National Aeronautics and Space Administration

Landsat Data Continuity Mission: Overview and Status

Brian Markham, LDCM Cal/Val Manager

March 29, 2011

JACIE

data continuity mission

LDCM
LANDSAT

NASA GSFC / USGS EROS

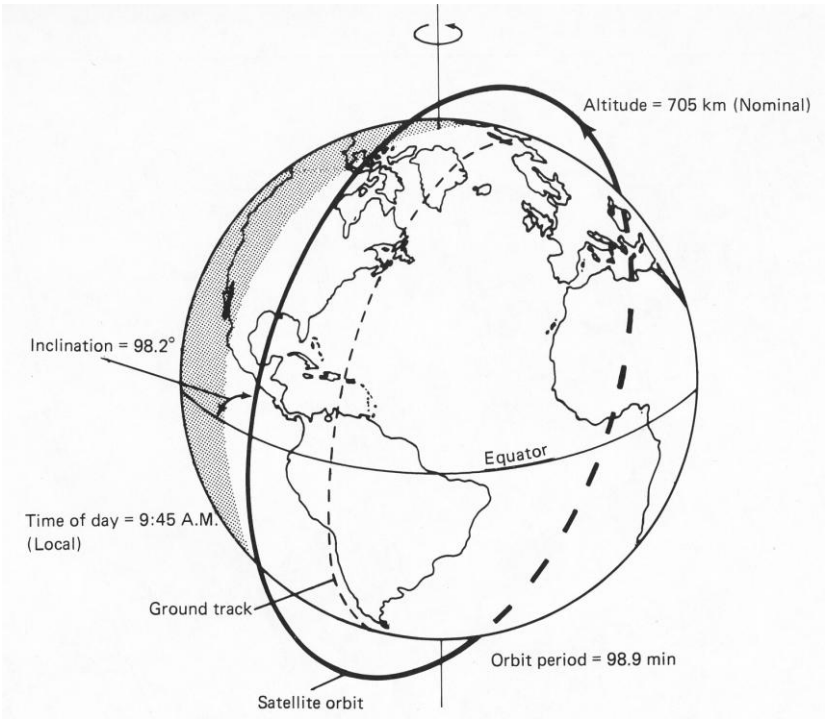
www.nasa.gov **www.usgs.gov**

Mission Objectives

- The following are the major mission objectives:
  - Collect and archive moderate-resolution, reflective multispectral image data affording seasonal coverage of the global land mass for a period of no less than five years.
  - Collect and archive moderate-resolution, thermal multispectral image data affording seasonal coverage of the global land mass for a period of no less than three years.
  - Ensure that LDCM data are sufficiently consistent with data from the earlier Landsat missions, in terms of acquisition geometry, calibration, coverage characteristics, spectral and spatial characteristics, output product quality, and data availability to permit studies of land cover and land use change over multi-decadal periods.
  - Distribute standard LDCM data products to users on a nondiscriminatory basis and at no cost to the users.

Top Level Mission Ops Concept - Continuity

- Fly LDCM observatory in legacy orbit (716 km, near-polar, sun-synchronous)
  - Ground tracks maintained along heritage WRS-2 paths with 10:00 a.m. equatorial crossing time
- Collect image data for multiple spectral bands (Vis/NIR/SWIR/TIR) across 185 km swath along each path
  - Provide coverage of global land mass each season by scheduling the collection of 400 WRS-2 scenes per day
  - Maintain rigorous calibration
- Archive data and distribute data products
  - Provide nondiscriminatory access to general public, generate Level 1 data products, distribute data products at no cost upon request



LDCM Overview

Instruments

- Operational Land Imager - BATC
- Thermal Infrared Sensor – GSFC

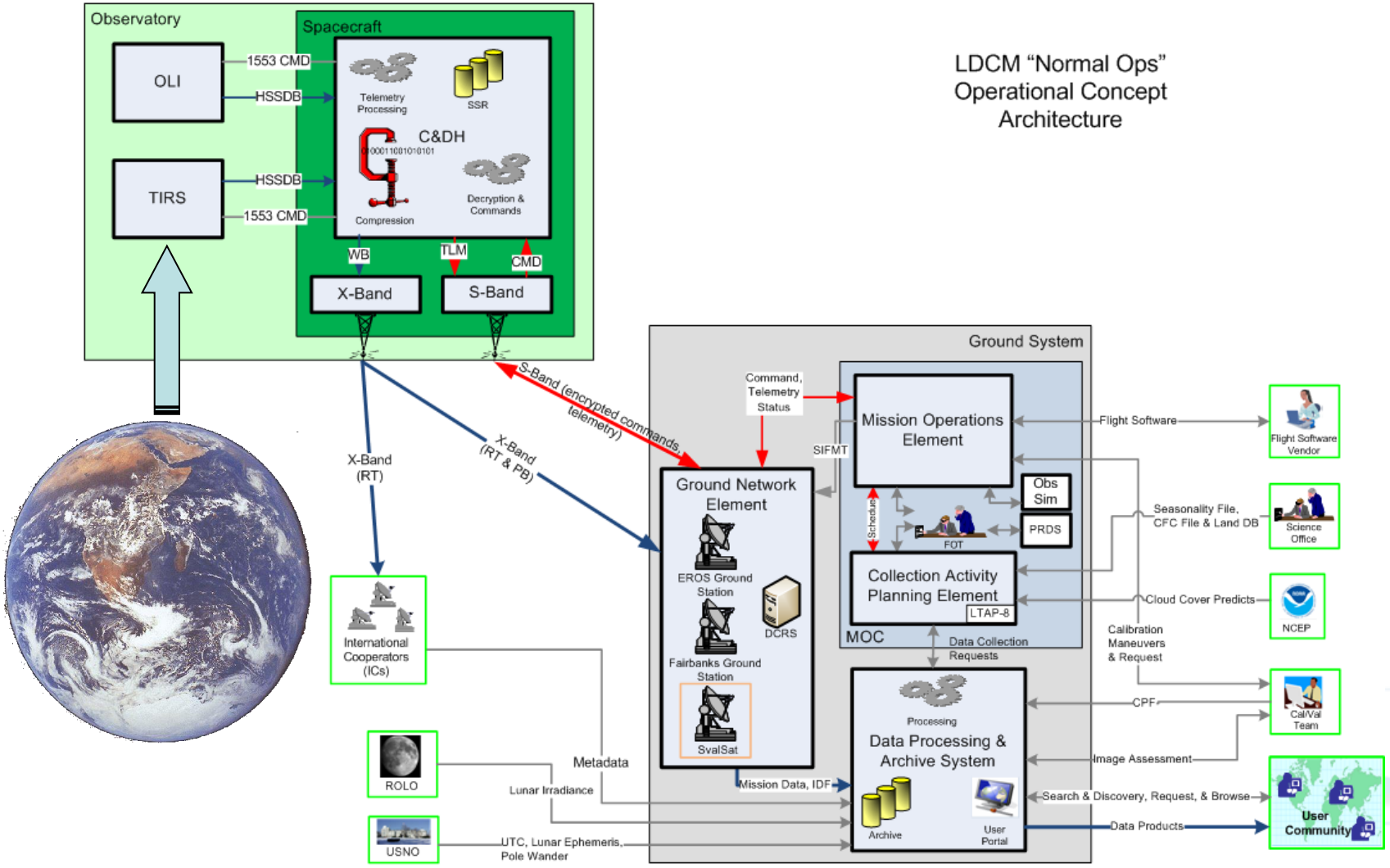
Spacecraft

- Orbital - Gilbert, AZ

Mission Team

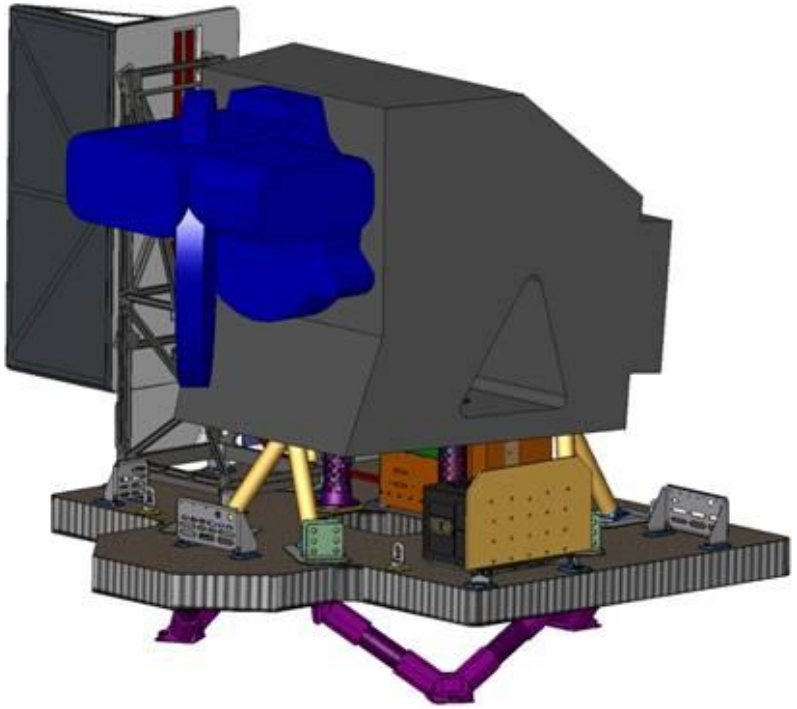
- NASA Goddard Space Flight Center
- Dept. of Interior's United States Geological Survey (USGS)
- NASA Kennedy Space Center

LDCM Operational Architecture

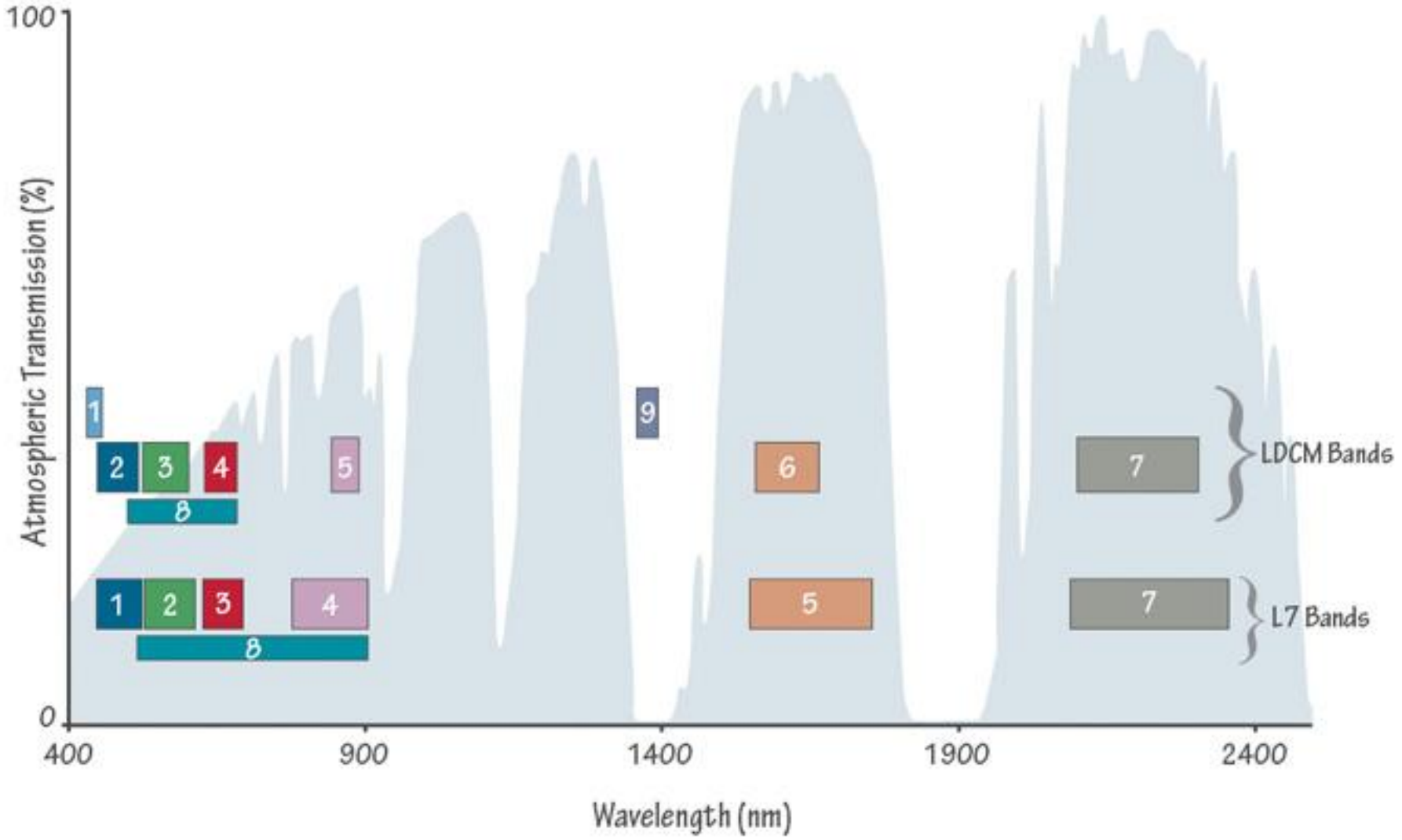


Operational Land Imager (OLI)

- Collects data for nine shortwave spectral bands
  - Provides continuity with seven TM and ETM+ shortwave spectral bands
  - Adds two new bands
- Collects 400 scenes per day using pushbroom design
  - Coincident with TIRS data collection
- Covers a 185 km swath
- Provides 30 m spatial resolution
  - 15 m panchromatic band
- Collects calibration data
  - Internal lamps, shutter, solar diffusers, lunar views, vicarious field campaigns, geometric super sites



OLI & ETM+ Spectral Bands



OLI Status

- Flight instrument completed
  - Focal Plane System
  - Calibration Subsystem
  - Electronics Boxes
  - Baseplate

- Flight OLI completed performance testing
  - Spatial, spectral, and radiometric testing complete

- Sensor integrated to baseplate
- EMI/EMC testing ongoing
- TVAC/TBT upcoming
- Delivery Summer 2011

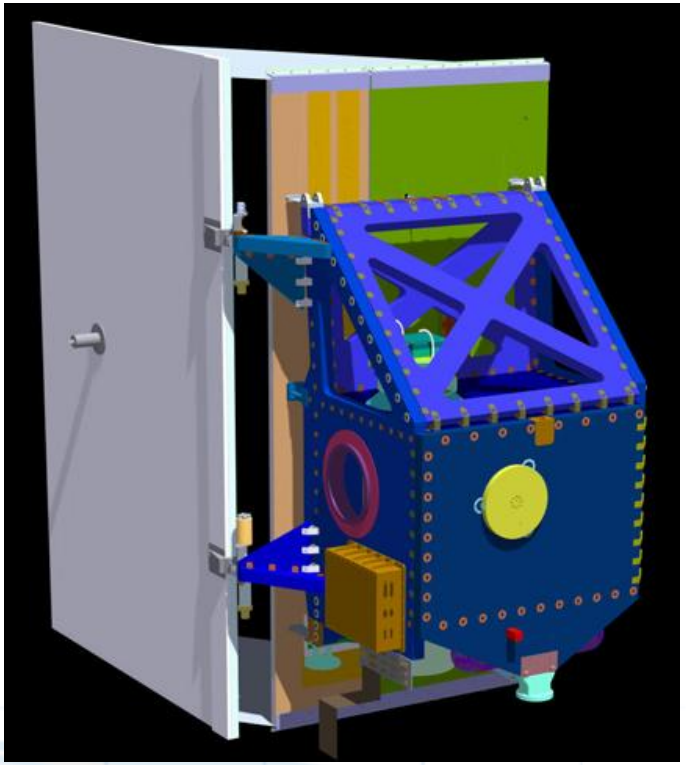
Completed OLI Instrument

Courtesy of Ball Aerospace & Technologies Corp.

Completed OLI Sensor with Electronics

Thermal Infrared Sensor (TIRS)

- Collects data for two long-wave spectral bands
  - Provides continuity with one TM/ETM+ thermal band
- Collects 400 scenes per day using a pushbroom design
  - Coincident with OLI data collection
- Covers a 185 km swath
- Provides a 100 m spatial resolution
- Collects calibration data
  - Space view, internal blackbody, vicarious calibration sites, geometric super sites

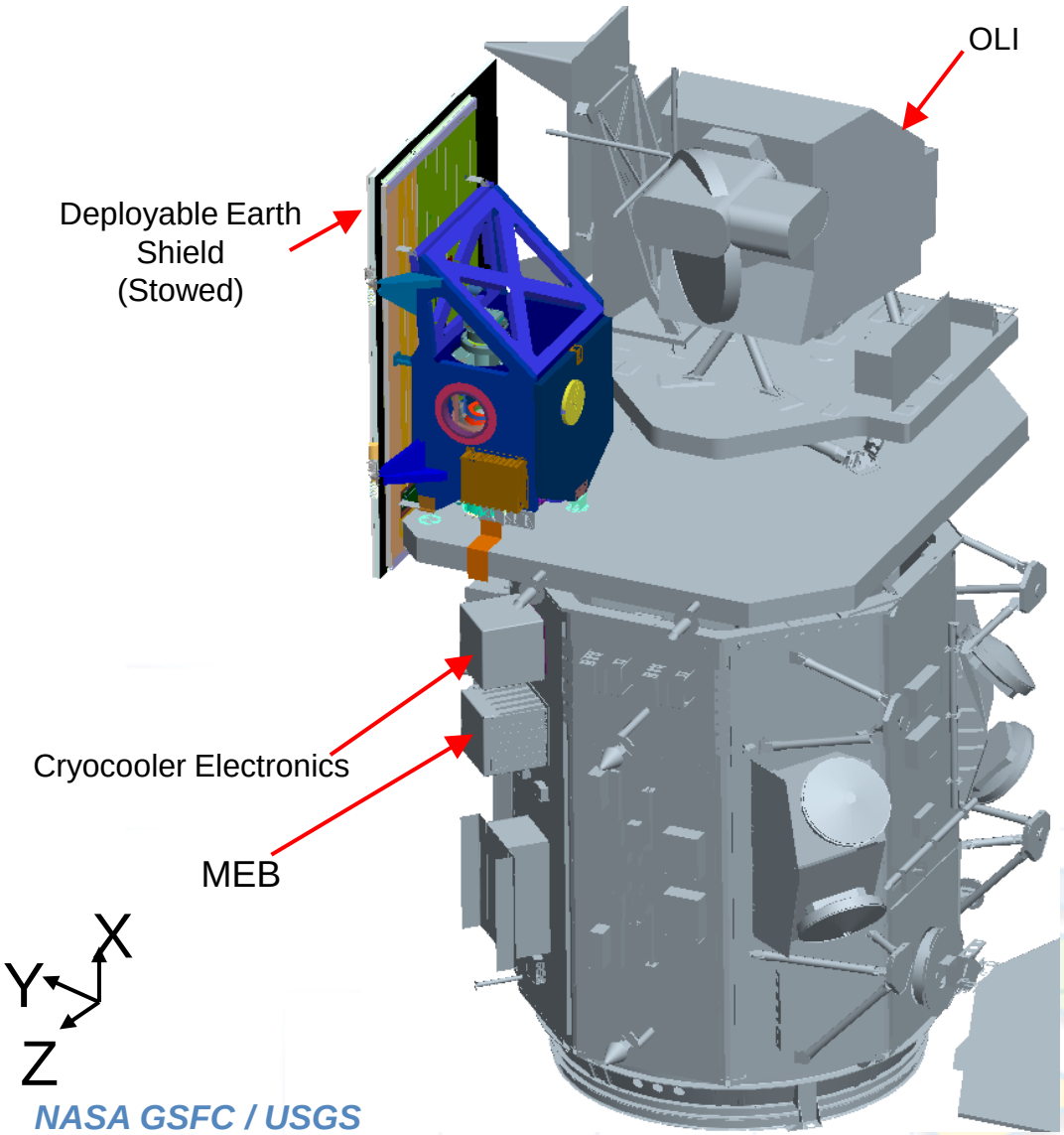


TIRS and ETM+ Spectral Bands

L7 ETM+ Thermal Band		LDCM TIRS Band Requirements		
Band 6	**60 m LWIR** 10.00 - 12.50	**100 m LWIR**	10.30 – 11.30	**Band 10**
		100 m LWIR	11.50 – 12.50	**Band 11**

- 120 m resolution TIRS requirement deemed sufficient to resolve most center-pivot irrigation fields in U.S. West - typically 400 to 800 m in diameter – TIRS design provides for 100 m resolution
- Landsat 4 & 5 TM's provided 120 m thermal images for a single thermal band
- Landsat 7 ETM+ provided 60 m thermal images for a single thermal band
- A two band instrument will enable atmospheric correction so that more accurate surface temperatures can be derived.

TIRS on LDCM Spacecraft



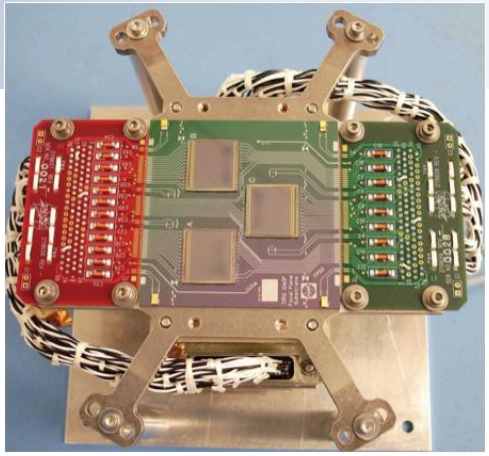
NASA GSFC / USGS

- Quantum well infrared photodetector (QWIP) focal plane array (built at GSFC), at 43K
- 2-Channel IR spectral imager
  - 10.8 μm and 12 μm
  - Split window atmospheric correction
- Two full aperture calibration sources
  - Onboard blackbody
  - Space view
  - Calibration every 34 minutes
- Scene select mirror selects between calibration sources, nadir
- 185 km ground swath (15° FOV)
- 100 meter resolution
- TIRS delivery December 2011
- 3.25 year life, Class C instrument

TIRS Status (1 of 2)

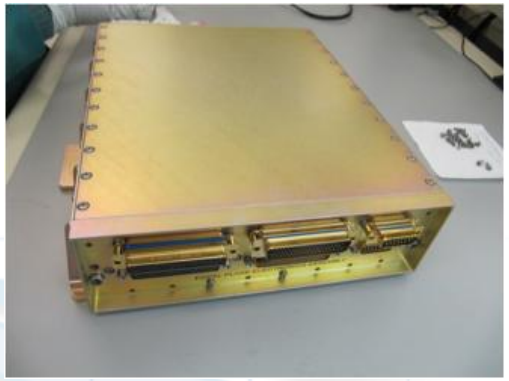
Completed

- Focal Plane Array
- Telescope
- Focal Plane Electronics



Nearly Completed

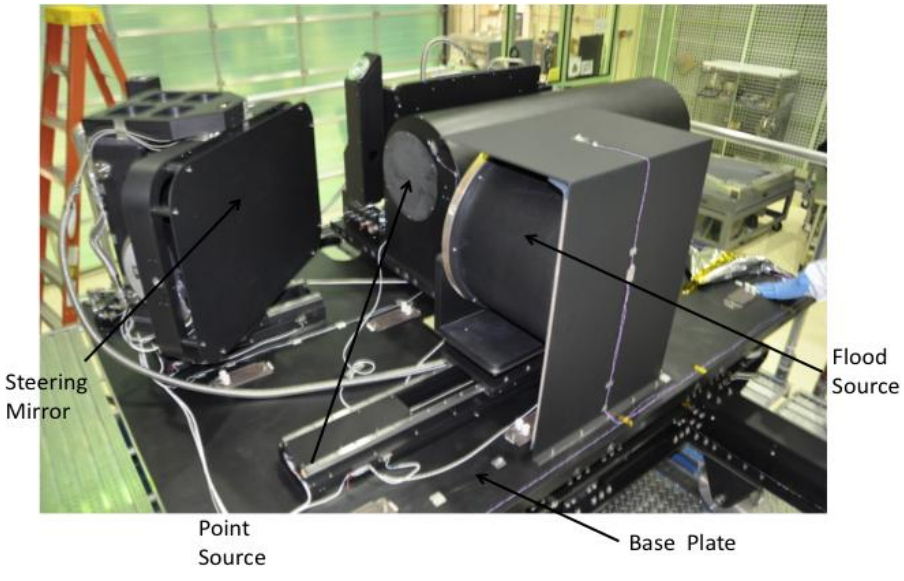
- Scene Select Mechanism
- Structure
- Earth Shield Mechanism
- Cryocooler
- Main Electronics Box



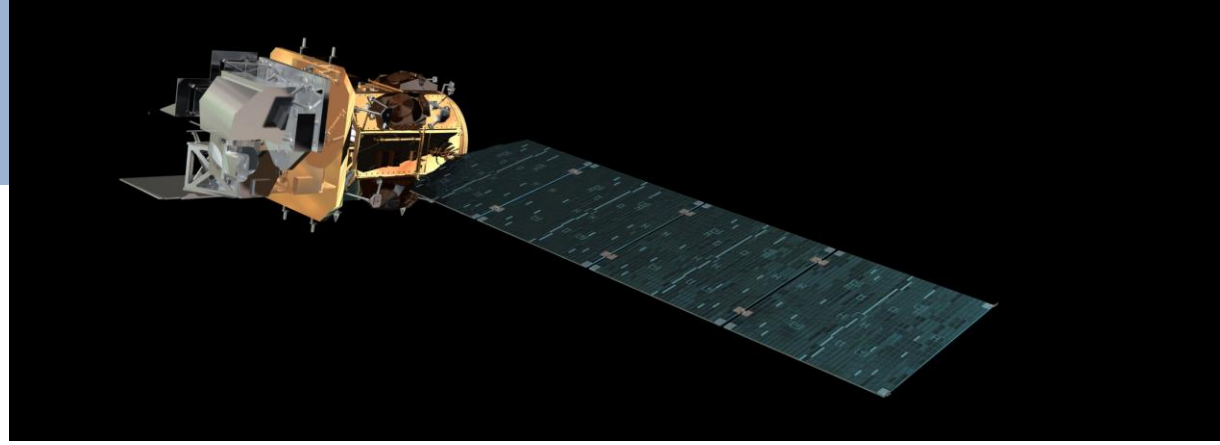
TIRS Status (2 of 2)

Integration and Testing (I&T):

- Integration:
  - Flight FPA to Flight Telescope - complete
  - Flight FPE integration – March 2011
- Testing
  - Focus testing complete, meets requirements
  - Interface testing between FPE and MEB testbed complete
  - Initial Calibration March-April 2011

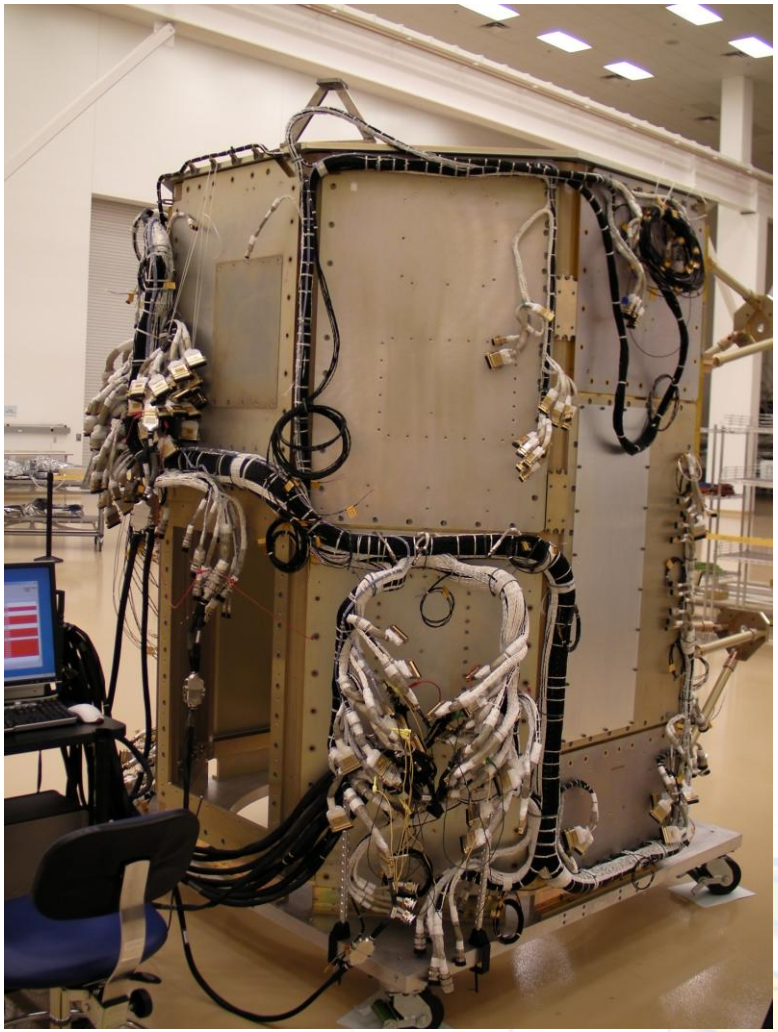


LDCM Spacecraft



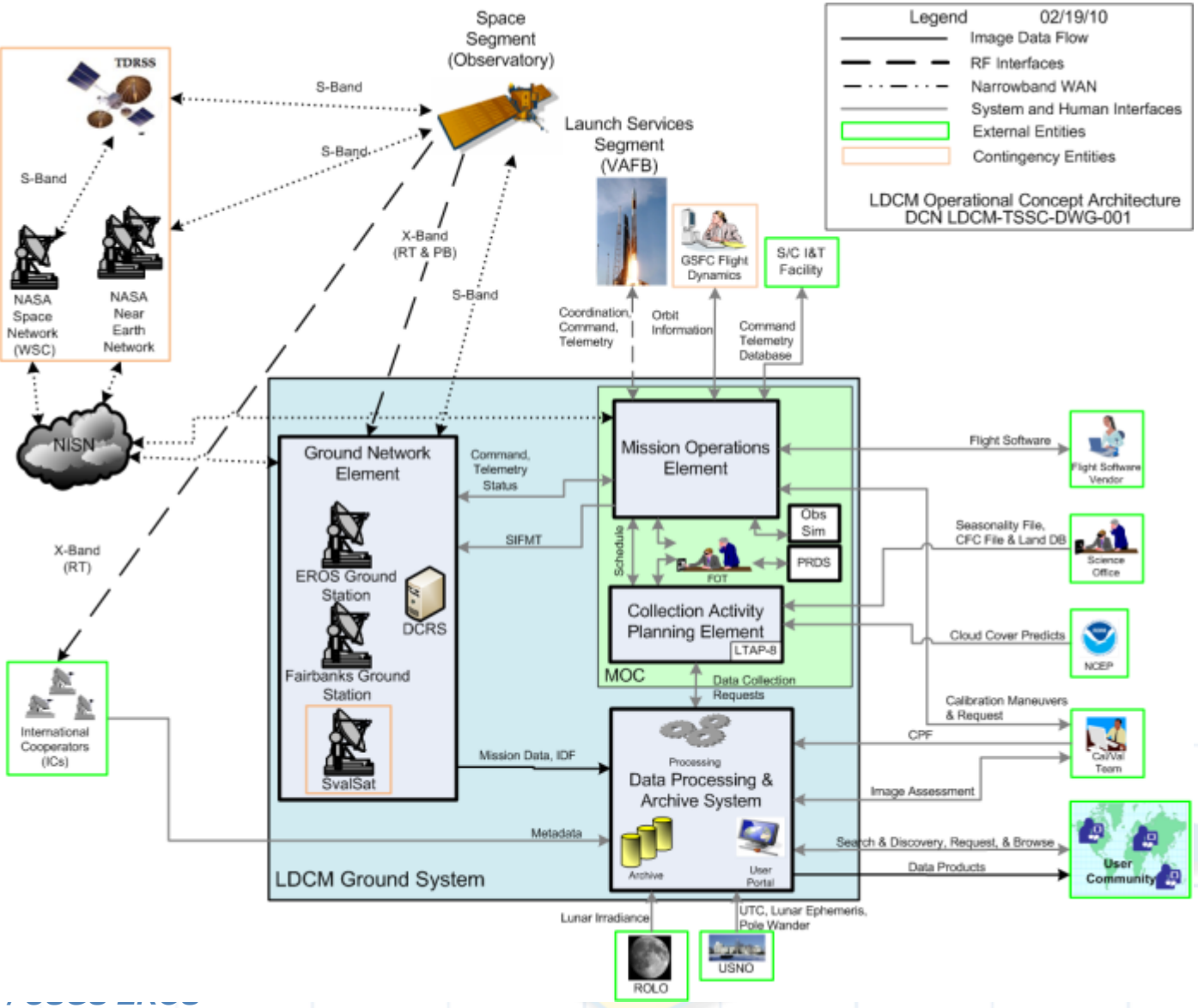
- 3.14 Tbit Solid-State Recorder (SSR)
  - Including all data sent real time to International Cooperators
- Data Transmission from an earth-coverage antenna
  - Real-time data received from PIE
  - Play-back data from SSR
  - To three LGN ground stations
  - To International Cooperator ground stations
- Maneuvers
  - Inclination adjustments and drag make-up – keeps ground tracks along WRS-2 paths and equatorial crossing time at 10:00 a.m.
  - Solar and Lunar calibration maneuvers
  - Off-nadir pointing – for collection of priority data

LDCM Spacecraft Status



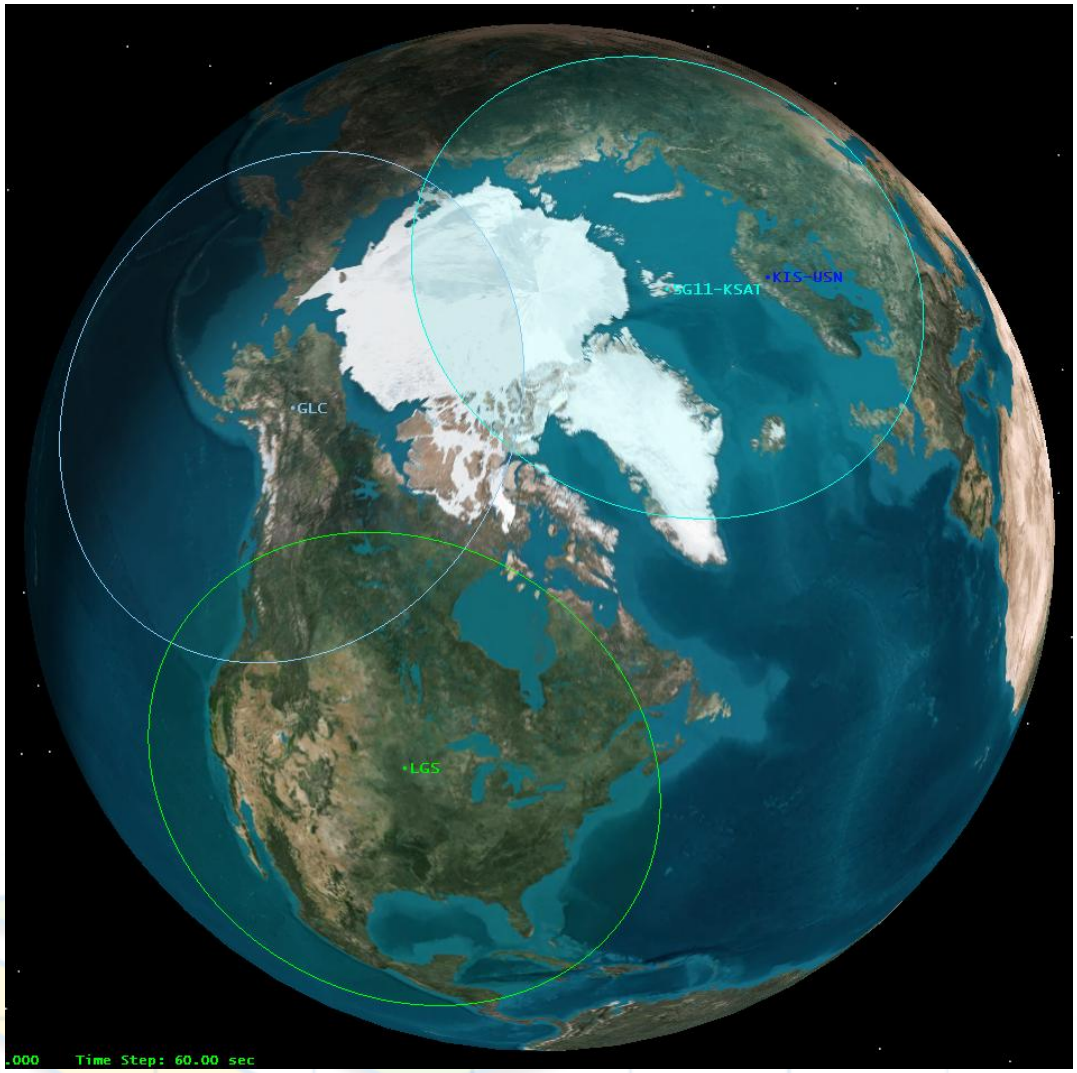
- Spacecraft bus I&T underway
  - Initial power on the bus in late January
  - Spacecraft Harness Installed
- Flight avionics boxes in test
- OLI Interface Simulator tested with S/C Interface Simulator
- Flight Battery cells activated

Ground System Architecture

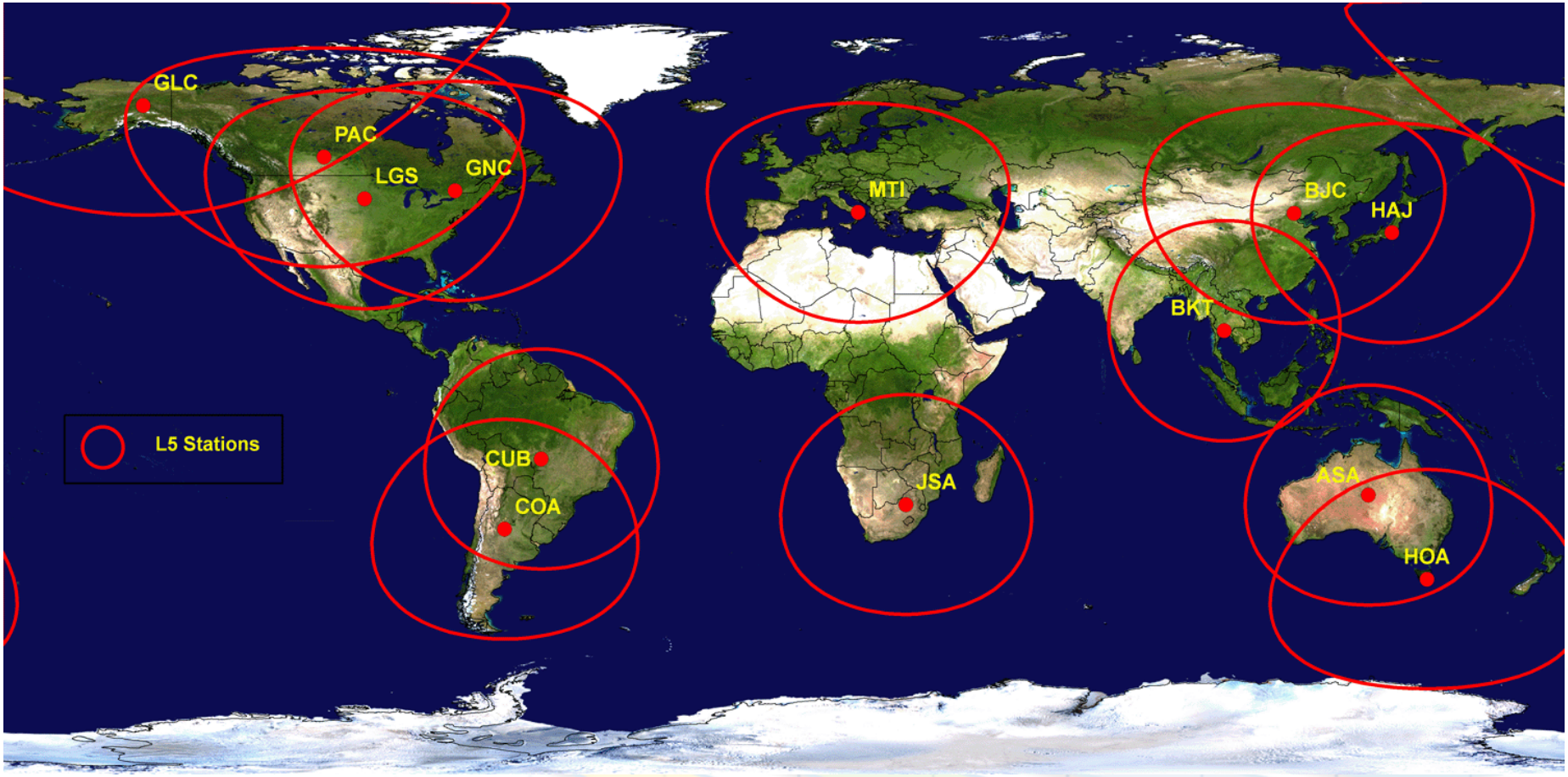


Ground System: Landsat Ground Network

- Receives mission data transmitted from the observatory at three ground stations
  - USGS EROS, Sioux Falls, SD
  - Gilmore Creek, AK
  - Svalbard, Norway
- Generates mission data files
- Sends mission data on to the Data Processing and Archive System (DPAS), USGS EROS, Sioux Falls, SD

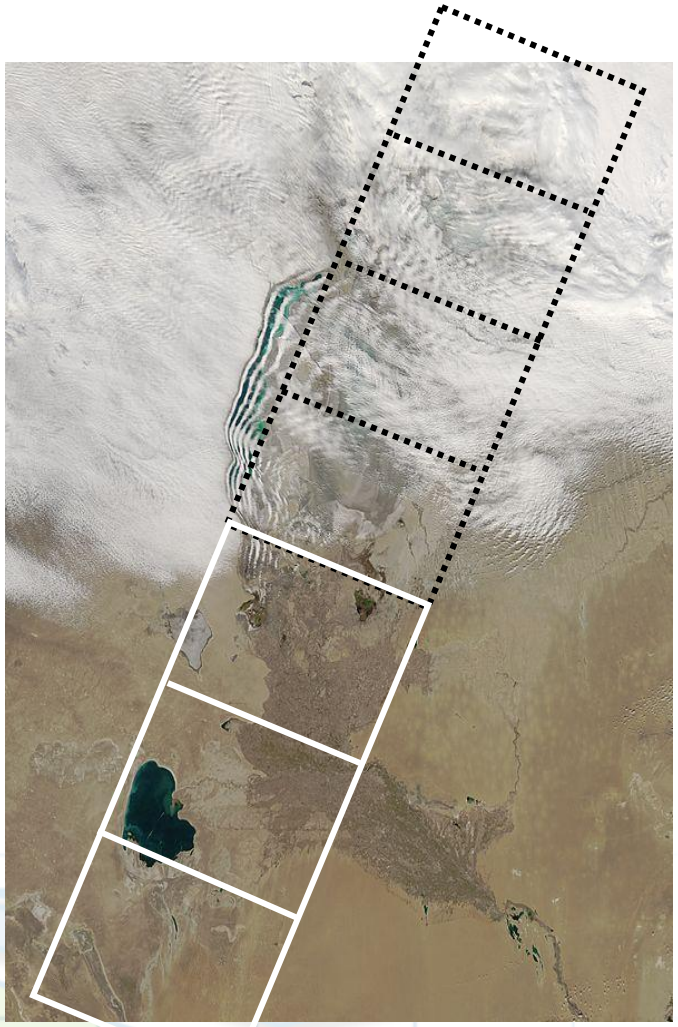


International Cooperator Network



Long Term Acquisition Plan - 8

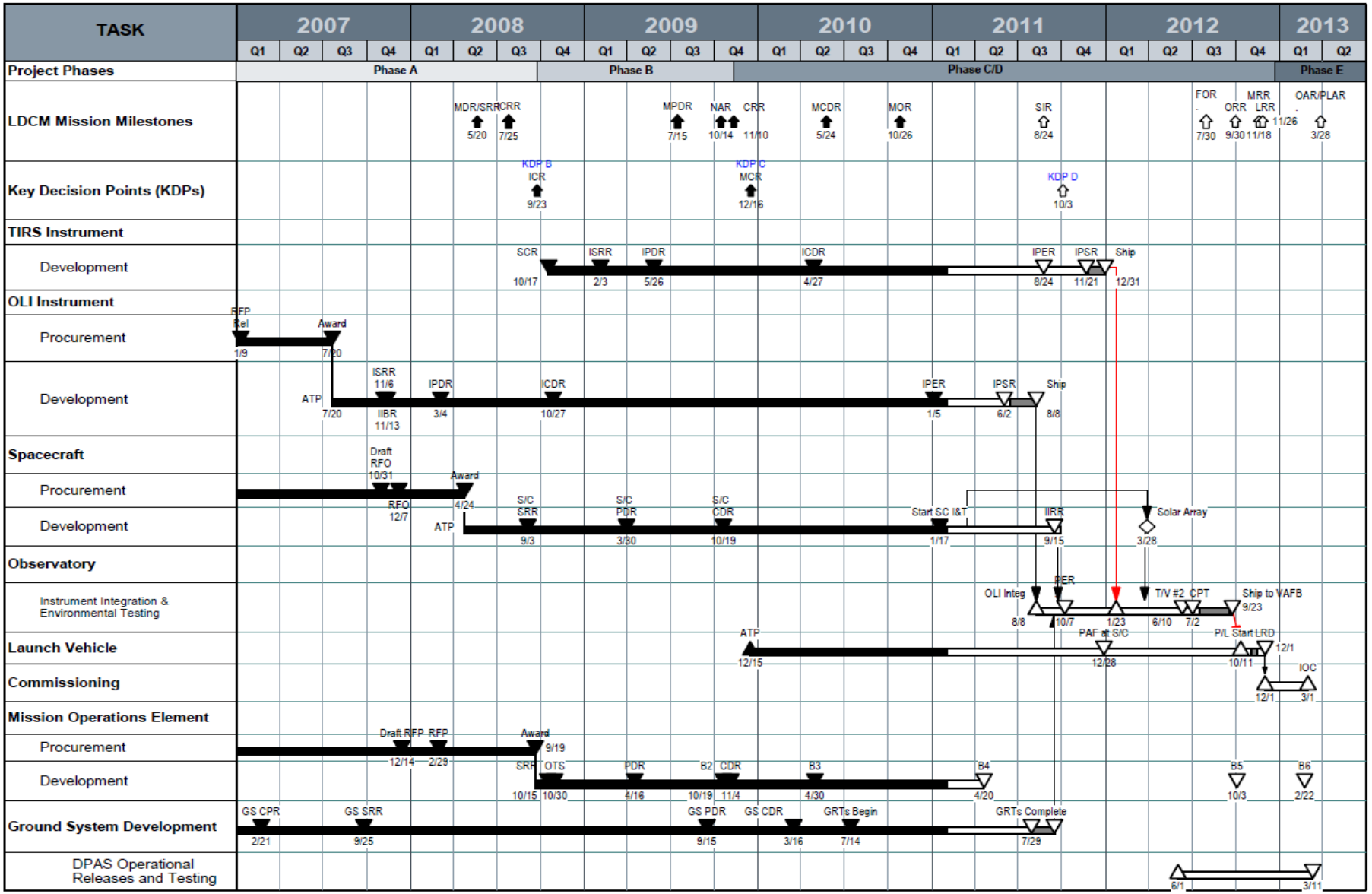
- The Long Term Acquisition Plan (LTAP) defines the OLI and TIRS data collection strategy for LDCM.
- Optimize data collection capacity of 400 scenes per day out of 800+ land scenes viewed
- LTAP Parameters
  - Historical cloud climatology
  - Seasonality
  - Begin / End date, Acquire once / always, Base priority values for land, islands, conterminous U.S.
  - Priority schema for non-LTAP data collection requests
  - Solar zenith angle constraints
  - Cloud cover predictions (NCEP)
  - Automated cloud cover assessments (DPAS)



Standard L1T and L1Gt Data Products

- LDCM standard Level-1 data products will be consistent with heritage Landsat product specifications
  - OLI and TIRS data will distributed as a combined product. Pixel size:15m/30m/30m
  - Quality Assurance (QA) “band” will be included
  - Media type: Electronic
  - Product type: Level-1T (precision, terrain correction)
  - Output format: GeoTIFF
  - Map projection: UTM (Polar Stereographic for Antarctica)
  - Datum: WGS84
  - Orientation: North up
  - Resampling: Cubic convolution

LDCM Master Schedule



- Launch Readiness Date (LRD) is December 1, 2012

Conclusion

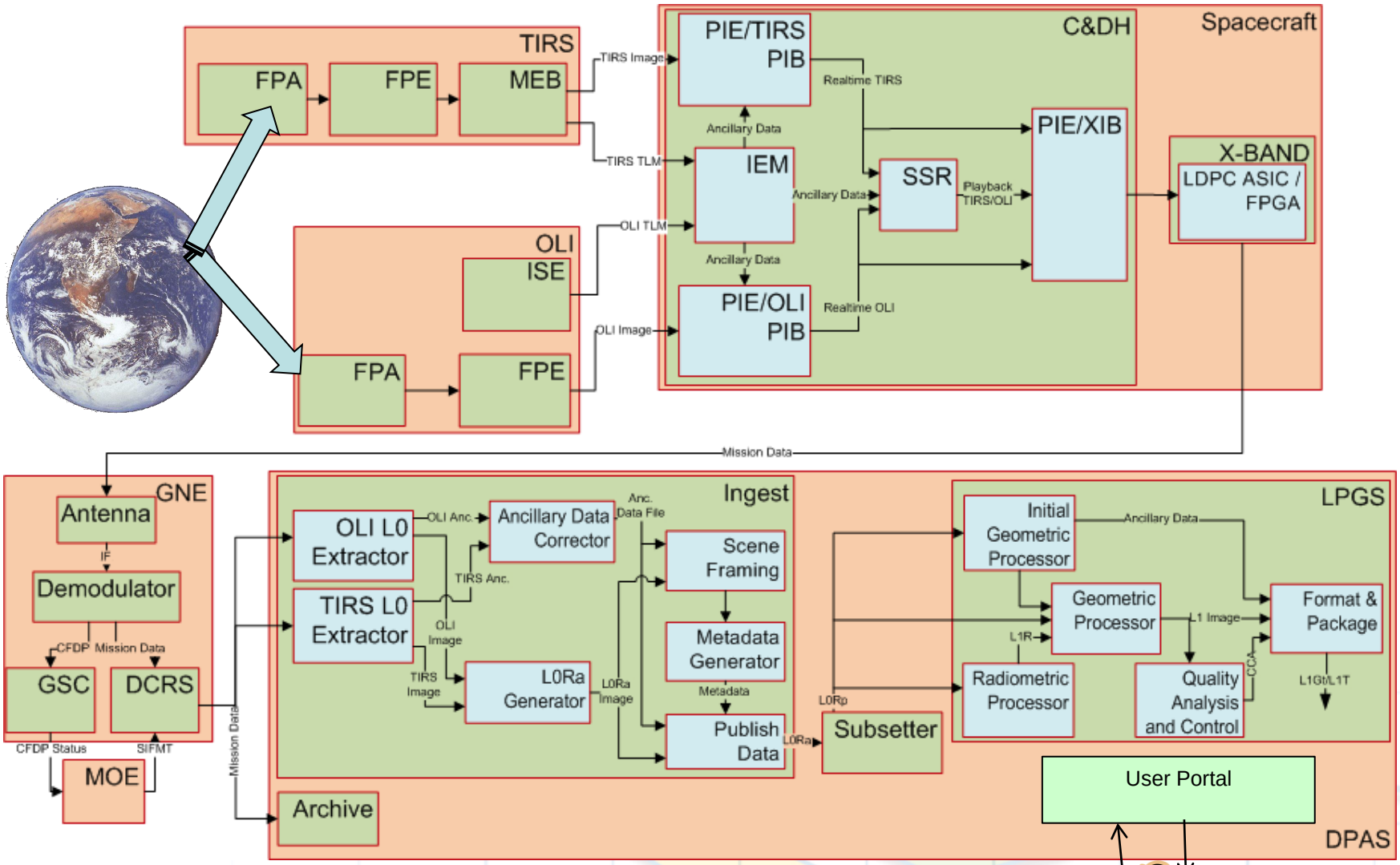
- LDCM (Landsat-8 post commissioning) will continue the Landsat mission for moderate resolution seasonal coverage of the global land mass
- LDCM is a generational change from earlier Landsats
  - MSS➔TM➔ETM+➔OLI/TIRS
  - Enhancements in spectral bands, radiometry
  - Rigorous calibration
- LDCM is on schedule for a 1 December 2012 launch

Backup Charts

OLI and ETM+ Spectral Bands

L7 ETM+ Bands			LDCM OLI Band Requirements		
			30 m Coastal/Aerosol	0.433 - 0.453	**Band 1**
Band 1	**30 m Blue**	0.450 - 0.515	**30 m Blue**	0.450 - 0.515	**Band 2**
Band 2	**30 m Green**	0.525 - 0.605	**30 m Green**	0.525 - 0.600	**Band 3**
Band 3	**30 m Red**	0.630 - 0.690	**30 m Red**	0.630 - 0.680	**Band 4**
Band 4	**30 m Near-IR**	0.775 - 0.900	**30 m Near-IR**	0.845 - 0.885	**Band 5**
Band 5	**30 m SWIR-1**	1.550 - 1.750	**30 m SWIR-1**	1.560 - 1.660	**Band 6**
Band 6	**60 m LWIR**	10.00 - 12.50	**N/A**		
Band 7	**30 m SWIR-2**	2.090 - 2.350	**30 m SWIR-2**	2.100 - 2.300	**Band 7**
Band 8	**15 m Pan**	0.520 - 0.900	**15 m Pan**	0.500 - 0.680	**Band 8**
			30 m Cirrus	1.360 - 1.390	**Band 9**

Follow the Science Data Flow

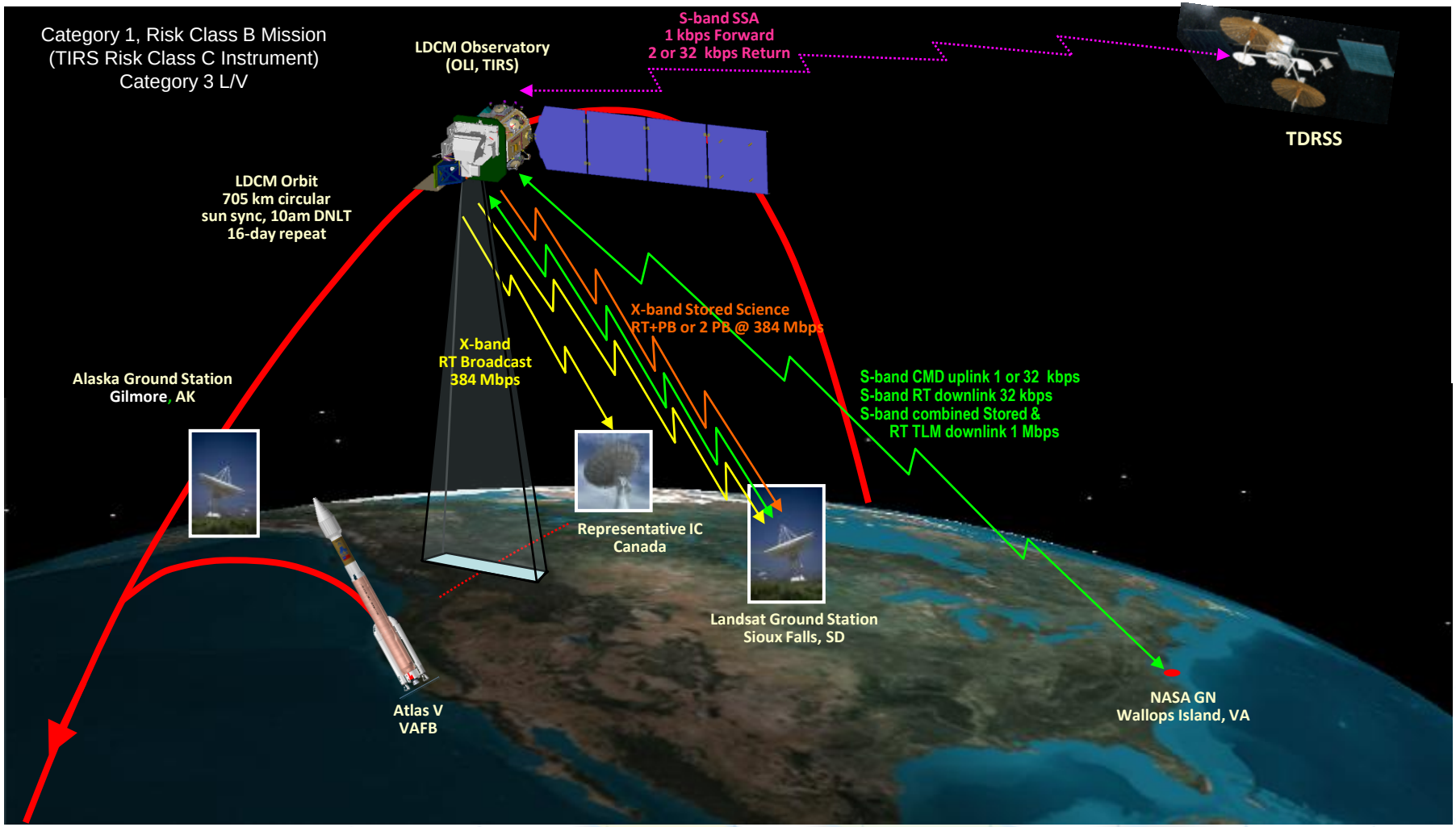


It All Starts in the Mission Ops Center (MOC)

- Collection Activity Planning Element (CAPE)
  - Ensures seasonal coverage of global land mass
    - Long Term Acquisition Plan – 8 (LTAP8)
  - Accepts external requests for scene collects – Data Acquisition Manager
    - International Cooperators, Priority Scenes (including off-nadir), User Requests
  - Delivers daily scene collection requests to MOE – 400 scenes per day

- Mission Operations Element (MOE)
  - Monitors observatory health and safety
  - Plans daily schedule on basis of CAPE scene requests
  - Transmits daily command load to observatory
  - Maintains satellite orbit along World Wide Reference System-Two (WRS-2) ground tracks with 10:00 a.m. equatorial crossing time
  - Plans and commands satellite maneuvers
    - Inclination adjustment and drag make-up maneuvers, solar and lunar calibration maneuvers, off-nadir pointing

Mission Overview



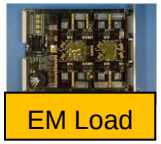
NASA GSFC / USGS EROS

Spacecraft Components

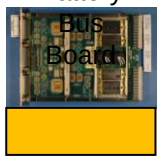

EM Charge Control Unit (CCU)

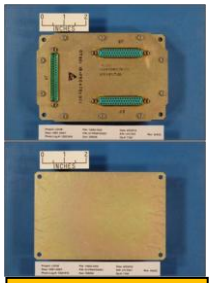

EM Load Control


EM I&T Battery


EM Load


FLT Battery


Bus Board

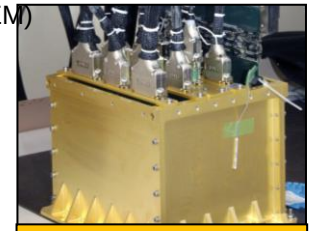

FLT Harness


EM


EM Integrated Electronics Module (IEM)


FLT RAD750


EM Solid State Recorder (SSR)

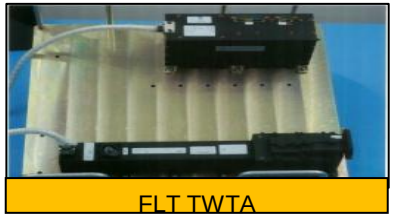

EM Payload Interface Electronics (PIE)

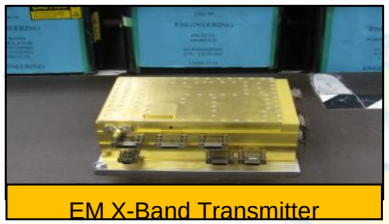

FLT 1553 Coupler


FLT OCXO

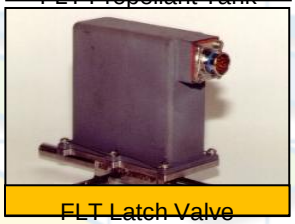

EM AMT (S-Band Transponder)


EM RF Filter

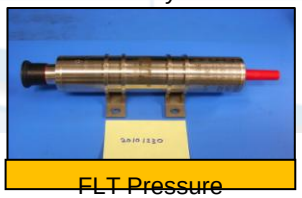

FLT TWTA


EM X-Band Transmitter

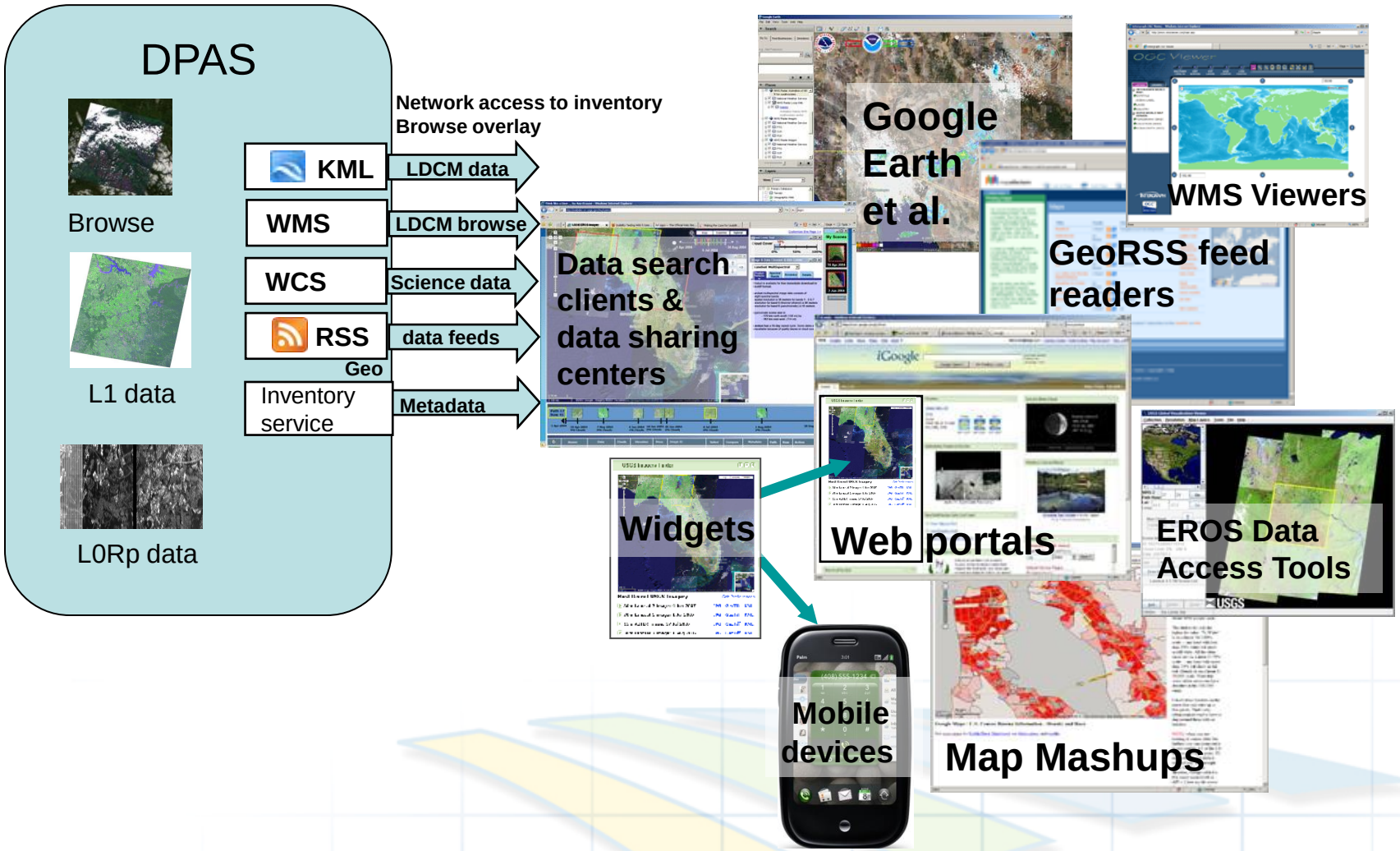

FLT Propellant Tank


FLT Latch Valve


FLT 22N Hydrazine

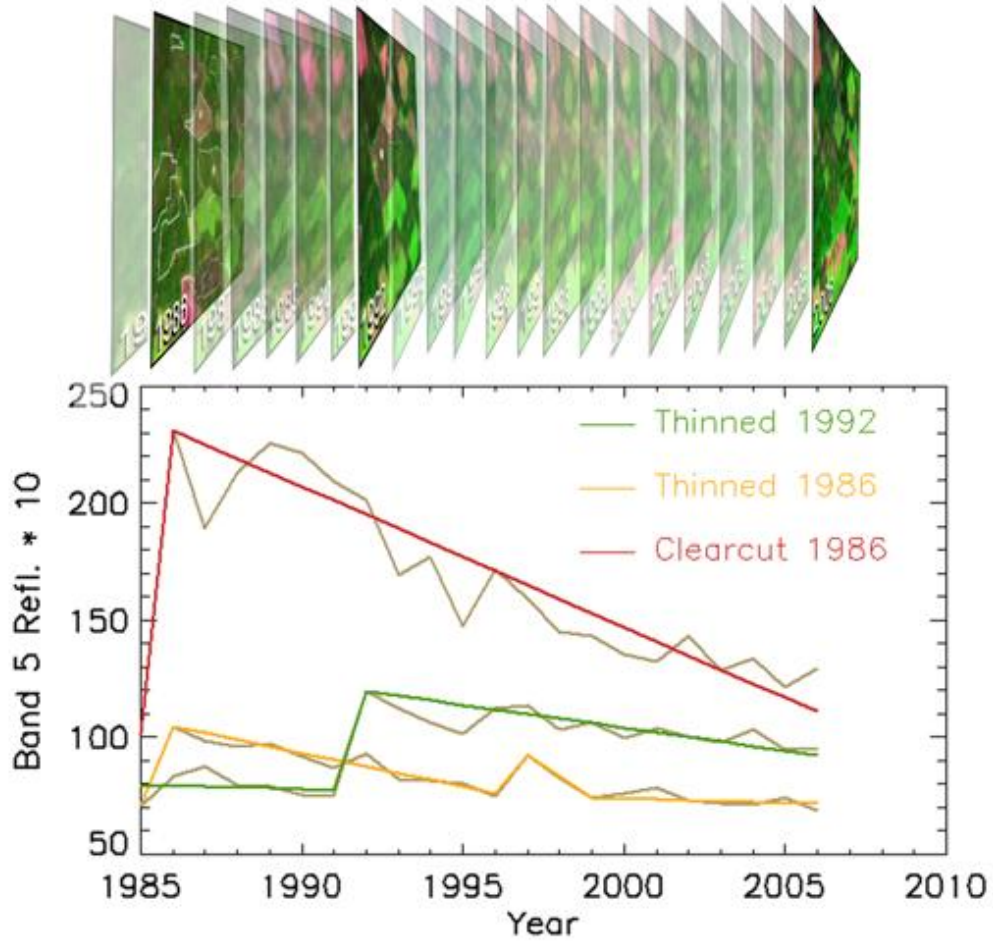

FLT Pressure Transducer

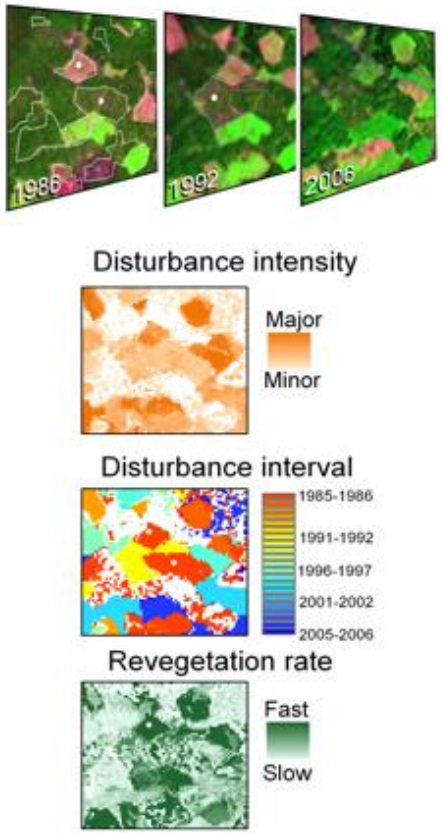
User Portal Services



Impact of Free Data

LandTrendr: Landsat-based Detection of Trends in Disturbance and Recovery – Kennedy and Cohen, Landsat Science Team - 2010





DPAS Subsystem Overview (1 of 3)

- Ingest Subsystem
  - Receives science mission data files from LGN stations
  - Decompresses OLI data
  - Processes science mission data to L0Ra data –interval-based
  - Sends L0Ra data to Storage and Archive Subsystem
  - Provides L0Ra metadata to the Inventory
  - Provides characterization data and bias parameters to the IAS
- Storage and Archive Subsystem
  - Provides shared storage to all DPAS subsystems
    - Archive Cache, Internal Cache, Online Cache
  - Provides an archive capability for LDCM mission data
  - Sends mission data files to off-site back-up archive
- Subsetter Subsystem
  - Spatially subsets L0Ra data to L0Rp data – WRS-2 scene-based

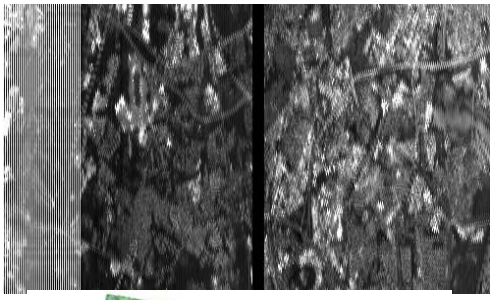
DPAS Subsystem Overview (2 of 3)

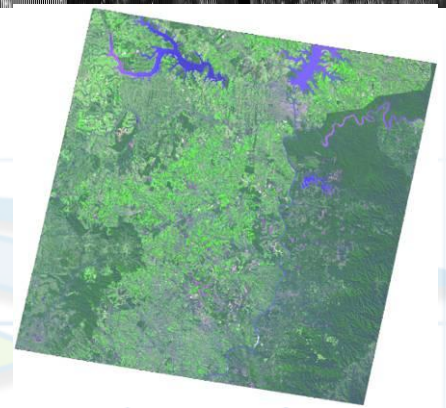
- Image Assessment Subsystem (IAS)
  - Provides a calibration / validation capability for OLI and TIRS
  - Maintains a detailed characterization DB for both instruments
  - Provides various auxiliary datasets (CPF, BPF, RLUT, GCPs)

- Level 1 Product Generation Subsystem (LPGS)
  - Processes L0Rp data to Level 1 products (nominally L1T)
  - Formats L1/L0Rp products and places them on the online cache
  - Provides L0Rp / Level 1 metadata to the Inventory
  - Generates at least 400 L1T data products per day

DPAS Processing Levels

- Level 0 Reformatted Archive (L0Ra)
  - Mission data files that have been combined, corrected, and processed into a single interval for long-term storage by the DPAS
  - Internal; not a distributed product
- Level 0 Reformatted Product (L0Rp)
  - L0Ra data that have been spatially subsetted (nominally to WRS-2 framing)
- Level 1 Terrain (L1T) / Systematic Terrain (L1Gt)
  - Level 0Rp data that have radiometric and geometric corrections applied
  - Digital Elevation Model (DEM) is applied to remove the effects of terrain on the corrected imagery
  - A precision model is generated by registering the data to a ground control library to provide a common geodetic reference base (L1T) – only systematic correction when ground control unavailable (L1Gt)
- Full resolution Browse Images





DPAS Subsystem Overview (3 of 3)

- Inventory Subsystem
  - Maintains metadata for L0Ra, L0Rp, L1Gt, and L1T datasets
  - Provides an interface to query / update inventory metadata

- User Portal Subsystem
  - Provides a search, order, and data distribution capability
  - Disseminates auxiliary information to LDCM data users
  - Distributes at least 1250 L1T scenes per day for first two years of mission ops, at least 3500 L1T scenes per day in subsequent years
    - At no cost to requestor/user
    - Available to general public on non-discriminatory basis
  - Provides multiple, standards-based, data access services

Salient Characteristics of the LDCM (1 of 2)

- Continuity mandate is fulfilled
  - Spectral bands comparable to TM and ETM+ sensors
  - Data collection along WRS-2 paths with identical 185 km swath width
  - LTAP-8 will ensure global coverage of land mass on seasonal basis
  - LDCM data will be backward compatible with data from previous Landsat sensors – long term retrospective studies to trend change over time

- Capabilities are advanced
  - Two new reflective bands, refined band widths avoid atmospheric absorption features, two thermal bands facilitate atmospheric correction
  - Improved radiometric performance – dynamic range, signal-to-noise ratios
  - More data – 400 scenes per day lead to improved global coverage

Salient Characteristics of the LDCM (2 of 2)

- Rigorous calibration is maintained
  - Image Assessment System
  - Internal cal lamps, solar panel, lunar maneuvers, deep space view, black body, vicarious field calibration, geographic super sites
  - Cal/Val Team of leading experts

- LDCM data will be forward compatible with data from commercial and international satellites (e.g. Sentinel-2)
  - TM/ETM+/OLI spectral bands are standard
  - Landsat sets the standard for rigorous calibration and systematic, comprehensive data collection

- Data will be free to the general public
  - Capabilities to process and analyze large volumes of Landsat data are advancing rapidly for long term and broad area studies

Mission Statement

- The LDCM, consistent with U.S. law and government policy, will continue the acquisition, archiving, and distribution of moderate-resolution multispectral imagery affording global, synoptic, and repetitive coverage of the earth's land surface at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time.