SECTION J OF RFP5-12345-JLB
ATTACHMENT B

Landsat Data Continuity Mission (LDCM)
Implementation Phase

Data Specification

January 6, 2003

Goddard Space Flight Center
Greenbelt, Maryland 20771

SECTION J OF RFP5-12345-JLB
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DOCUMENT REVISION HISTORY

Document Title: Landsat Data Continuity Mission (LDCM) Implementation Phase Data Specification			
Issue	Date	Pages Affected	Description
Initial 427-14-01-003	10-04-02		
427-14-01-003 RFP Review Version I	11-08-02	All	CCRs: 298, 315, 317, 318, 319, 324, 325, 326, 328, 329, 331, 332, 333, 344, 349, 354
427-14-01-003 RFP Review Version II	12-16-02		CCRs: 316, 348, 360, 361, 362, 372, 374, 376, 387, 388, 402
427-14-01-003 Baseline Version	01-06-03		

CONTRACT CHANGE HISTORY

Mod. #	Date	CCR #	Date	Section(s)

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Introduction

1.1 Background

The Land Remote Sensing Policy Act of 1992 requires U.S. Government Landsat Program Management to "assess options for a successor land remote sensing system to Landsat 7." The act further requires that the assessment of options consider the ability to "maintain data continuity with the Landsat system" and to "incorporate system enhancements ... which may potentially yield a system that is less expensive to build and operate, and more responsive to data users." The data requirements listed herein derive from the following premise: The LDCM will be required to provide multispectral digital image data for global coverage of the Earth's land mass on a seasonal basis and in a manner that ensures continuity of the Landsat 7 mission.

1.2 Scope

This document specifies the data, and associated data services, required from the LDCM Contractor and includes all the verifiable requirements for these data and services. The contractor developed, owned, and operated system which meets this specification shall hereinafter be referred to as the "System."

1.3 Overview

The System performs the following basic functions (data rights for the delivered data are subject to the limitations and restrictions per the LDCM Data Policy):

- Acquisition of multispectral digital image data affording global coverage of the Earth's landmass on a seasonal basis. These data must be sufficiently consistent in terms of acquisition geometry, coverage characteristics, spectral characteristics, output product quality, and data availability to ensure continuity of the Landsat mission.

- Execution of developed algorithms and processing software to produce required LDCM Data Packages and Validation Data Products.

- Daily delivery of (on average) 250 WRS-2 scenes, within 24 hours nominally of acquisition, that fulfill the global coverage and quality requirements to the USGS/EDC Active Archive.

- Production and Delivery of Validation Data Products to the Government Calibration/Validation (Cal/Val) System to ensure data quality throughout the life of the contract and facilitate efficient data anomaly resolution.

- Periodic Transfer of NSLRSDA Data Packages to the Government long-term archive (NSLRSDA).

The high-level functionality of the LDCM is illustrated in Figure 1.3-1. The Contractor provides the system to deliver LDCM data to the USGS/EDC Active Archive and NSLRSDA. The Government will periodically provide a seasonality file (Section 3.0) that guides the collection of WRS-2 scenes that satisfy the LDCM global coverage requirement. Additionally the Government can request high priority scenes on short notice (Section 3.0) for special acquisitions. Based on a daily scene acquisition schedule developed by the Contractor, an average of 250 LDCM designated scenes are acquired and stored each day. The Contractor is required to use this data to generate the Data Packages and Validation Data Products that meet the spectral (Section 4.0), spatial (Section 5.0), radiometric (Section 6.0) and geometric (Section 7.0) data specifications.

The System transfers Active Archive Data Packages (Section 2.4) to the USGS/EDC Active Archive. These Packages contain data covering the daily average of 250 WRS-2 scenes, and any necessary information (ancillary, metadata) required to create Level 1 Data products (Level 1R, 1Gs, 1Gt – Section 2.5). The Packages are delivered nominally within 24 hours of LDCM Sensor Data acquisition. Receipt of the LDCM Active Archive Data Package(s) enables the USGS/EDC Active Archive to offer this imagery to the public and fulfill requests for Level 1 LDCM Data Products.

To ensure the integrity of the long term archival of LDCM digital image data, the System periodically provides (Section 2.3) NSLRSDA Data Packages consisting of all LDCM Level 0 data, ancillary and metadata to the NSLRSDA long term archive that are also sufficient for USGS/EDC to produce Level 1 Data products.

To ensure the Contractor's end-to-end responsibility for delivering LDCM quality data and enable the Government's independent validation and timely resolution of data product anomalies, the System is required to provide a limited and specific set of Validation Data Products on request from the Government's Cal/Val team (Section 2.5). The Validation Data Products are meant to ensure LDCM data quality specifications are continuously met throughout the lifetime of the contract. All of the VDPs are delivered to the Government Cal/Val System.

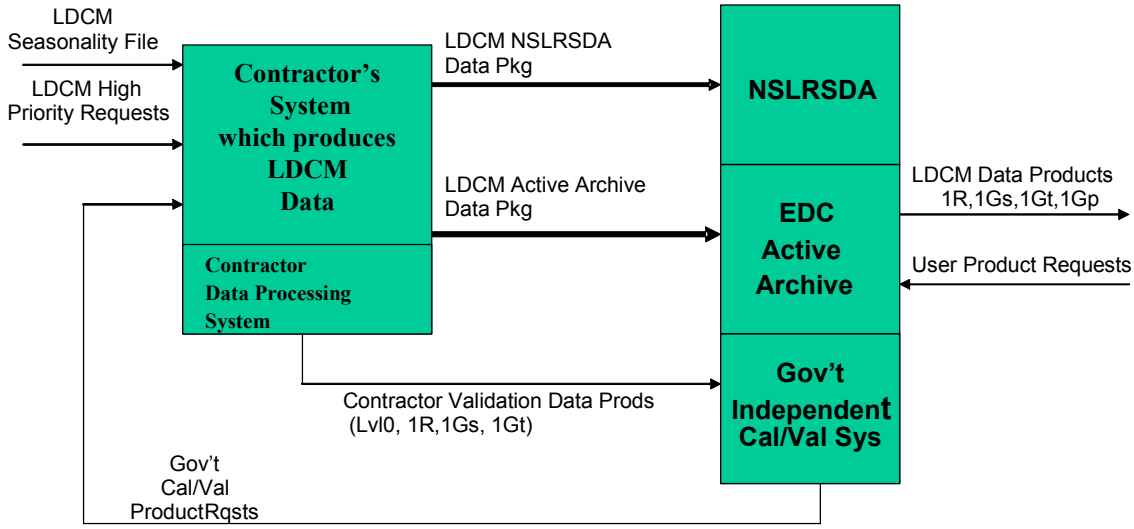

Figure 1.3-1 LDCM Mission Architecture Overview

1.4 Document Organization

The following major sections describe and specify the characteristics of the LDCM data required to be provided by the LDCM Contractor. Section 1 is an overview of the system and system interfaces required of the System to provide LDCM data; Section 2 specifies the LDCM data produced and distributed by the Contractor's system; Section 3 specifies the spatial coverage and temporal resolution of the LDCM data; Section 4 specifies the required spectral characteristics of the LDCM data; Section 5 specifies the spatial resolution of the LDCM data; Section 6 specifies the radiometric characteristics of the LDCM data; Section 7 specifies the geometry of the LDCM data.

1.5 Applicable Documents

a) Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (revised June 1998), FGDC-STD-001-1998. Federal Geographic Data Committee, Washington DC. (http://www.fgdc.gov/metadata/contstan.html)

b) Top of Atmosphere Radiance Values, MODTRAN 4 Model (**http://ldcm.nasa.gov/**)

c) World Geodetic System 1984 (WGS84), National Imagery and Mapping Agency, Department of Defense World Geodetic System 1984: Its Definition and Relationships

with Local Geodetic Systems, Technical Report 8350.2, Third Edition, January 2000. (**http://www.wgs84.com/wgs84/downloads.htm**)

d) Landsat 7 Worldwide Reference System-2 (WRS-2): U.S. Geological Survey EROS Data Center, Landsat 7 Image Assessment System (IAS) Geometric Algorithm Theoretical Basis Document, Version 3.2, Sioux Falls, South Dakota, July 1998, pp. 74-76.

2.0 LDCM Data, Data Packages and Validation Data Products

The System shall acquire the LDCM sensor and ancillary data as specified in Section 2.1, store the Data as specified in Section 2.2, deliver the LDCM Data Packages as specified in Sections 2.3 and 2.4, and generate and deliver Validation Data Products (VDPs) as defined in Section 2.5 and the SOW.

The specifications given herein shall apply post IOC.

2.1 Acquire LDCM Sensor Data and Ancillary Data

The System shall acquire all of the LDCM Sensor Data and Ancillary Data needed to generate the LDCM Data Packages specified in Sections 2.3 and 2.4.

LDCM Sensor Data are the originally measured detector or detector column output counts at the native spatial and spectral resolution from the LDCM Sensor(s), possibly adjusted by reversible offset and scale corrections.

Note: A detector column is a set of physical detectors imaging the same spatial locations, which are treated as a single sensing element by having their outputs combined in Time-Delay Integration (TDI). Offset and scale correction reversibility implies that the relationship between the original detector counts and the remapped data counts is one-to-one for all measured detector output values.

LDCM Ancillary Data consist of satellite and sensor housekeeping data, calibration data and any other supplementary data required to generate the specified higher-level validation data products.

2.1.1 Spatial and Temporal Coverage

The LDCM Sensor Data acquired by the System shall at a minimum afford the spatial and temporal coverage specified in Section 3.

2.1.2 Spectral Coverage

The LDCM Sensor Data acquired by the System shall at a minimum provide data for the spectral bands specified in Section 4.

2.1.3 LDCM Data Bit Error Rate

The process of acquiring, storing, and delivering to the USGS/EDC Active Archive or NSLRSDA any LDCM Data Packages shall result in a bit error rate (BER) of no more than 1 bit per 10^9 bits in the LDCM Data and associated ancillary data.

2.1.4 Dead, Inoperable, and Out-of-spec Pixels

The LDCM data packages delivered to the NSLRSDA and Active Archive shall possess the following characteristics when processed to Level 1R data products:

2.1.4.1 Dead or Inoperable Pixels
Less than 0.1% of the LDCM Level 1R image pixels in any WRS-2 scene shall be dead or inoperable.
Note: Dead or inoperable pixels may be removed from any performance averages and standard deviations for determining compliance to performance specifications.

2.1.4.2 Dead or Inoperable Pixels per Band
Less than 0.25% of the LDCM Level 1R image pixels in any spectral band in any WRS-2 scene shall be dead or inoperable.

2.1.4.3 Out-of-Spec Pixels
Less than 0.25% of the operable LDCM Level 1R image pixels in any spectral band in any WRS-2 scene shall fail to meet one or more performance requirements. Note: Out-of-spec pixels may be removed from any performance averages and standard deviations for determining compliance to performance specifications.

2.1.5 Data Compression
Any data compression applied at any point to LDCM Sensor Data, Level A Data, Level 0 Data, Ancillary Data, Metadata, or other LDCM-related data delivered for the contract shall be lossless.

2.2 Store LDCM Sensor Data and Ancillary Data
The System shall store all acquired LDCM Sensor Data and Ancillary Data at least until the corresponding LDCM Data Packages derived from these data are delivered to both the USGS/EDC Active Archive and NSLRSDA and verified.

2.3 NSLRSDA Data Packages
The System shall produce and deliver to NSLRSDA, NSLRSDA Data Packages consisting of the LDCM Level 0 Digital Image Data, Ancillary Data and associated Metadata.

LDCM Level 0 Digital Image Data are LDCM Sensor Data that have undergone Level 0 processing. Level 0 Processing is the processing of the wideband data that removes or corrects all transmission and formatting artifacts, provides time, spatial, and band sequentially ordered LDCM Sensor Data and all specified ancillary or metadata as the output.

2.3.1 Provide All Necessary Information
The NSLRSDA Data Packages delivered to NSLRSDA shall provide all of the data and information required to produce the Level 0, Level 1R, and Level 1Gs and 1Gt (with the exception of GCPs and DEMs) Validation Data Products specified in Section 2.5.

2.3.2 Content and Quality of the LDCM Level 0 Digital Image Data

2.3.2.1 Spatial and Temporal Coverage
The LDCM Level 0 Digital Image Data delivered with the NSLRSDA Data Packages shall at a minimum afford the spatial and temporal coverage specified in Section 3.

2.3.2.2 Spectral Coverage
The LDCM Level 0 Digital Image Data delivered with the NSLRSDA Data Packages shall at a minimum provide data for the spectral bands specified in Section 4.

2.3.2.3 Spatial Resolution
The LDCM Level 0 Digital Image Data delivered with the NSLRSDA Data Packages shall preserve the native spatial resolution of the LDCM Sensor Data.

2.3.3 Content of the LDCM Ancillary Data
The LDCM Ancillary Data delivered with the NSLRSDA Data Packages shall include, but not be limited to:

2.3.3.a satellite and sensor housekeeping data;

2.3.3.b calibration data and calibration coefficients required to produce Level 0, Level 1R, and Level 1Gs LDCM Validation Data Products specified in Section 2.5; and

2.3.3.c any other supplementary data required to produce Level 0, Level 1R, and Level 1Gs LDCM Validation Data Products specified in Section 2.5.

2.3.3.1 Sensor and Satellite Housekeeping Data
The LDCM sensor and satellite housekeeping data in the LDCM Ancillary Data shall at a minimum:

2.3.3.1.a quantify the state of the LDCM sensor and satellite systems during acquisition of the LDCM Sensor Data;

2.3.3.1.b provide the sensor/satellite state information required to produce Level 0, Level 1R, and Level 1Gs LDCM Validation Data Products specified in Section 2.5;

2.3.3.1.c provide the sensor/satellite state information required to verify the performance of the LDCM sensor(s) and satellite(s); and

2.3.3.1.d either be in metric engineering units or the Ancillary Data shall provide the conversion factors required to convert the housekeeping data to metric engineering units.

2.3.4 Content of the LDCM Metadata

2.3.4.a Each NSLRSDA Data Package shall include metadata for each interval of LDCM Level 0 Digital Image Data within the Data Package.

2.3.4.b The metadata shall adhere to the Federal Geographic Data Committee (FGDC) content standards for digital geospatial metadata.

2.3.4.c The metadata shall include but not be limited to:

2.3.4.c.1 The WRS-2 path and row for each WRS-2 scene within a digital image interval,

2.3.4.c.2 The acquisition date and time for the start and end of the digital image data interval measured and specified with an absolute accuracy of 1 millisecond,

2.3.4.c.3 The acquisition date and time for the start and end for each of the WRS-2 scenes within the interval measured and specified with an absolute accuracy of 1 millisecond,

2.3.4.c.4 Solar azimuth and zenith angles (in degrees, accurate to 3 decimal places) at the center of each WRS-2 scene within a digital image interval at the date and time of data acquisition,

2.3.4.c.5 Identification of the satellite and sensor that acquired the digital image data,

2.3.4.c.6 Identification of the ground station that initially received the digital image data interval,

2.3.4.c.7 Identification of the data's path to Contractors Data Storage Facility,

2.3.4.c.8 The spectral bands provided by the digital image data,

2.3.4.c.9 The geographic location of the corner points of the digital image data interval with an uncertainty of less than or equal to 250 meters (90% circular error), excluding terrain effects,

2.3.4.c.10 The geographic location of the corner points of each WRS-2 scene within a digital image data interval with an uncertainty of less than or equal to 250 meters (90% circular error), excluding terrain effects,

2.3.4.c.11 The geographic location of the center of each WRS-2 scene within a digital image data interval with an uncertainty of less than or equal to 250 meters (90% circular error), excluding terrain effects,

2.3.4.c.12 The percentage cloud cover for each WRS-2 scene within a digital image data interval such that the error in cloud cover percentage is no greater than plus-or-minus 10% for 95% of the WRS-2 scenes within all of the delivered digital image data intervals,

2.3.4.c.13 The percentage cloud cover for each of the four scene quadrants of each WRS-2 scene within a digital image data interval, such that the error in cloud cover percentage is no greater than plus-or-minus 10% for 95% of the WRS-2 scene quadrants within all of the delivered digital image data intervals,

2.3.4.c.14 Data quality metrics for each WRS-2 scene within a digital image data interval,

2.3.4.c.15 Locations of corrupted or invalid data within the digital image data interval,

2.3.4.c.16 Descriptions or characterizations of the corrupted or invalid data,

2.3.4.c.17 The sensor settings for variable sensor states at the time of data acquisition,

2.3.4.c.18 The date of data shipment to the Government, and

2.3.4.c.19 Identification of the facility, computer system, and software versions used to process the digital image data.

2.3.5 Deliver NSLRSDA Data Packages

2.3.5.a The System shall provide NSLRSDA with all NSLRSDA Data Packages.

2.3.5.b Delivery of the first acquired post-IOC data in an NSLRSDA Data Package shall occur no later than 6 months after it is acquired.

2.3.5.c After delivery of the first NSLRSDA Data Package, each subsequent NSLRSDA Data Package shall be delivered within 3 months of the previous package.

2.3.5.d No NSLRSDA Data Package shall contain data acquired more than 6 months prior to the package's delivery.

2.3.6 Provide in Digital Form

NSLRSDA Data Packages shall be provided in digital form, either through electronic transmission or physical delivery on mutually agreeable media.

2.4 Active Archive Data Packages

The System shall produce and deliver Active Archive Data Packages, consisting of the LDCM Level A Digital Image Data and/or Level 0 Digital Image Data, Ancillary Data and associated Metadata, to the USGS/EDC Active Archive.

LDCM Level A Digital Image Data are the Level 0 Digital Image Data that have been aggregated to LDCM-specified ground sample distances and may have undergone radiometric preprocessing.

Note: NSLRSDA Data Packages (as defined in Section 2.3, 2.3.1, 2.3.2, 2.3.3, 2.3.4) meet the requirements of Active Archive Data Packages (as defined in Sections 2.4, 2.4.1, 2.4.2, 2.4.3, 2.4.4) and therefore can meet the requirements for delivery of both NSLRSDA and Active Archive Data Packages, if delivered within the timeframe specified in Section 2.4.5.

2.4.1 Provide All Necessary Information

The Active Archive Data Packages delivered to the USGS/EDC Active Archive shall provide all of the data and information required to produce the Level 1R and Level 1Gs LDCM Validation Data Products specified in Section 2.5.

2.4.2 Content and Quality of the LDCM Level A and/or Level 0 Digital Image Data

2.4.2.1 Spatial and Temporal Coverage

The LDCM Digital Image Data delivered with the Active Archive Data Packages shall at a minimum provide the spatial and temporal coverage specified in Section 3.

2.4.2.2 Spectral Coverage

The LDCM Digital Image Data delivered with the Active Archive Data Packages shall at a minimum provide data for the spectral bands specified in Section 4.

2.4.3 Content of the LDCM Ancillary Data

The LDCM Ancillary Data delivered with the Active Archive Data Packages shall include, but not be limited to:

2.4.3.a satellite and sensor housekeeping data;

2.4.3.b calibration data and calibration coefficients required to produce Level 1R and Level 1Gs LDCM Validation Data Products specified in Section 2.5; and

2.4.3.c any other supplementary data required to produce Level 1R and Level 1Gs LDCM Validation Data Products specified in Section 2.5.

2.4.3.1 Sensor and Satellite Housekeeping Data

The sensor and satellite housekeeping data in the LDCM Ancillary Data shall at a minimum:

2.4.3.1.a quantify the state of the LDCM sensor and satellite systems during acquisition of the LDCM Sensor Data;

2.4.3.1.b provide the sensor/satellite state information required to produce Level 1R and Level 1Gs LDCM Validation Data Products specified in Section 2.5;

2.4.3.1.c provide the sensor/satellite state information required to verify the performance of the LDCM sensor(s) and satellite(s); and

2.4.3.1.d either be in metric engineering units or provide the conversion factors required to convert the housekeeping data to metric engineering units.

2.4.4 Content of the LDCM Metadata

2.4.4.a Each LDCM Active Archive Data Package shall include metadata for each interval of LDCM Digital Image Data within the Data Package.

2.4.4.b The metadata shall adhere to the Federal Geographic Data Committee (FGDC) content standards for digital geospatial metadata.

2.4.4.c The metadata shall include but not be limited to the metadata specified in Section 2.3.4.c.

2.4.4.d The metadata shall indicate for each spectral band whether the digital image data are Level A or Level 0 data.

2.4.5 Deliver Active Archive Data Packages

The System shall provide the USGS/EDC Active Archive with all Active Archive Data Packages such that 90% of the Data Packages are delivered no later than 24 hours after collection by the sensor and 100% of the Data Packages are delivered no later than 36 hours after collection by the sensor.

2.4.6 Provide in Digital Form

Active Archive Data Packages shall be provided in digital form, either through electronic transmission or physical delivery on mutually agreeable media.

2.5 Validation Data Products

This section defines the required Validation Data Products to be produced and delivered by the System on request to the Government.

2.5.a WRS-2 Scenes

For Government requested scenes, the System shall be able to produce Validation Data Products for any acquired scene within the heritage Worldwide Reference System-2 (WRS-2) path/row scenes (185 x 180 km).

2.5.b Validation Data Product Format

Validation Data Products shall be provided in the unencapsulated Hierarchical Data Format (HDF).

2.5.c Validation Data Product Compression

Validation Data Products shall not include any compressed data.

2.5.1 Level 0 Validation Data Products

Level 0 Validation Data Products shall consist of Level 0 Digital Image Data, Level 0 Ancillary Data, and Level 0 Metadata.

2.5.1.a Level 0 Validation Data Products shall provide all of the data required to produce the Level 1R and Level 1Gs Validation Data Products specified in Sections 2.5.2 and 2.5.3, respectively.

2.5.1.b Level 0 Validation Data Products shall be produced using only the Level 0 Digital Image Data, ancillary data, and metadata that would be identical to the data included in a NSLRSDA Data Package.

2.5.1.1 Level 0 Digital Image Data

2.5.1.1a Spectral Coverage

The Level 0 Digital Image Data delivered with the Level 0 Validation Data Products shall at a minimum provide data for the spectral bands specified in Section 4.

2.5.1.1.b Spatial Resolution

The Level 0 Digital Image Data delivered with the Level 0 Validation Data Products shall preserve the native spatial resolution of the LDCM Sensor Data.

2.5.1.2 Level 0 Ancillary Data

2.5.1.2.a Level 0 Ancillary Data shall provide all of the ancillary data required to produce the Level 1R and Level 1Gs Validation Data Products specified in Sections 2.5.2 and 2.5.3, respectively.

2.5.1.2.b The Level 0 Ancillary Data shall include, but not be limited to, the calibration coefficients and the sensor and satellite housekeeping data required to produce the Level 1R and Level 1Gs Validation Data Products specified in Sections 2.5.2 and 2.5.3, respectively, in metric engineering units.

2.5.1.3 Level 0 Metadata

2.5.1.3.a Level 0 Metadata shall describe the associated Level 0 Digital Image Data and Level 0 Ancillary Data.

2.5.1.3.b Level 0 Metadata shall adhere to the Federal Geographic Data Committee (FGDC) content standards for digital geospatial metadata.

2.5.1.3.c Level 0 Metadata shall include, but not be limited to:

2.5.1.3.c.1 The WRS-2 path and row,

2.5.1.3.c.2 The acquisition date for the digital image data,

2.5.1.3.c.3 The acquisition start time and end time for the digital image data,

2.5.1.3.c.4 Solar azimuth and zenith angles (in degrees, accurate to 3 decimal places) at the center of the WRS-2 scene at the date and time of digital image data acquisition,

2.5.1.3.c.5 Identification of the satellite and sensor that acquired the digital image data,

2.5.1.3.c.6 Identification of the ground station that initially received the digital image data,

2.5.1.3.c.7 Identification of the digital image data's path to the Contractor's storage facility,

2.5.1.3.c.8 The spectral bands provided by the digital image data,

2.5.1.3.c.9 The geographic location of the corner points of the WRS-2 scene covered by the digital image data with an uncertainty of less than or equal to 250 meters (90% circular error), excluding terrain effects,

2.5.1.3.c.10 The geographic location of the center of the WRS-2 scene covered by the digital image data with an uncertainty of less than or equal to 250 meters (90% circular error), excluding terrain effects,

2.5.1.3.c.11 The percentage cloud cover for the WRS-2 scene covered by the digital image data,

2.5.1.3.c.12 The percentage cloud cover for each of the four quadrants of the WRS-2 scene covered by the digital image data,

2.5.1.3.c.13 Data quality metrics for the digital image data,

2.5.1.3.c.14 Locations of corrupted or invalid data within the data product,

2.5.1.3.c.15 Descriptions or characterizations of the corrupted or invalid data,

2.5.1.3.c.16 The sensor settings for variable sensor states at the time of digital image data acquisition,

2.5.1.3.c.17 Identification of the facility, computer system, software, and software versions that generated the data product, and

2.5.1.3.c.18 Date of data product generation.

2.5.2 Level 1R Validation Data Products

Level 1R Validation Data Products shall consist of Level 1R Digital Image Data, Level 1R Ancillary Data, and Level 1R Metadata.

2.5.2.a Level 1R Validation Data Products shall provide all of the data required to produce the Level 1Gs Validation Data Products specified in Section 2.5.3.

2.5.2.b Level 1R Validation Data Products shall be produced using LDCM Level 0 or Level A digital image and ancillary data that would be identical to the data included in a LDCM Active Archive Data Package.

2.5.2.1 Level 1R Digital Image Data

2.5.2.1.a Level 1R Digital Image Data shall provide radiometrically corrected digital image data consisting of digital values linearly scaled to at-aperture spectral radiance.

2.5.2.1.b The linear scale shall be constant for all the data from a particular spectral band.

2.5.2.1.1 Spectral Coverage
The Level 1R Digital Image Data delivered with the Level 1R Validation Data Products shall at a minimum provide data for the spectral bands specified in Section 4.

2.5.2.2 Level 1R Ancillary Data

2.5.2.2.a Level 1R Ancillary Data shall provide all of the ancillary data required to produce the Level 1Gs Validation Data Products specified in Section 2.5.3.

2.5.2.2.b The Level 1R Ancillary Data shall include, but not be limited to, the calibration coefficients and the sensor and satellite housekeeping data required to produce the Level 1Gs Validation Data Products specified in Section 2.5.3, in metric engineering units.

2.5.2.2.c The Level 1R Ancillary Data shall provide all of the radiometric calibration coefficients used to correct the Level 0 or Level A Digital Image Data and produce the Level 1R Digital Image Data.

2.5.2.3 Level 1R Metadata

2.5.2.3.a Level 1R Metadata shall describe the associated Level 1R Digital Image Data and Level 1R Ancillary Data.

2.5.2.3.b Level 1R Metadata shall adhere to the Federal Geographic Data Committee (FGDC) standards for metadata.

2.5.2.3.c Level 1R Metadata shall include, but not be limited to:

2.5.2.3.c.1 all of the items listed in Section **2.5.1.3.c ,**

2.5.2.3.c.2 The version of the calibration coefficients used to generate the Level 1R Digital Image Data, and

2.5.2.3.c.3 The radiometric scaling factors required to convert the digital values of the Level 1R digital image data to units of spectral radiance with the accuracy specified in Section 6.1.

2.5.3 Level 1Gs Validation Data Products

Level 1Gs Validation Data Products shall consist of Level 1Gs Digital Image Data and Level 1Gs Metadata.

2.5.3.a Level 1Gs Validation Data Products shall be produced using LDCM Level 0 or Level A digital image and ancillary data that would be identical to the data included in a LDCM Active Archive Data Package.

2.5.3.1 Level 1Gs Digital Image Data

2.5.3.1.1 Level 1Gs Radiometric and Geometric Reference
Level 1Gs Digital Image Data shall provide radiometrically corrected digital image data consisting of digital values linearly scaled to at-aperture spectral radiance and resampled for registration to acarto-graphic projection, referenced to the World Geodetic System 1984 (WGS84), G873 or current version.

2.5.3.1.2 Level 1Gs Radiometric Scale
The linear radiometric scale shall be constant for all the data from a particular spectral band.

2.5.3.1.3 Level 1Gs Map Projection
The Level 1Gs Digital Image Data shall be registered to a selectable map projection grid as requested by the Government Calibration / Validation Team including:

2.5.3.1.3.a Universal Transverse Mercator,

2.5.3.1.3.b Polar Stereographic.

2.5.3.1.4 Level 1Gs Orientation
The Level 1Gs Digital Image Data output image grid shall be aligned to map projection grid north.

2.5.3.1.5 Level 1Gs Resampling Method
Image resampling shall be performed using a selectable resampling method as requested by the Government Calibration / Validation Team including:

2.5.3.1.5.a Cubic convolution interpolation,

2.5.3.1.5.b Nearest neighbor.

2.5.3.1.6. Level 1Gs Spectral Coverage
The Level 1Gs Digital Image Data delivered with the Level 1Gs Validation Data Products shall at a minimum provide data for the spectral bands specified in Section 4.

2.5.3.1.7 Level 1Gs Resampled Grid Cell Size Characteristics
The Level 1Gs Digital Image Data shall be resampled into a selected cartographic projection system using grid cell (i.e., resampled output pixel) sizes, with the characteristics as requested by the Government Calibration / Validation Team as defined in the following subsections.

2.5.3.1.7.1 Level 1Gs Selectable Resampled Grid Cell Sizes
The Level 1Gs Digital Image Data grid cell sizes shall be independently selectable for the following band groups:

2.5.3.1.7.1.a standard reflective bands (bands 1 through 7),

2.5.3.1.7.1.b sharpening band (band 8),

2.5.3.1.7.1.c cirrus band (band 9).

2.5.3.1.7.2 Level 1Gs Resampled Grid Cell Size Ranges
The Level 1Gs Digital Image Data grid cell sizes shall be as requested by the Government Calibration / Validation Team with the minimum ranges specified in Table 2.5.3.1.7.2-1. Note: product throughput will be based upon Level 1G product grid cell sizes equal to the Level 1R product band GSD.

Table 2.5.3.1.7.2-1: Level 1Gs Resampled Grid Cell Sizes

Band Group	Standard Reflective Bands	Sharpening Band	Cirrus Band
Size Range	10 m - 30 m	10 m - 30 m	30 m - 120 m

2.5.3.2 Level 1Gs Metadata
Level 1Gs Metadata shall describe the associated Level 1Gs Digital Image Data.

2.5.3.2.a Level 1Gs Metadata shall adhere to the Federal Geographic Data Committee (FGDC) content standards for digital geospatial metadata.

2.5.3.2.b Level 1Gs Metadata shall include, but not be limited to:

2.5.3.2.b.1 all of the items listed in Section **2.5.1.3.c**,

2.5.3.2.b.2 The version of the calibration coefficients used to generate the Level 1Gs Digital Image Data,

2.5.3.2.b.3 The radiometric scaling factors required to convert the digital values of the Level 1Gs digital image data to units of spectral radiance with the accuracy specified in Section 6.1,

2.5.3.2.b.4 The cartographic projection,

2.5.3.2.b.5 The cartographic projection parameters,

2.5.3.2.b.6 The current version of the WGS84 ordinate reference frame,

2.5.3.2.b.7 Identification of any supplementary data used to generate the Level 1Gs Digital Image Data,

2.5.3.2.b.8 Product corner points with the accuracy specified in Section 7.3,

2.5.3.2.b.9 The resampling method, and

2.5.3.2.b.10 The output resampled pixel size for each of the spectral band groups identified in Section 2.5.3.1.7.1.

2.5.4 Level 1Gt Validation Data Products

Level 1Gt Validation Data Products shall consist of Level 1Gt Digital Image Data and Level 1Gt Metadata.

2.5.4.a Level 1Gt Validation Data Products shall be produced using LDCM Level 0 or Level A digital image and ancillary data that would be identical to the data included in a LDCM Active Archive Data Package and Government provided ground control and digital elevation data. (See Sections 7.4.3 and 7.4.4 for information on the digital elevation data needed to create these products.)

2.5.4.1 Level 1Gt Digital Image Data

2.5.4.1.1 Level 1Gt Radiometric and Geometric Reference

Level 1Gt Digital Image Data shall provide radiometrically corrected digital image data consisting of digital values linearly scaled to at-aperture spectral radiance and resampled for orthorectification and registration to a cartographic projection, referenced to the World Geodetic System 1984 (WGS84), G873 or current version.

2.5.4.1.2 Level 1Gt Radiometric Scale

The linear radiometric scale shall be constant for all the data from a particular spectral band.

2.5.4.1.3 Level 1Gt Map Projection

The Level 1Gt Digital Image Data shall be registered to a selectable map projection grid as requested by the Government Calibration / Validation Team including:

2.5.4.1.3.a Universal Transverse Mercator,

2.5.4.1.3.b Polar Stereographic.

2.5.4.1.4 Level 1Gt Orientation
The Level 1Gt Digital Image Data output image grid shall be aligned to map projection grid north.

2.5.4.1.5 Level 1Gt Resampling Method
Image resampling shall be performed using a selectable resampling method as requested by the Government Calibration / Validation Team including:

2.5.4.1.5.a Cubic convolution interpolation,

2.5.4.1.5.b Nearest neighbor.

2.5.4.1.6. Level 1Gt Spectral Coverage
The Level 1Gt Digital Image Data delivered with the Level 1Gt Validation Data Products shall at a minimum provide data for the spectral bands specified in Section 4.

2.5.4.1.7 Level 1Gt Resampled Grid Cell Size Characteristics
The Level 1Gt Digital Image Data shall be resampled into a selected cartographic projection system using grid cell (i.e., resampled output pixel) sizes, with the characteristics as requested by the Government Calibration / Validation Team as defined in the following subsections.

2.5.4.1.7.1 Level 1Gt Selectable Resampled Grid Cell Sizes
The Level 1Gt Digital Image Data grid cell sizes shall be independently selectable for the following band groups:

2.5.4.1.7.1.a standard reflective bands (bands 1 through 7)

2.5.4.1.7.1.b sharpening band (band 8)

2.5.4.1.7.1.c cirrus band (band 9).

2.5.4.1.7.2 Level 1Gt Resampled Grid Cell Size Ranges
The Level 1Gt Digital Image Data grid cell sizes shall be as requested by the Government Calibration / Validation Team with the minimum ranges specified in Table 2.5.4.1.7.2-1. Note:

product throughput will be based upon Level 1G product grid cell sizes equal to the Level 1R product band GSD.

Table 2.5.4.1.7.2-1: Level 1Gt Resampled Grid Cell Sizes

Band Group	Standard Reflective Bands	Sharpening Band	Cirrus Band
Size Range	10 m - 30 m	10 m - 30 m	30 m - 120 m

2.5.4.2 Level 1Gt Metadata

Level 1Gt Metadata shall describe the associated Level 1Gt Digital Image Data.

2.5.4.2.a Level 1Gt Metadata shall adhere to the Federal Geographic Data Committee (FGDC) content standards for digital geospatial metadata.

2.5.4.2.b Level 1Gt Metadata shall include, but not be limited to:

2.5.4.2.b.1 all of the items listed in Section 2.5.1.3.c,

2.5.4.2.b.2 The version of the calibration coefficients used to generate the Level 1Gt Digital Image Data,

2.5.4.2.b.3 The radiometric scaling factors required to convert the digital values of the Level 1Gt digital image data to units of spectral radiance with the accuracy specified in Section 6.1,

2.5.4.2.b.4 The cartographic projection,

2.5.4.2.b.5 The cartographic projection parameters,

2.5.4.2.b.6 The current version of the WGS84 ordinate reference frame,

2.5.4.2.b.7 Identification of any supplementary data used to generate the Level 1Gt Digital Image Data,

2.5.4.2.b.8 Product corner points with the accuracy specified in Section 7.4,

2.5.4.2.b.9 The resampling method, and

2.5.4.2.b.10 The output resampled pixel size for each of the spectral band groups identified in Section 2.5.4.1.7.1.

3.0 LDCM Spatial Coverage and Temporal Resolution

The System shall acquire multispectral LDCM Sensor and ancillary data which covers the Earth's land areas on a seasonal basis, as defined in the following sections.

3.1 Spatial Coverage and Revisit Frequency

The System shall be capable of providing LDCM Sensor and Ancillary data for every point on the Earth's continental and coastal surfaces between ± 81.8º latitude every 16 days or less.

3.1.1 LDCM Global Archive Coverage

This section includes requirements for coverage area and overall volume of data acquired for the LDCM data packages.

3.1.1.1 Daily LDCM Global Archive Coverage

The LDCM Sensor and ancillary data acquired daily shall provide an average daily coverage of at least 250 full WRS-2 (see Section 1.5) land scenes averaged quarterly.

WRS-2 land scenes are defined in the WRS Land Database, Revision 2.1, to include continental regions, coastal areas, islands, ice caps, and reefs.

3.1.1.2 LDCM Global Archive Acquisition Strategy

The System shall implement a WRS-2 acquisition strategy such that at least 90% (averaged quarterly) of the LDCM scenes acquired each day will be from among the top 250 acquisition priority scores possible, as calculated in the Appendix to this Specification.

Note: for LDCM, night imaging scenes (as defined in 3.2.3), United States acquisition scenes (as defined in 3.2.1) and high-priority target scenes (as defined in 3.2.2) will be given the highest possible priority.

3.1.1.3 Special Acquisitions Strategy
The System shall acquire all night imaging scenes (as defined in 3.2.3), United States acquisition scenes (as defined in 3.2.1) and high-priority target scenes (as defined in 3.2.2).

3.1.1.4 Acquisition Priority Updates
The System shall update the LDCM acquisition strategy quarterly, using the seasonality file (defined in the Appendix to this specification) supplied by the Government.

3.1.2 Minimum Cross-Track Extent
The LDCM Sensor Data shall have a minimum cross-track extent of 185 km.

3.1.3 WRS-2 Orientation
The LDCM Sensor Data shall be acquired in accordance with the Worldwide Reference System 2 (WRS-2) grid, such that the swath center of the LDCM Sensor data is within 5 km of the center of the corresponding WRS-2 path.

3.2 Special Acquisitions

3.2.1 United States Coverage
The System shall acquire LDCM Sensor data for the fifty United States and District of Columbia and their coastal areas at least once every 16 days, when daily predicted WRS-2 scene cloud cover is less than 80%, and subject to the solar zenith requirement 3.3.1.1.

3.2.2 High-Priority Target Coverage
The System shall acquire LDCM Sensor Data for all Government requested scenes, not to exceed twelve WRS-2 scenes per day, for high-priority targets of opportunity (e.g. natural disasters, volcanic eruptions, etc), which will be identified by the Government at least 36 hours prior to collection time.

3.2.3 Night Images

3.2.3.a The System shall acquire up to 25 of the 250 WRS-2 scenes at night during any 24-hour period upon Government request. Specific targets will be provided by the Government at least 36 hours in advance of collection time.

3.2.3.b The System shall be capable of acquiring up to 10 night WRS-2 scenes, which may be contiguous, during any single eclipse.

3.3 Solar Illumination

The LDCM Sensor Data shall be composed of primarily of daylight coverage as defined in the following sections.

3.3.1 Global Daylight Coverage

3.3.1.1 Solar Zenith Angle

LDCM Sensor data shall be acquired in daylight when the solar zenith angle is less than 88°.

3.3.1.2 Local Mean Solar Time

All LDCM Sensor data acquired shall be consistent with an orbit that maintains a local mean solar time (LMST), at the descending node, at 10:00 am (+/- 15 minutes).

3.4 Viewing Geometry; Maximum Viewing Zenith Angle

The LDCM Sensor data shall be acquired with viewing zenith angles less than or equal to 10°.

4.0 LDCM Spectral Bands

The LDCM Sensor(s) shall have spectral bands per the specifications in this section.

4.1 Spectral Band Widths

4.1.a The full-width-half-maximum (FWHM) points of the relative spectral radiance response curve for each spectral band shall fall within the range of the minimum 50% lower band edge and the maximum 50% upper band edge as listed in Table 4.1-1.

4.1.b The center wavelength listed in Table 4.1-1 for each spectral band shall be located (within the associated tolerance listed in Table 4.1-1) halfway between the full-width-half-maximum (FWHM) points of the actual relative spectral radiance response curve for each spectral band.

#	Band	Center Wavelength (nm)	Center Wavelength Tolerance (±nm)	Minimum Lower Band Edge (nm)	Maximum Upper Band Edge (nm)	Band Heritage/ Usage
1	Coastal Aerosol	443	2	433	453	ALI/MODIS
2	Blue	482	5	450	515	ETM+ Band 1
3	Green	562	5	525	600	ETM+ Band 2
4	Red	655	5	630	680	ETM+ Band 3
5	NIR	865	5	845	885	ETM+ Band 4/ALI
6	SWIR 1	1610	10	1560	1660	ETM+ Band 5
7	SWIR 2*	2200	10	2100	2300	ETM+ Band 7
8	Sharpening **	590	10	500	680	ETM+ Pan Band/ALI
9	Cirrus	1375 or 1875***	5	1360 or 1835	1390 or 1915	MODIS

Table 4.1-1 Spectral bands and band widths

* Minimum bandwidth is 180 nm for band 7

** The band may be panchromatic with a center wavelength as specified and a bandwidth of at least 160 nm or a red band with band 4 specification.

*** The Cirrus band may be centered at either 1.375 um or 1.875 um

4.2 Spectral Band Shape

4.2.1 Spectral Flatness

4.2.1.1 Flatness Between Band Edges

The relative spectral radiance response between the lower band edge (lowest wavelength with 0.5 of peak relative response) and the upper band edge (highest wavelength with 0.5 of peak relative response) shall have the following properties:

4.2.1.1.1 Average Response

The average relative spectral radiance response shall be greater than 0.8.

4.2.1.1.2 Minimum Response

No relative spectral radiance response shall be below 0.4.

4.2.1.2 Flatness Between 80% relative response points

The relative spectral radiance response between the minimum wavelength with a 0.8 relative response point and the maximum wavelength with a 0.8 relative response point shall always exceed 0.7.

4.2.2 Out of Band Response

4.2.2.a The ratio of the integrated relative spectral radiance response beyond the 1% relative response points to the integrated response between the 1% relative response points shall be less than 2%. The integrated responses will be weighted by the solar exoatmospheric irradiance. The 1% relative response points are the points closest to the center wavelength where the relative response first drops to 1% of the peak relative response on each side of the center wavelength. Electrical crosstalk is not included within this requirement.

4.2.2.b Additionally, the value of the relative spectral radiance response shall not exceed 0.1% at any wavelength more than 50 nm for all VNIR bands and the cirrus band and 100 nm for all SWIR and sharpening bands from the corresponding 50% relative response band edge. If a red band is used for sharpening, then Band 4 requirements apply. Electrical crosstalk is not included within this requirement.

4.2.3 Edge Slope

4.2.3.a The wavelength interval between the first 5% and the first 50% of peak relative response and the last 50% and the last 5% of peak relative response ranges shall not exceed the values in Table 4.2.3-1.

4.2.3.b The wavelength interval between the 1% relative response points and the corresponding 50% relative response band edge shall not exceed the values in Table 4.2.3-1.

Table 4.2.3-1 Edge Slope Intervals for LDCM bands

#	Band	Lower Edge Slope Interval 1% to 50%** (nm)	Lower Edge Slope Interval 5% to 50%** (nm)	Upper Edge Slope Interval 50% to 5%** (nm)	Upper Edge Slope Interval 50% to 1%** (nm)
1	Coastal Aerosol	15	10	10	15
2	Blue	25	20	20	25
3	Green	25	20	20	25
4	Red	25	20	15	20
5	NIR	25	20	15	20
6	SWIR 1	40	30	30	40
7	SWIR 2	50	40	40	50
8	Sharpening*	50	40	40	50
9	Cirrus	15	10	10	15

* If a red band is used for sharpening, then Band 4 edge slope requirements apply.
** % of peak relative spectral response for the band

4.3 Spectral Uniformity
Within a band, all pixels bandwidths shall be within ±3% of the mean bandwidth. Additionally see Section 6.2.3.

4.4 Spectral Stability
Band center wavelengths and band edges shall not change by more ± 2 nm over the expected life of the mission.

4.5 Spectral Band Simultaneity
For any point within a single WRS-2 scene, the LDCM Sensor(s) shall acquire LDCM Sensor data for all spectral bands within a five-second period.

5.0 LDCM Spatial Resolution

5.1 Ground Sample Distance

5.1.1 Multispectral Ground Sample Distance

5.1.1.a LDCM Sensor data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a ground sampling distance (GSD) of 30 m or less across the WRS-2 scene for LDCM spectral bands 1, 2, 3, 4, 5, 6, and 7.

5.1.1.b LDCM Level 1R Digital Image Data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a ground sampling distance (GSD) of 30 m or less across the WRS-2 scene for LDCM spectral bands 1, 2, 3, 4, 5, 6, and 7.

5.1.2 Sharpening Band and Cirrus Band Ground Sample Distance

5.1.2.a LDCM Sensor data shall provide a single sharpening band with a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a GSD of 15 m or less across the WRS-2 scene.

5.1.2.b LDCM Level 1R Digital Image Data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a GSD of 15 m or less across the WRS-2 scene for the single sharpening band.

5.1.2.c LDCM sensor data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a GSD 120 m or less across the WRS-2 scene for LDCM spectral band 9.

5.1.2.d LDCM Level 1R Digital Image Data shall provide a pixel-to-pixel increment, in the in-track and cross-track directions, equivalent to a GSD 120 m or less across the WRS-2 scene for LDCM spectral band 9.

5.2 Edge Response

The mean relative edge response slope in the in-track and cross-track directions (mean of slope between 40%-60%) for Level 1R Digital Image Data shall conform to the criteria described in the following subsections.

Note: Table 5.2-1 lists the bands, their maximum allowable GSD, and the minimal edge slope. The edge response, in the context below, is the normalized response of the imaging system to an edge. That is, the edge response is normalized so that the mean minimum edge response is set to zero and the mean maximum response is set to 100%.

Table 5.2-1 GSD / Minimum Slope Specification

#	Band	Type	Maximum GSD	Slope
1	Coastal Aerosol	Standard	30 m	.027 / m
2	Blue	Standard	30 m	.027 / m
3	Green	Standard	30 m	.027 / m
4	Red	Standard	30 m	.027 / m
5	NIR	Standard	30 m	.027 / m
6	SWIR 1	Standard	30 m	.027 / m
7	SWIR 2	Standard	30 m	.027 / m
8	Sharpening	Sharpening	15 m	.054 / m
9	Cirrus	Atmospheric	120m	.006 / m

5.2.1 Standard Band Edge Response Slope
The mean relative edge response slope for LDCM spectral bands 1, 2, 3, 4, 5, 6, and 7 (<=30 m GSD) shall exceed 0.027/meter for Level 1R Digital Image Data across the entire Field-of-View.

5.2.2 Sharpening Band Edge Response Slope
The mean relative edge response slope for the sharpening band, LDCM spectral band 8 (<=15 m GSD), shall exceed 0.054/meter for Level 1R Digital Image Data across the entire Field-of-View.

5.2.3 Cirrus Band Edge Response Slope
The mean relative edge response slope for the cirrus band, LDCM spectral band 9 (< =120 m), shall exceed 0.006/meter for Level 1R Digital Image Data across the entire Field-of-View.

5.2.4 Edge Response Overshoot
The overshoot of any edge response for all bands shall not exceed 5% for Level 1R Digital Image Data.

5.2.5 Edge Response Uniformity
The mean relative edge response slope shall not vary by more than 10% (maximum deviation from the band average) in any band across the Field-of-View and by not more than 20% (maximum deviation from the multi-band average) between LDCM spectral bands 1,2,3,4 (if not used as the sharpening band), 5, 6,and 7 for Level 1R Digital Image Data.

5.3 Aliasing

The product of the mean relative edge response slope and the GSD provided by Level 1R Digital Image Data shall be less than 1.0 for both the in-track and cross track directions.

5.4 Stray Light Rejection and Internal Light Scattering

The effectiveness of the rejection of stray light and internal light scattering in the LDCM data is defined in terms of a scene with the following characteristics: The LDCM data are collected from a circular region having a radius = 0.25 degrees and having a uniform target radiance = L_T. That target region is surrounded by an annular region having an inner radius = 0.25 degrees and an outer radius = 25 degrees and having a uniform background radiance = L_B.

When $L_B = L_T$, the LDCM Level 1R radiance measured at the center of the target region has a nominal value = L_T. When L_B is not equal to L_T, the magnitude of the change in measured LDCM Level 1R radiance at the center of the target region shall be less than 0.004 times the magnitude of the difference between L_B and L_T. This requirement applies to all spectral bands for the duration of the nominal LDCM mission for target and background radiance levels ranging from a minimum of zero to a maximum of $L_{Max,}$ such that $L_T - L_B$ ranges from a minimum of $- L_{Max}$ to a maximum of L_{Max}.

6.0 LDCM Radiometry

6.1 Absolute Radiometric Accuracy

The digital values in Level 1 Digital Image Data shall be linearly scaled to at-aperture spectral radiance with an uncertainty less than or equal to 5% (1 sigma) across the range of Ltypical to 0.9 Lmax (Table 6.1-1) and less than or equal to 5.5% (1 sigma) across the range of 0.3 Ltypical to < Ltypical with all uncertainties established relative to National Institute for Standards and Technology (NIST) standards. This requirement applies to extended, spatially uniform, unpolarized targets with a known spectral shape. Uncertainty estimates include the NIST standard uncertainties, but if referenced to the sun, need not include in excess of 1% additional uncertainties in the solar exoatmospheric spectral irradiance.

Table 6.1-1 Radiance/Temperature Levels for Signal-to-Noise Ratio (SNR) Requirements and Saturation Radiances

#	Band	Radiance Level for SNR, L (W/m^2 sr µm)		Saturation Radiances, L_{Max} (W/m^2 sr µm)
		Typical, $L_{Typical}$	High, L_{high}	Requirement
1	Coastal Aerosol	40	190	564
2	Blue	40	190	592
3	Green	30	194	553
4	Red	22	150	470
5	NIR	14	150	285
6	SWIR 1	4.0	32	72.5
7	SWIR 2	1.7	11	24.7
8	Sharpening*	23	156	524
9	Cirrus (Optional)	6.0 (1.38 µm) 2.8 (1.88 µm)	N/A	90 (1.38 µm) 41 (1.88 µm)

* If a red band is used for sharpening, then Band 4 Radiance levels apply for SNR and Saturation Radiance requirements.

6.2 Radiometric Signal to Noise

6.2.1 Pixel Signal-to-Noise Ratios (SNRs)

The median SNRs required for all LDCM Level 1 Digital Image Data for each spectral band shall be as listed in Table 6.1-1 and 6.2.1-1.

6.2.1.a 50% of all pixels for each band shall meet or exceed these SNR values.

6.2.1.b Any pixel below 80% of these values shall be considered out-of-spec per section 2.1.4.3.

Table 6.2.1-1 SNR Requirements

#	Band	SNR Requirements	
		At $L_{Typical}$	At L_{High}
1	Coastal Aerosol	130	290
2	Blue	130	360
3	Green	100	390
4	Red	90	340
5	NIR	90	460
6	SWIR 1	100	540
7	SWIR 2	100	510
8	Sharpening*	80	230
9	Cirrus	130	N/A

* If the sharpening band is chosen to be a red band with band 4 spectral specifications, then the SNR requirements are the band 4 SNR requirements divided by 2 and evaluated at the Band 4 $L_{typical}$ and L_{high} radiance values.

6.2.2 LDCM Digital Image Data Quantization

LDCM Level 0 and Level 1 Digital Image Data SNR performance shall not be quantization noise limited at Ltypical and above, i.e., system noise is greater than or equal to 0.5 Digital Number.

6.2.3 Pixel-to-Pixel Uniformity

6.2.3.1 Full Field of View

For a spatially uniform source above 2*$L_{typical}$, the standard deviation of the calibrated values across all pixels within a line of LDCM Level 1R Digital Image Data within a band shall not exceed 0.25% of the average radiance. Temporal (within column) noise may be averaged to verify compliance with this specification.

6.2.3.2 Banding

a. For a spatially uniform source above 2*$L_{typical}$, the root mean square of the deviation from the average radiance across the line for any 100 contiguous pixels within a line of LDCM Level 1R Digital Image Data within a band shall not exceed 0.5% of that average radiance. Temporal (within column) noise may be averaged to verify compliance with this specification.

b. For a uniform source above 2*$L_{typical}$, the standard deviation of the calibrated values across any 100 contiguous pixels within a line of LDCM Level 1R Digital Image Data within a band shall not exceed 0.25% of the average radiance across the line. Temporal (within column) noise may be averaged to verify compliance with this specification.

6.2.3.3 Streaking

For a spatially uniform source above 2*Ltypical, the maximum value of the streaking parameter within a line of Level 1R digital image data shall not exceed 0.50% of the band average radiance for bands 1-7 and 9 or 1.0% of the average radiance for the sharpening band (band 8 or band 4, if the red band is used as the sharpening band). Temporal (within column) noise may be averaged to verify compliance with this specification.

The streaking parameter is defined by the following equation:

$$S_i = 100 \times \left| L_i - \frac{1}{2}\left(L_{i-1} + L_{i+1}\right) \right| / L_i$$

where:

L_i is the calibrated radiance value measured for a pixel at an input radiance level;

L_{i-1} and L_{i+1} are similarly defined for the $(i-1)^{th}$ and $(i+1)^{th}$ pixels.

Note: These requirements apply for target radiances with spectral characteristics as follows: the spectral radiance from bare soil as observed through a dry atmosphere (excluding band 9), spectral radiance proportional to the exoatmospheric solar irradiance, and spectral radiance from a dense vegetation target as observed through a moist atmosphere (excluding band 9) (See Figure 6.2.3-1 and Top of Atmosphere Radiance Values, MODTRAN 4 Model table values, Section 1.5, Reference b). The target radiances are all determined using the same calibration coefficients.

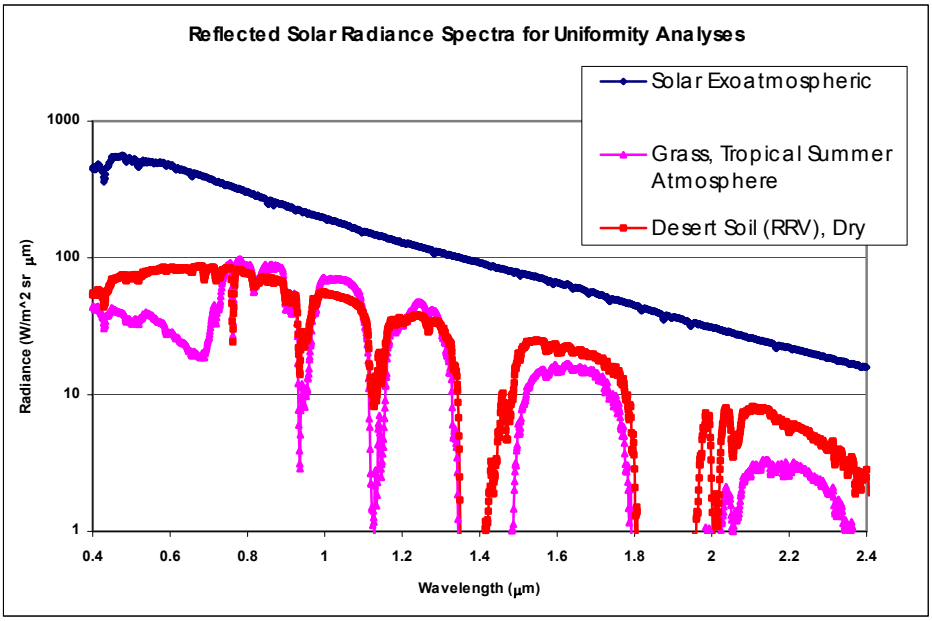

Figure 6.2.3-1

6.2.4 Coherent Noise

The magnitude of the autocorrelation of a dark (zero-radiance) LDCM Level 1R WRS-2 scene, and normalized to 1.0 at zero lag, shall not exceed 0.25 at any non-zero spatial lag.

6.3 Dynamic Range

The LDCM Level 0 and Level 1 Digital Image Data shall cover, without saturating, signals up to the Lmax as shown in table 6.1-1. Note**:** For bands 1-8, this corresponds to the radiance reflected off of a Lambertian target of 100% reflectance illuminated by the sun at a solar zenith angle of 20°.

6.4 Polarization Sensitivity

The LDCM Sensor shall not exhibit polarization sensitivity, such that the linear polarization factor, defined as PF = (Imax-Imin)/(Imax+Imin), is less than 0.05.

6.5 Radiometric Stability

6.5.a Over any time up to 16 days, the LDCM Level 1 Digital Image Data for radiometrically constant targets with radiances greater than or equal to $L_{typical}$ shall not

vary by more than plus or minus (95% or 2-sigma confidence interval) the following sum: 1% of the target radiance plus 0.025% of L_{max}.

6.5.b Over any time period between 16 days and 5 years, the LDCM Level 1 Digital Image Data for radiometrically constant targets with radiances greater than or equal to $L_{typical}$ shall not vary by more than plus or minus (95% or 2-sigma confidence interval) the following sum: 2% of the target radiance plus 0.025% of L_{max}.

6.6 Image Artifacts

6.6.1 Bright Target Recovery

The LDCM Level 1R digital image data shall be such that for an image pixel that has been exposed to a radiance level of less than or equal to 1.5 times that of the saturation radiances (Table 6.1-1), the pixels outside the 7 x 7 region around that pixel are not altered by more than 1% of their radiance for bands 1-7 and 9 and 2% for the sharpening band for radiances at or above Ltypical. If band 4 is used as the sharpening band, the 1% requirement also applies at the ground distance corresponding to a 7 x 7 pixel region of the non-sharpening spectral bands.

6.6.2 Pixel-to-Pixel Crosstalk

The LDCM level 1R data shall be such that the electrical crosstalk-induced artifacts in neighboring pixels caused by regions of pixels having radiance levels less than the saturation level and which are more than ten pixels away, shall not exceed 1% of the affected pixels' radiances, in total, after radiometric correction, for affected pixel radiance at or above Ltypical.

7.0 LDCM Geometric Precision, Geolocation, and Cartographic Registration

7.1 Band-to-Band Registration

Level 1Gs and 1Gt Validation Data Products shall exhibit band-to-band registration accuracy for targets at the Earth's surface as specified in the following sections and in Table 7.1.2-1.

7.1.1 Level 1Gs Validation Data Product Band-to-Band Registration

Corresponding pixels from the digital images of the spectral bands in Level 1Gs Validation Data Products created using the cubic convolution resampling method shall be co-registered with an uncertainty as specified in table 7.1.2-1 or less in the line and sample directions at the 90% confidence level for target areas within 100 meters of the WGS84 (G873 or current version) Earth ellipsoid surface.

7.1.2 Level 1Gt Validation Data Product Band-to-Band Registration

Corresponding pixels from the digital images of the spectral bands in Level 1Gt Validation Data Products created using the cubic convolution resampling method shall be co-registered with an uncertainty as specified in table 7.1.2-1 or less in the line and sample directions at the 90% confidence level.

Table 7.1.2-1: Level 1G Band Registration Requirements

Registration requirements for each band pair are found by reading down the appropriate column and across the appropriate row.	Standard Bands 1, 2, 3, 4, 5, 6, 7, and 8	Cirrus Band 9
Standard Bands 1, 2, 3, 4, 5, 6, 7, and 8	4.5 meters	18 meters
Cirrus Band 9	18 meters	N/A

7.2 Image-to-Image Registration

Level 1G Validation Data Products shall exhibit image-to-image registration accuracy as specified in the following sections.

Notes: The image-to-image registration requirements for Level 1G products that are created using the nearest neighbor resampling method are specified with reference to the corresponding cubic convolution product to ensure consistent geometry across resampling methods. The multi-temporal image-to-image registration requirements apply to the other resampling methods.

7.2.1 Level 1Gt Validation Data Product Image-to-Image Registration
Two Level 1Gt Validation Data Products of the same area, derived from data acquired on different dates, created using the cubic convolution re-sampling method shall be capable of being co-registered by a lateral (line and/or sample) shift with no rotation or other distortion, with an uncertainty less than or equal to 12 meters**,** in the line and sample directions at the 90% confidence level when image-to-image correlation is applied to data from the same spectral band. This requirement applies to data from all spectral bands except the cirrus band (band 9).

7.2.2 Level 1Gs Nearest Neighbor Validation Data Product Image-to-Image Registration
Two Level 1Gs Validation Data Products derived from the same input data, one created using the nearest neighbor re-sampling method and the other using the cubic convolution re-sampling method shall be co-registered with an uncertainty less than or equal to 0.5 times the LDCM GSD values specified in Sections 5.1 and 5.2, in the line and sample directions at the 90% confidence level when image-to-image correlation is applied to data from the same spectral band. This requirement applies to data from all spectral bands.

7.3 Level 1Gs Validation Data Product Geodetic Accuracy

7.3.1 Level 1Gs Validation Data Product Absolute Geodetic Accuracy

The pixels for targets at the Earth's topographic surface in the Level 1Gs Validation Data Products, created using the cubic convolution re-sampling method, shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 65 meters (90% circular error*)*, excluding terrain effects. This specification applies to the horizontal error of ground control points measured in the 1Gs image, after compensation for control point height.

7.3.2 Level 1Gs Validation Data Product Relative Geodetic Accuracy
The pixels for targets at the Earth's topographic surface in the Level 1Gs Validation Data Products, created using the cubic convolution resampling method, shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 25 meters (90% circular error), excluding terrain effects, over an area of 180 km by 180 km, after the removal of constant offsets. This specification applies to the standard deviation of ground control points measured in the 1Gs image, after compensation for control point height.

7.4 Level 1Gt Validation Data Product Geodetic Accuracy

The pixels for targets at the Earth's topographic surface in the Level 1Gt orthorectified Validation Data Products, created using the cubic convolution resampling method shall be located relative to the WGS84 geodetic reference system, G873 or current version, with an uncertainty less than or equal to 12 meters (90% circular error), including compensation for terrain effects. The following sections describe the product characteristics and support data assumptions to be used in creating the Level 1Gt Validation Data Products for demonstration of Level 1Gt geometric performance.

7.4.1 Level 1Gt Validation Data Product Size

Level 1Gt Validation Data Products shall cover an area corresponding to a single WRS-2 scene.

7.4.2 Level 1Gt Validation Data Product Cloud Cover

Level 1Gt Validation Data Products shall be created for WRS-2 scenes that are 5% cloud covered or less.

7.4.3 Level 1Gt Validation Data Product Ground Control Points

Level 1Gt Validation Data Products shall be created using Government furnished ground control points accurate to 3 meters (90% circular error) horizontally and 12 meters (90% linear error) vertically, with 5 or more points distributed across the WRS-2 scene area.

7.4.4 Level 1Gt Validation Data Product Elevation Data

Level 1Gt Validation Data Products shall be created using Government furnished digital elevation data accurate to 12 meters (90% linear error) completely covering the WRS-2 scene area.

Note: This specifies the accuracy with which the elevation for an arbitrary point within the WRS-2 scene area can be retrieved from the digital elevation data, not the accuracy of the individual elevation samples within the digital elevation data set and, thus, includes the effects of sample spacing and horizontal error.

SECTION J OF RFP5-12345-JLB
ATTACHMENT B

Appendix: LTAP Acquisition Priority Algorithm

The Landsat-7 Long Term Acquisition Plan (LTAP) automates the selection of Landsat scenes to periodically refresh a global archive of sunlit, substantially cloud-free land images. By applying a set of algorithms on a daily basis, the LTAP is designed to ensure optimal collection of Landsat-7 ETM+ imagery for scientific applications, while minimizing the effects of cloud-cover and system constraints. Further background information on the Landsat-7 LTAP may be found within 427-HDBK-00005, LDCM Functional Description. This Appendix details the algorithm used to calculate acquisition priority scores referred to in Section 3.1.1.2.

The calculation of overall request priorities in the LTAP begins with the "base priority" of a particular scene. The base priority is a function of location (path-row) and date (acquisition window), but is normally set to 50 for scenes listed as "acquire once" or "acquire always" for a particular acquisition window. Thus, base priorities include both routine NDVI-derived acquisitions as well as niche science acquisitions.

For scenes with a predicted cloud cover ($CC_{predict}$) greater than 80%, the acquisition priority score is zero. For scenes with ($CC_{predict}$) < 80%, P_r is defined as:

$$\mathbf{P_r = P_b * (}\max(0, \mathbf{[1 + CC_{boost} * (CC_{nominal} - CC_{predict}) / 100] * MO_{current}))} \quad \mathbf{(1)}$$

Where:
P_b is the base priority of scene (usually 50);
CC_{boost} is the cloud cover priority boost constant, set to 3.0;
$CC_{predict}$ is the predicted cloud cover of the current scene from the forecast, ranging from 0-100;
$CC_{nominal}$ is the average seasonal cloud cover for this scene from the ISCCP data, ranging from 0-100;
$MO_{current}$ is the missed opportunity priority boost:

$$\mathbf{MO_{current} = MO_{boost} + [MO_{prior} * (1\text{-}IQ_{max})]} \quad \mathbf{(2)}$$

Where:
MO_{boost} is the missed opportunity priority boost constant, set to 1.0.

MO_{prior} is the value of $MO_{current}$ from the previous 16-day cycle if (i) the path row was scheduled as "acquire once" or "acquire always" during a different acquisition window and (ii) no successful acquisition occurred. If the request is new (i.e. there was no request for this path-row in the previous 16-day cycle as part of another acquisition window), then MO_{prior} is set to 3.0.

IQ_{max} is the image quality of the best (clearest) acquired image of the current location during the lifetime of the current scene request (acquisition window). If no image has

been acquired for the current request then $IQ_{max} = 0$. IQ_{max} ranges from 0 to 1.0 according to:

$$\mathbf{IQ_{max}} = \min (1.0, \max (0, \mathbf{1 - [(CCA_{best} - T_{success}) / (T_{fail} - T_{success})]})) \quad \mathbf{(3)}$$

Where:
CCA_{best} ranges from 0 to 100% and is (a) for "acquire once" cases, the lowest actual cloud-cover score of all images acquired during the current request period; or (b) for "acquire always" cases, the actual cloud-cover score of the most recently acquired image during the current request period.
$T_{success}$ is a constant defining the actual cloud-cover score below which an image is considered "cloud-free", currently set to 10%;
T_{fail} is a constant defining the actual cloud-cover score above which an image is considered to cloudy to be useful, currently set to 60%.

Note also that for "acquire once" cases at latitudes above/below 59 degrees north/south, CCA_{best} is actually the best cloud-cover score that can be mosaiced from images along adjacent paths.