is Not Meeting the Goals and Intent of the Land Remote
Sensing Policy Act of 1992”
July 2009**

Finding A: Landsat’s Ability to Meet Congressional Goals in Hampered by a Lack of Accountability

Recommendation 1: The Associate Administrator for SMD should coordinate with USGS to assist in developing a plan for continuous provision of Landsat-type data, should Landsat 7 and Landsat 5 become inoperable before LDCM is operational.

Management’s Response: Concur with the recommendation. Since the April 2008 Report to Congress on LDCM, USGS has conducted further analysis of fuel usage for both Landsat 5 and Landsat 7. As reported to Congress in June 2009, we believe that Landsat 7 has sufficient fuel to operate through 2012 and perhaps longer. In addition, the Landsat Data Gap Study Team continues to conduct assessments of the viability of alternative data sources should Landsat 5 or Landsat 7 fail before LDCM data is available. NASA will coordinate with USGS to document a formal plan for the partial mitigation of the potential data gap by August 31, 2010.

Recommendation 2: The Associate Administrator for SMD should coordinate with USGS to assist in establishing the National Land Imaging Program, to include developing detailed plans for future Landsat acquisitions and agency funding responsibility for the program.

Management’s Response: Concur with the recommendation. In August 2007, the Office of Science and Technology Policy issued a report, “A Plan for a U.S. National Land Imaging Program”, calling for this program. NASA was an active participant in the development of the report and continues to meet on a monthly basis with USGS to discuss implementation. Full implementation by USGS is on hold pending legislation authorizing the program and the subsequent appropriation of funds. Consistent with the 2009 Omnibus Appropriations Act, NASA will work with OSTP and USGS to plan for a follow-on mission to LDCM in time to inform the President’s FY2012 Budget Request. This information is due to OMB by September 1, 2010.

Finding B: Reinstatement of Thermal Imaging Increased Costs and May Further Delay Launch

Recommendation 3: The Associate Administrator for SMD should request an independent analysis of the impact on the spacecraft’s development cost and schedule due to the late change of LDCM requirements.

Management's Response: Concur with the recommendation. An independent analysis of LDCM's development cost and schedule will be conducted as a matter of course in preparation for Key Decision Point-C, currently scheduled for October 2009.

Recommendation 4: The Associate Administrator for SMD should issue guidance affirming the need for Space Flight Programs and Projects to quantify technical and programmatic risks associated with undefined system-level requirements, which can impact cost and schedule, prior to contract award for any major mission element.

Management's Response: Concur with recommendation. The requirement to quantify technical and programmatic risks (as well as cost, schedule, management, and safety risks) is codified in NASA Procedural Requirement 7120.5D, "NASA Space Flight Program and Project Management Requirements". SMD's Management Handbook, released in February 2008, affirms the need for all programs and projects to follow this NPR through all mission phases. Accordingly, risk management approach, risk identification, and risk mitigations have been and will continue to be critically evaluated at all major program/project reviews and key decision points. In the case of LDCM, the Thermal Infrared Sensor (TIRS) requirements issue was identified and purposely mitigated by structuring the LDCM spacecraft RFP so as not to preclude its late introduction, thereby minimizing subsequent cost impact. It is requested that the recommendation be closed since SMD has taken all actions recommended by the OIG.

Recommendation 5: The Associate Administrator for SMD should re-emphasize the provisions of NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," which require that NASA programs and projects adequately consider stakeholder expectations and user community interests prior to contract award for development of any major mission element, revisiting these expectations and interests whenever fundamental changes are made to the mission implementation approach.

Management's Response: Concur with the recommendation, but note that these decisions are the responsibility of NASA Headquarters, not the program or project. SMD is committed to working with our stakeholder community through numerous mechanisms to develop missions that are responsive to scientific and other needs, as detailed in the February 2008 SMD Management Handbook and consistent with NPR 7123.1A. The decision to make fundamental changes to a mission (e.g. descopes, launch slips, or cancellations) resides with SMD management, taking into consideration all stakeholder expectations, including Congressional direction, and community interest. For LDCM, the Landsat Science Team was specifically tasked to prioritize a thermal imaging capability vis-à-vis a launch readiness date and the higher priority was placed on an earlier launch readiness date. It is requested that the recommendation be closed since SMD has taken all actions recommended by the OIG.

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