

LDCM Requirements & Specifications

presented by

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at the

Inaugural Landsat Science Team Meeting

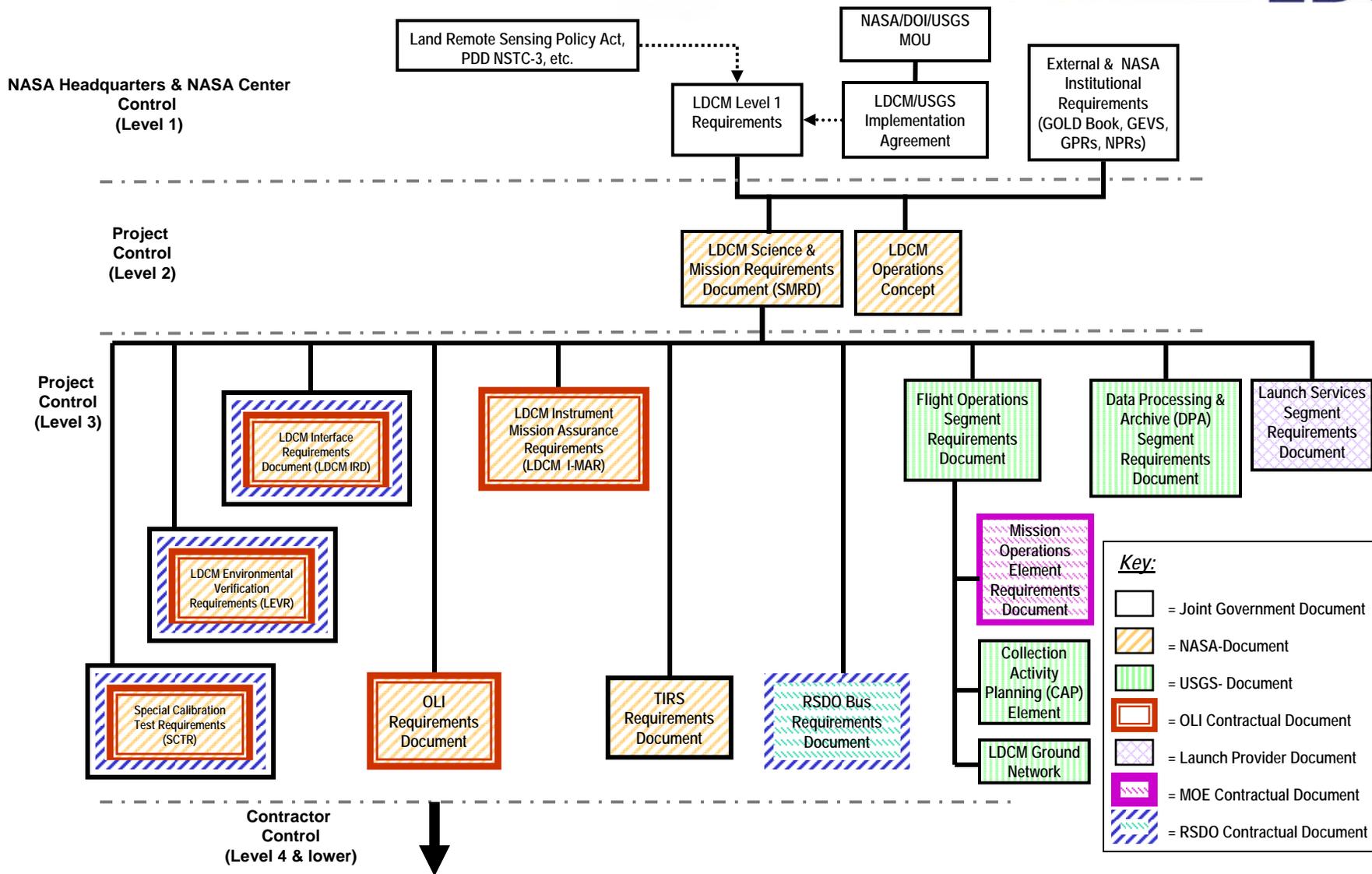
USGS EROS

Sioux Falls, SD

January 09, 2007

LDCM Requirements Hierarchy

LDCM



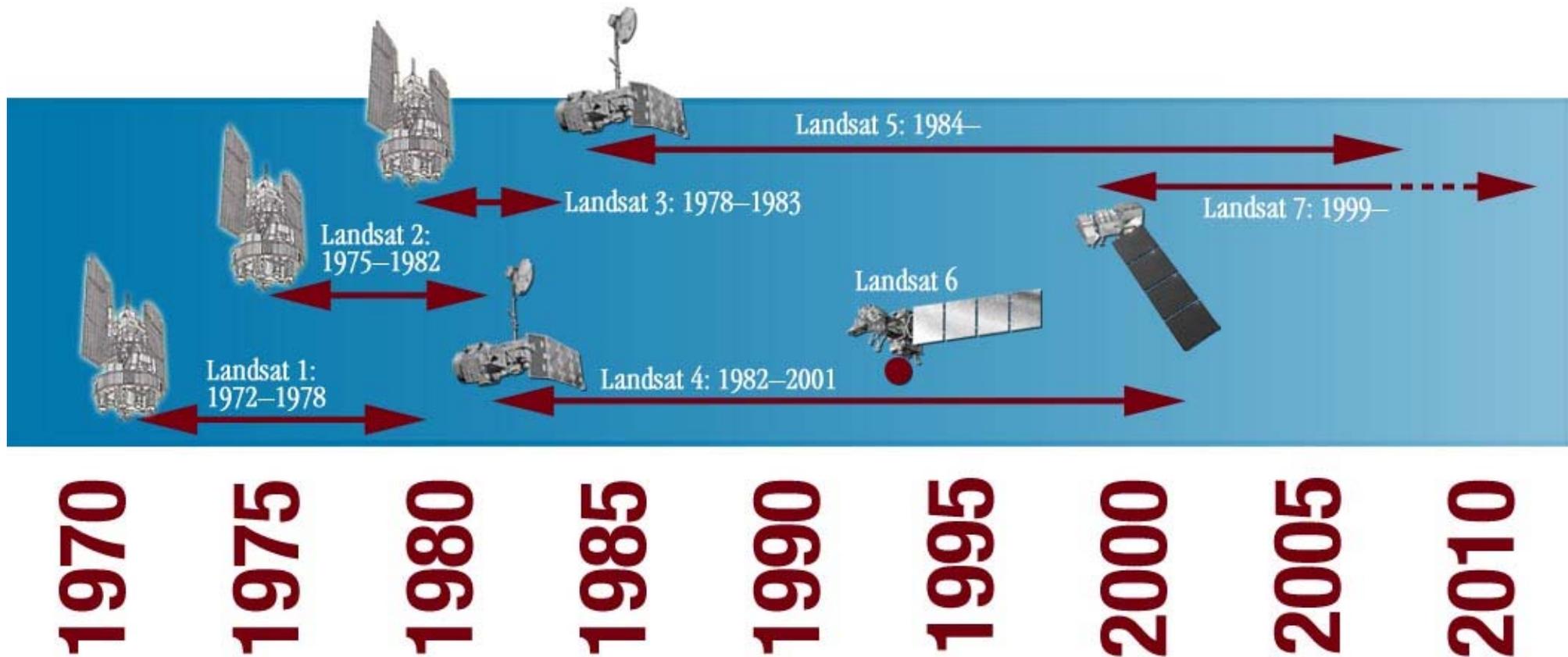
Sources of LDCM Requirements

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- **LDCM requirements derive from:**
 - The societal benefits of continuing land cover / land use change observations
 - The Land Remote Sensing Policy Act of 1992
 - Landsat program heritage and the Landsat 7 benchmark
 - LDCM mission objectives
 - Previous LDCM implementation attempts & the LDCM Data Specification
 - The state of current technology (e.g., ALI tech demo)
 - Guidance from the Executive Office of the President (OSTP memoranda)
 - An eye to the future of land observations from space

30+ Years of Continuous Land Observations

LDCM



Importance of Landsat Data Continuity

LDCM

- Land cover and land use are changing at rates unprecedented in human history with profound societal consequences
 - Food and fiber production
 - Water consumption and quality
 - Weather and climate change
 - Human health

Dubai, United Arab Emirates



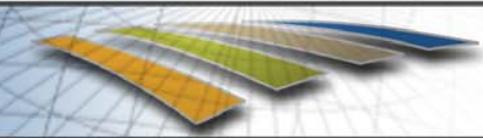
Landsat 1 MSS, 1973



Landsat 4 TM, 1990



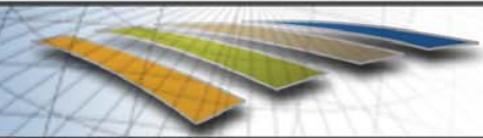
Landsat 7 ETM+, 2006

The Land Remote Sensing Policy Act of 1992

LDCM

- **The Act (P.L. 102-555) direct Landsat Program Management to study options for a successor mission to Landsat 7 that:**
 - **“adequately serve the civilian, national security, commercial, and foreign policy interests of the United States”**
 - **“maintain data continuity with the Landsat system”**
 - **“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”**

- **The Act defines data continuity as:**
 - **“the continued acquisition and availability of unenhanced data which are, from the point of view of the user --**
 - (A) 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; and**
 - (B) compatible with such data and with methods used to receive and process such data.”**

The image shows a stylized representation of Landsat satellite data, with several overlapping, curved bands in shades of yellow, green, and blue, set against a grid background. This graphic is positioned to the left of the main title.

Importance of Landsat Data Continuity

LDCM

- **The importance of the Landsat program derives not only from current sensor observations, but also from:**
 - **Rigorous calibration / cross-calibration**
 - **A long-term data archive**
 - The DoI / USGS preserves a 33-yr archive of Landsat data in the National Satellite Land Remote Sensing Data Archive (NSLRSDA) at USGS EROS, Sioux Falls, SD
 - DoI is the only federal agency with a mandate to preserve this archive for public access (the Land Remote Sensing Policy Act of 1992)
 - No other nation is committed to preserving a comparable record of the global land surface
 - **A global data acquisition strategy**
 - No other nation's satellite system is designed or operated to achieve even annual global coverage at the Landsat scale
 - **An open data policy**
 - DoI provides non-discriminatory public access to the Landsat data archive
 - No restrictions are placed on Landsat data sharing

The Landsat 7 Benchmark

LDCM

- **Landsat 7 has established a benchmark for its successor mission with respect to:**
 - **Sensor and system performance, characterization, and calibration**
 - On-orbit characterization and calibration over mission life via an Image Assessment System (IAS)
 - **Mission operations and data acquisition**
 - Archive-driven, systematic , substantially cloud-free, global coverage on seasonal basis - The Long Term Acquisition Plan (LTAP)
 - **Data archival and data product distribution**
 - USGS archive provides nondiscriminatory access
 - Data products are available in consistent formats on consistent media
 - Secondary distribution is unrestricted

Future Planning

LDCM

- **National Science and Technology Council (NSTC) Future of Land Imaging - Interagency Working Group (FLI-IWG)**
 - **OSTP Chair**
- **International Group on Earth Observations (GEO) and the Global Earth Observing System of Systems (GEOSS)**
 - **Committee on Earth Observation Satellites (CEOS) and the Land Surface Imaging Constellation**
- **National Research Council Decadal Survey: Earth Science and Applications from Space: A Community Assessment and Strategy for the Future.**

The LDCM needs to serve as a foundation upon which future land imaging systems can be built

Level 1 LDCM Objective

LDCM

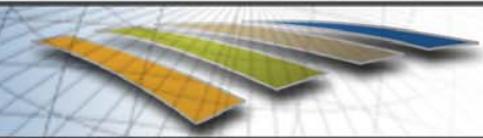
- **The LDCM, consistent with U.S. law and government policy, will continue the acquisition, archival, and distribution of multi-spectral imagery affording global, synoptic, and repetitive coverage of the Earth's land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time**
- **The following are the major mission objectives:**
 - **Collect and archive medium resolution (circa 30 m spatial resolution) multi-spectral image data affording seasonal coverage of the global land mass for a period of no less than five years.**
 - **Ensure that LDCM data are sufficiently consistent with data from the earlier Landsat missions, in terms of acquisition geometry, calibration, coverage characteristics, spectral characteristics, output product quality, and data availability to permit studies of land cover and land use change over multi-decadal periods.**
 - **Distribute LDCM data products to the general public on a nondiscriminatory basis and at a price no greater than the incremental cost of fulfilling a user request.**

What Are Level 1 Requirements

LDCM

- **Traditional:**
 - **A contract / commitment between a NASA field center (GSFC) and NASA HQ with respect to the technical implementation of a mission**
 - NASA Jargon
 - Field center manages the “project”
 - NASA HQ manages the “program”
 - **Changes to Level 1 requirements require a waiver from NASA HQ**
- **LDCM Specific**
 - **Joint NASA / USGS document; includes technical commitments between NASA and USGS**
 - NASA HQ & USGS HQ approval
 - **LDCM project-specific requirements**
 - Not all-encompassing Landsat program requirements
 - Does not include requirements for past or future Landsat satellite systems

Note: Level 1 requirements are not the requirements provide to the bidders in the RFP; the requirements in the RFP should trace to the Level 1 requirements.

1.0 Introduction

LDCM

1.1 Background

1.2 Strategic Importance

1.3 Scope

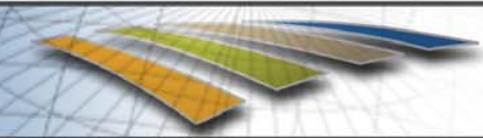
1.4 Major LDCM Mission Objectives

The goal of the LDCM, consistent with U.S. law and government policy, is to continue the acquisition, archival, and distribution of multi-spectral imagery affording global, synoptic, and repetitive coverage of the Earth's land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time

The following major mission objectives follow from this goal:

- Collect and archive medium resolution (*circa* 30 m ground sample distance) multi-spectral image data affording seasonal coverage of the global land mass for a period of no less than five years.
- Ensure that LDCM data are sufficiently consistent with data from the earlier Landsat missions, in terms of acquisition geometry, spatial resolution, calibration, and coverage characteristics, to permit studies of land cover and land use change over multi-decadal periods.
- Distribute LDCM data products to the general public on a nondiscriminatory basis and at a price no greater than the incremental cost of fulfilling a user request.

1.5 Scientific and Operational Goals

1.0 Introduction (cont.)

LDCM

1.6 Definitions

Data Products

Digital LDCM images that have been processed for reformatting, radiometric correction, pixel geolocation, registration to a cartographic projection, and/or orthorectification along with associated telemetry data and metadata.

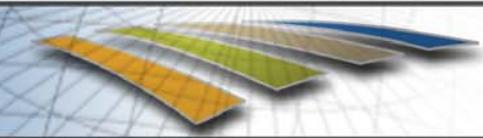
WRS-2

The Second World Wide Reference System (WRS-2): A path/row coordinate system used to define the ground tracks of the Landsat 4, Landsat 5, and Landsat 7 satellites as well as to catalog the image data acquired from these satellites (Jim Storey has written appendix to better describe WRS-2)

Scene

A set of LDCM data or an LDCM data product affording an 185-km-cross-track-by-180-km-along-track multispectral image of the earth surface with the geolocations of the image center and corner points corresponding to a path/row designation in WRS-2.

Note: WRS-2 and Scene are defined as devices for specifying requirements

2. Minimum Mission Success Requirements**LDCM**

2.1 Mission Lifetime

5 years

2.2 Consumable Resources

10 years

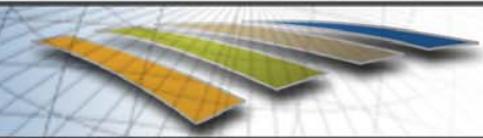
2.3 Earth Spatial-Temporal Coverage

- multi-spectral digital image data affording seasonal coverage of the global land mass.

2.4 Landsat Data Consistency

Sufficiently consistent with ETM+ data / the “mother” requirement

Note: More detail than conventional

2.4.1 Acquisition Geometry & 2.4.2 Coverage**LDCM**

2.4.1.1 World-Wide Reference System

The LDCM shall collect image data referenced to the second World Wide Reference System (WRS-2).

2.4.1.2 Equatorial Observation Time

Along each WRS-2 path, the LDCM shall be capable of imaging an area centered on the earth equator at a mid-morning local solar time.

2.4.2 Coverage Characteristics

The LDCM shall be capable of imaging any sun-lit area within the WRS-2 coverage area at least once every 16 days.

2.4.3 Spectral Characteristics

Table 1. Required Spectral Bands and Spatial Resolution

#	Band	Minimum Lower Band Edge (nm)	Maximum Upper 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

* Contingent upon requirement trades between program elements, technical requirements, and mission risk as part of the LDCM procurement.

2.4.4 Output Product Quality

LDCM

2.4.4.1 Radiometric Performance

The LDCM shall provide radiometric accuracy, dynamic range, and precision sufficient to detect land cover change using historic Landsat data.

2.4.4.2 Geometric Performance

The LDCM shall provide geolocation knowledge, band to band registration, and internal geometric accuracy sufficient to detect land cover change using historic Landsat data.

2.4.5 Data Availability

LDCM

2.4.5.1 Public Access

The LDCM shall allow the general public to search the LDCM data archive and order LDCM data products on a nondiscriminatory basis per U.S. Code Title 15, Chapter 82.

2.4.5.2 Algorithm Release

The LDCM shall document and publicly release all algorithms used to create LDCM data products.

2.4.5.3 Scene Collection Rate

The LDCM shall collect and provide to the U.S. archive image data and associated telemetry covering a daily (24 hour) average of at least 400 WRS-2 scenes as averaged over the period covering each cycle of WRS-2 paths.

2.4.5 Data Availability (cont.)

LDCM

2.4.5.4 Data Product Generation and Distribution

The LDCM shall be capable of generating and distributing at least 400 WRS-2 scene-equivalent orthorectified LDCM data products per day.

2.4.5.5 International Cooperator Support

The LDCM shall be capable of transmitting image data and associated telemetry to ground receiving stations operated by International Cooperators.

2.4.5.6 Priority Scheme

The LDCM shall collect priority image data.

**Everything Else****LDCM**

- 3. EXTERNAL AGREEMENTS**
- 4. INTERNAL AGREEMENTS AND DEPENDENCIES**
- 5. LDCM EDUCATION AND PUBLIC OUTREACH**
- 6. TAILORING**
- 7. REQUIRED APPROVALS**
- 8. REFERENCES**