LDCM Project Report for Landsat Science Team

December 13, 2012

Del Jenstrom
NASA LDCM Deputy Project Manager
GSFC Code 427

Agenda

- Mission Overview
- NASA/USGS Partnership
- General Project Status
- Operational Land Imager (OLI)
- Thermal Infrared Sensor (TIRS)
- Spacecraft/Observatory
- Launch Vehicle and Launch Site Processing
- Preparations for Mission Transition to USGS
- On To Launch!
- Project Summary

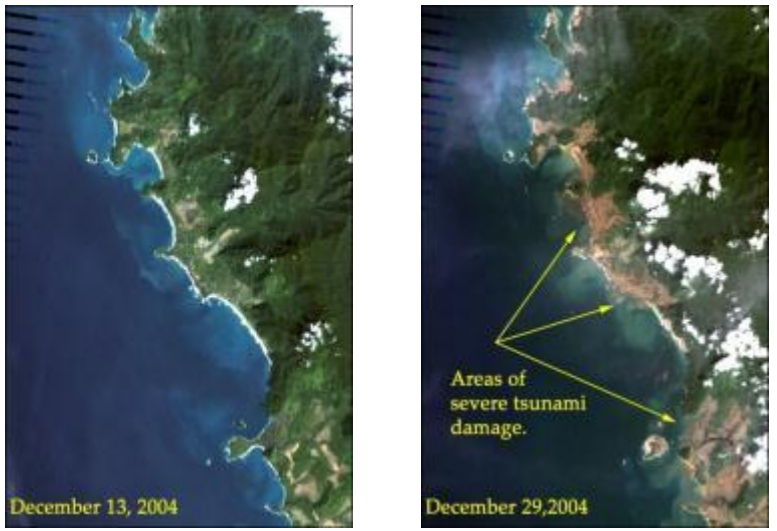
Note: LDCM Ground System and Operations are covered by other presentations

LDCM Mission Overview

LDCM Overview

Mission Objectives

- **Provide continuity in the multi-decadal Landsat land surface observations to study, predict, and understand the consequences of land surface dynamics**
  - **Land cover/use change**
  - **Human settlement and population**
  - **Ecosystem dynamics**
  - **Landscape scale carbon stocks**
  - **Resource management/societal needs**



Landsat 7 data used to aid Indonesian government with tsunami relief efforts (David Skole, Michigan State University)

LDCM Data Needed to Address NASA Earth Science Focus Areas, Questions, and Applications

Focus Areas	*Science Questions*
• Carbon Cycle, Ecosystems, & Biogeochemistry • Water & Energy Cycle • Earth Surface & Interior	- What are the changes in global land cover and land use, and what are their causes? - How do ecosystems, land cover & biogeochemical cycle respond to and affect environmental change? - What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems? - What are the consequences of increased human activities on coastal regions?

Instruments

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

Spacecraft

- **Orbital Sciences Corporation**

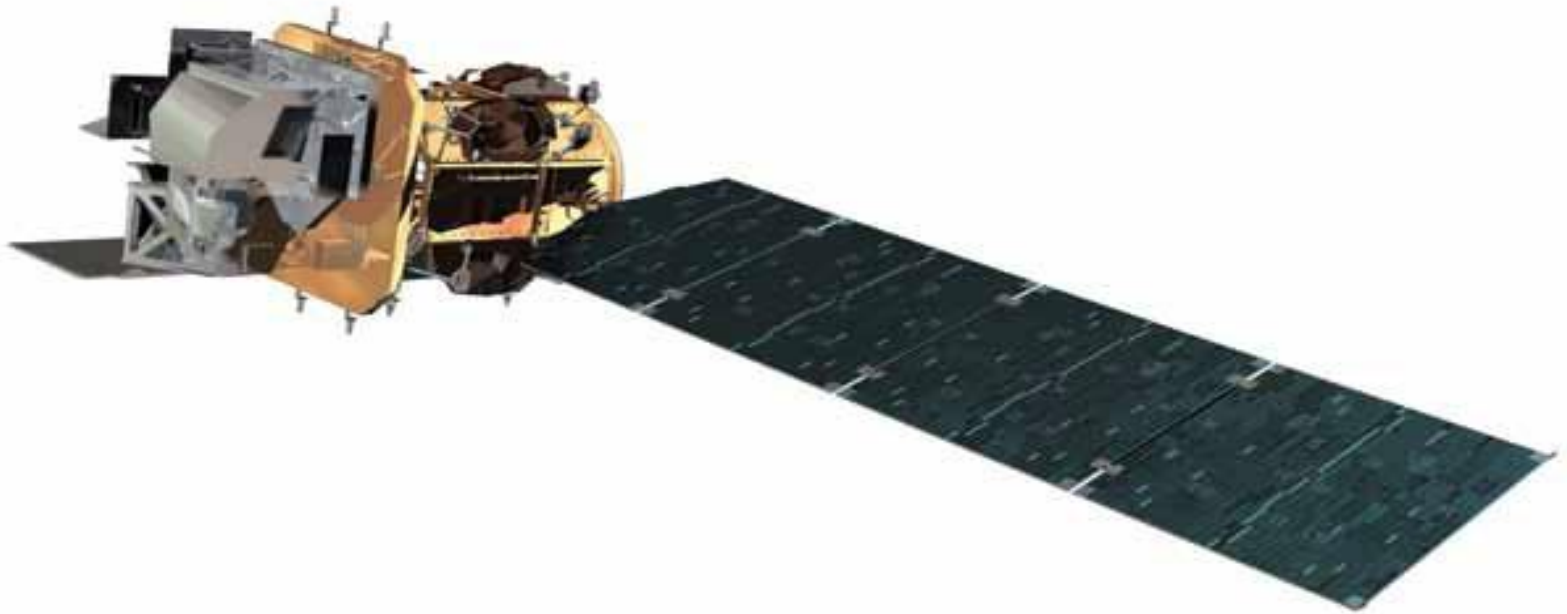
Mission Team

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

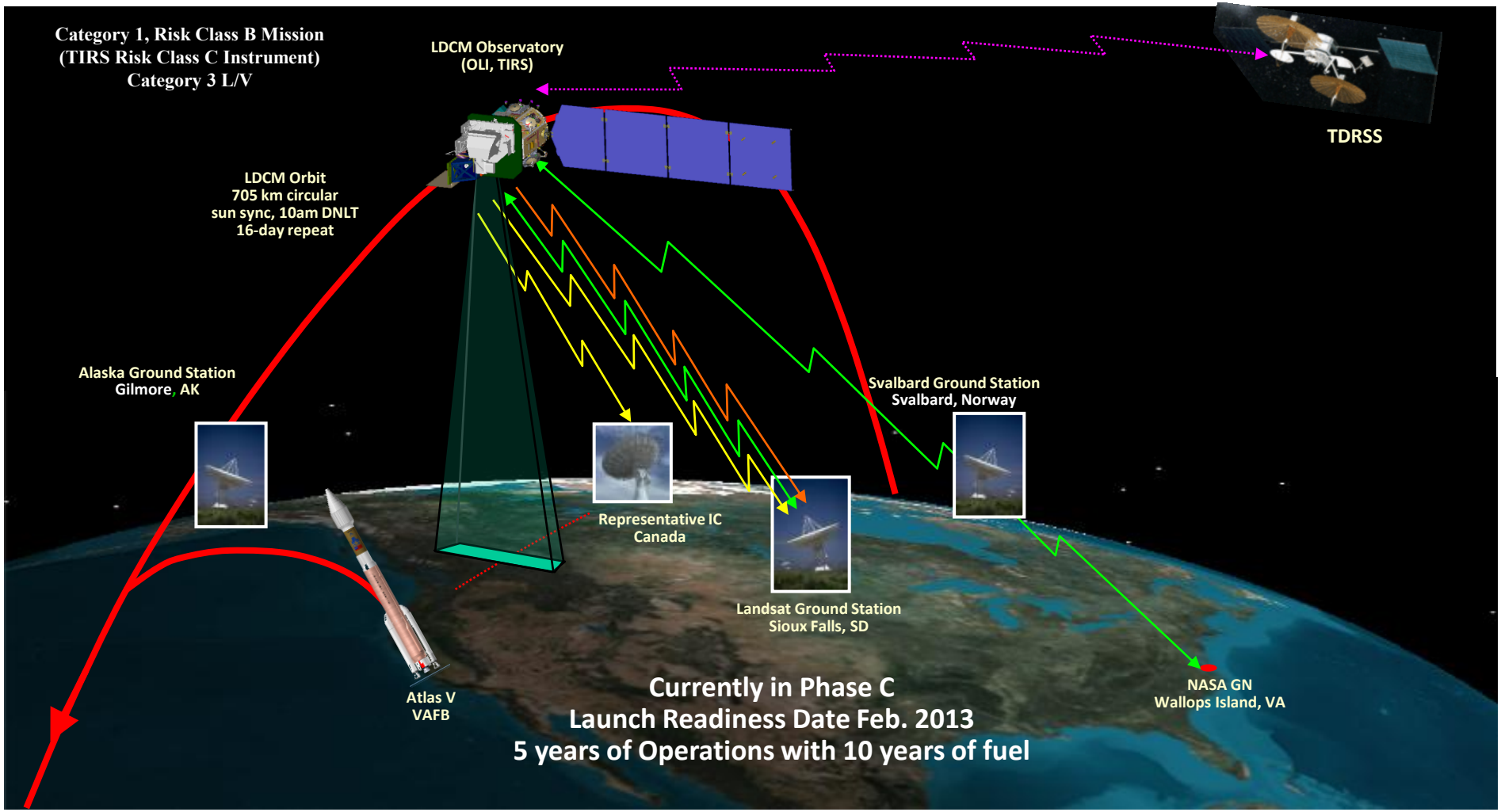
Landsat Data Continuity Mission

LDCM

The Landsat Data Continuity Mission (LDCM) is under development for a February, 2013 launch
Developed as a NASA / USGS partnership

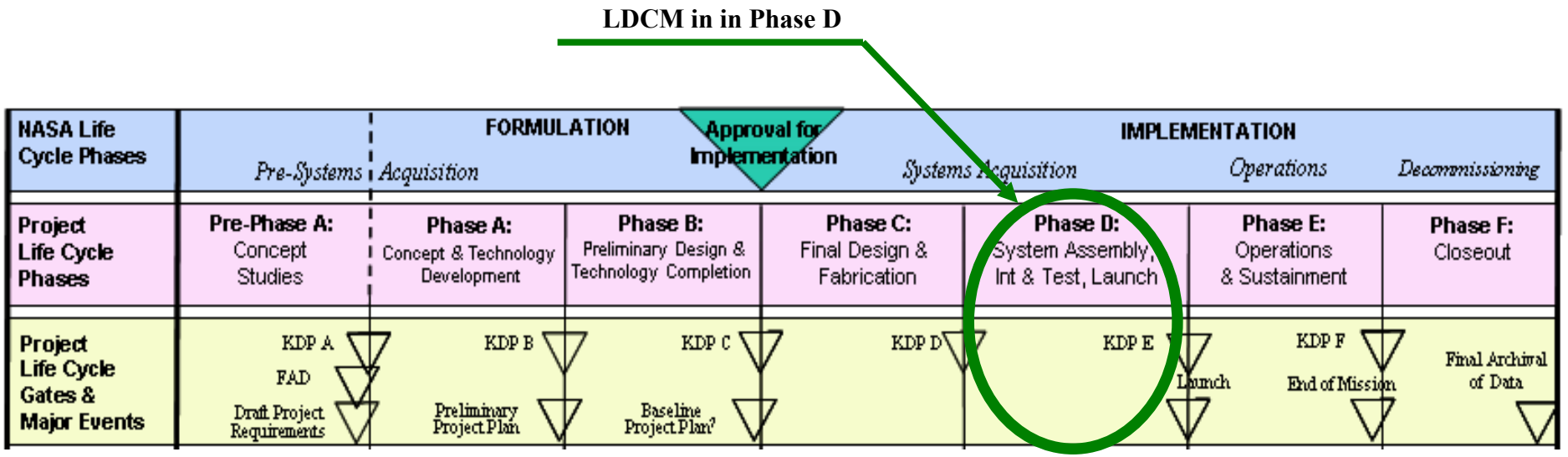


LDCM Overview



Mission Life Cycle

- **As a NASA Category 1 Mission, LDCM requires highest level approval of the Agency Program Management Council to initiate each phase of the project life cycle – Key Decision Point (KDP) reviews**
  - **Phase D includes the final integration, test, and launch**
  - **An independent Standing Review Board evaluates each major mission review an makes recommendations to the Agency Program Management Council**



NASA/USGS Partnership

NASA/USGS Responsibilities

- **NASA Responsibilities**
  - Space Segment, Launch Segment, and Mission Operations Element (MOE)
  - Lead mission development as system integrator and lead missions systems engineering for all mission segments throughout development, on-orbit check-out, and acceptance
  - Lead Mission Operations through completion of on-orbit checkout period
  - Accountable for mission success through on-orbit check-out and acceptance across all mission segments

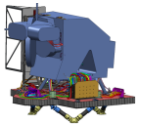
- **USGS Responsibilities**
  - Development of Ground System
    - Excluding the MOE
  - Lead, fund, and manage the Landsat Science Team
  - Lead LDCM mission operations, after the completion of the on-orbit checkout period
  - Accept and execute all responsibilities associated with the transfer of the LDCM Operational Land Imager (OLI) instrument, spacecraft bus, Mission Operations Element, and NSC/KSAT contracts from NASA following on-orbit acceptance of the LDCM system including assuming contract management

NASA /USGS Mission Responsibilities

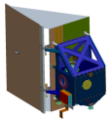
LDCM

Space Segment

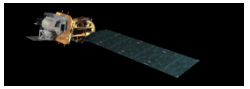
Operational Land Imager
- Multi-Spectral Imaging Instrument
- Pushbroom VIS/SWIR sensor
- Four mirror telescope
- FPA consisting of 14 SCAs



Thermal Infrared Sensor
- 2 thermal channels
- Pushbroom design
- QWIP detectors
- Actively cooled FPA

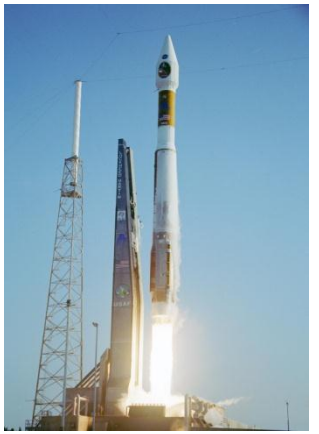


Spacecraft
- 3-axis stabilized
- Accommodated OLI & TIRS



Launch Segment

Atlas V 401



Ground System

Ground Network Element (GNE)
- Antenna & associated equipment for X-Band image & S-Band telemetry data downlink reception and generation of S-Band command uplink

Collection Activity Planning Element (CAPE)
- Generates high level imaging mission schedules

Mission Operations Element (MOE)
- Mission planning & scheduling, command & control, monitoring and analysis, flight dynamics & onboard memory management

Data Processing and Archive System (DPAS)
- Ingests and generates L0Ra data from GNE-provided Mission data
- Stores and archives LDCM data (Mission, L0Ra, and product)
- Provides inventory and metrics database services
- Provides Product Generation, Image Assessment, & Subsetter
- Provides web interface to facilitate: data discovery, product selection & ordering (for Cal/Val), & product distribution

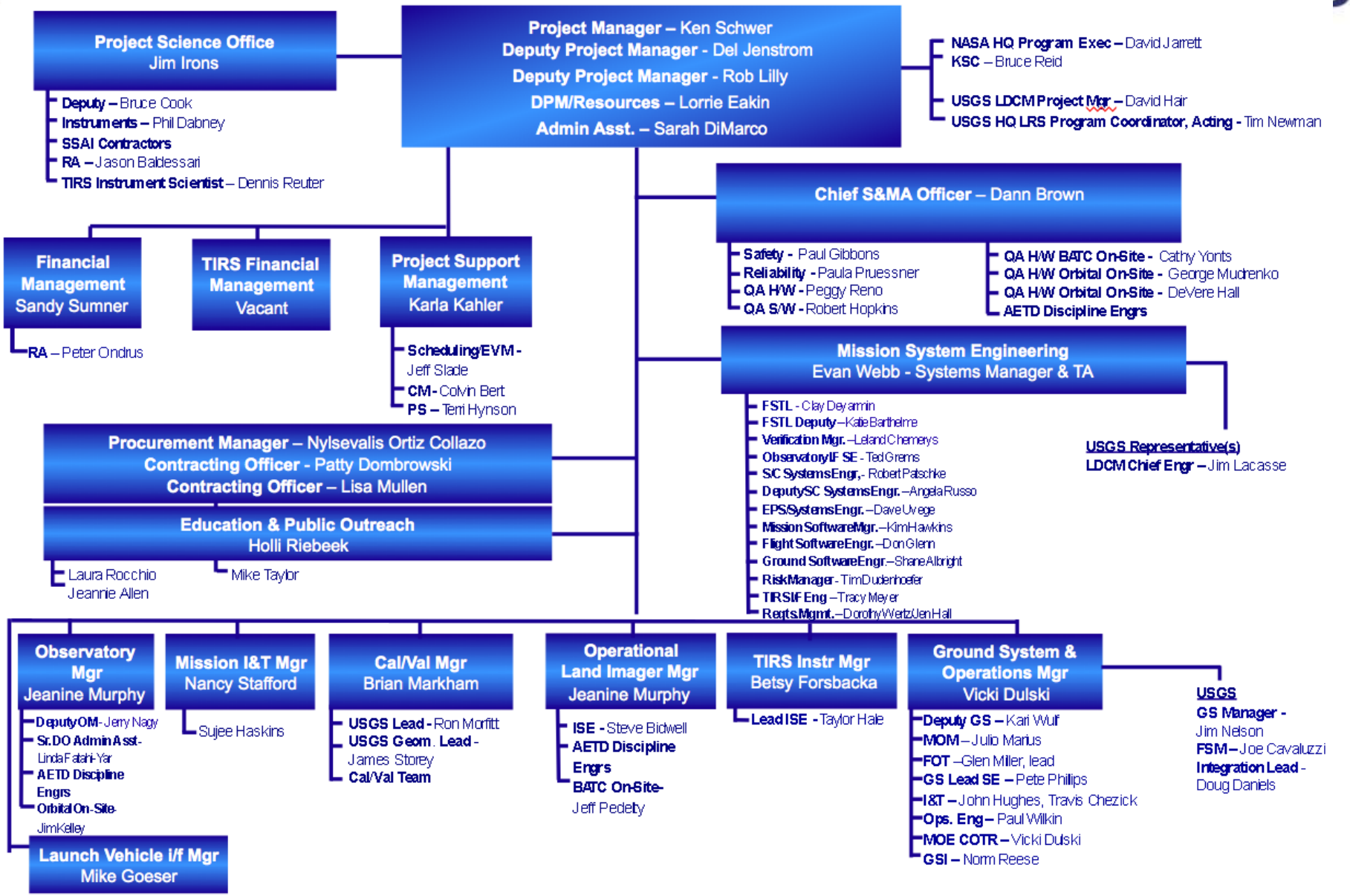
Blue – NASA
Green - USGS

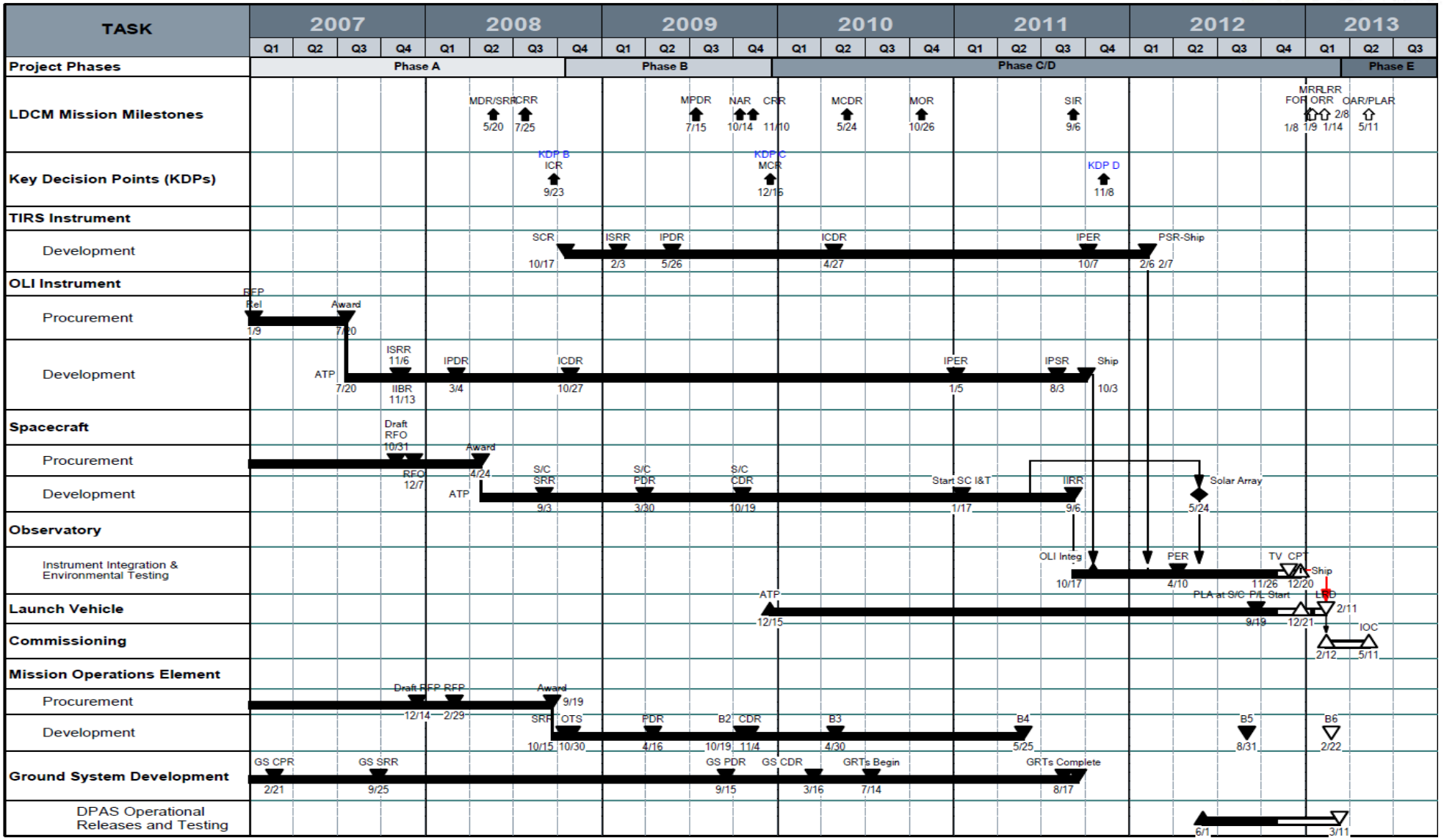
Project Status

Project Status

- **General**
  - Ken Schwer is now LDCM Project Manager
    - Phil Sabelhaus retired in early 2012
  - Also joining LDCM is Rob Lilly as Deputy Project Manager
    - LDCM now has two DPM's, Rob Lilly and Del Jenstrom
  - Lorrie Eakin is now LDCM Deputy Project Manger for Resources
    - Michele Marrie retired in late 2011
  - Changes to Atlas launch manifest have resulted in LDCM launch window moving from Dec 1-31, 2012 to Jan 15, 2013 to Feb 15, 2013
    - Launch Readiness Date (LRD) is February 11, 2013
- **Major Reviews Over Last Year Or So**
  - OLI Pre-Ship Review (PSR) held in August 2011 at Ball
  - LDCM System Integration Review (SIR) held September 2011 at Orbital
  - TIRS Pre-Ship Review held February 2012 at GSFC
  - LDCM Observatory Pre-Environmental Review (PER) held April 2012 at Orbital
- **Major Progress**
  - Observatory is fully integrated and has completed environmental testing
    - On track to meet our launch readiness date
  - End-to-end mission readiness testing completed to ensure the space, ground, and operations segments are all prepared for successful launch and on-orbit operations

LDCM - Project Organization

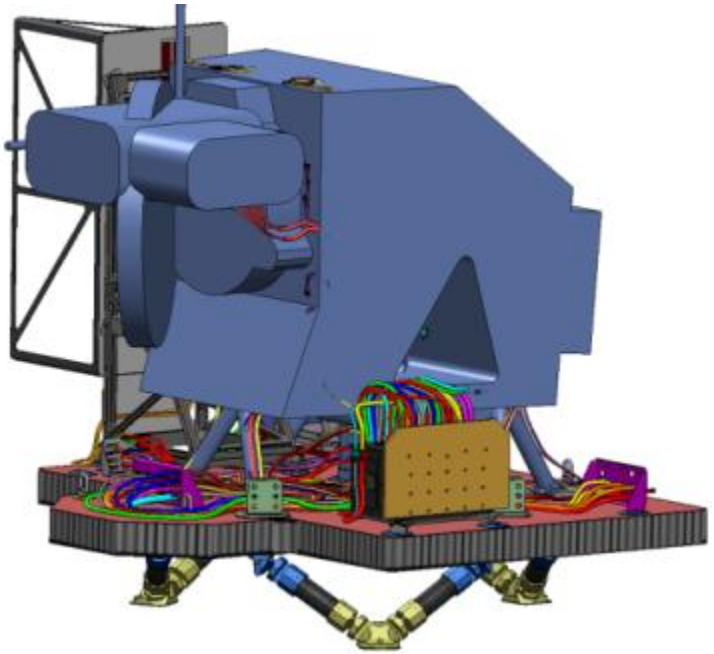



TASK
2007
2008
2009
2010
2011
2012
2013
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3
Project Phases
Phase A
Phase B
Phase C/D
Phase E
LDCM Mission Milestones
MDR/SRR 5/20
CRR 7/25
MPDR 7/15
NAR 10/14
CRR 11/10
MCDR 5/24
MOR 10/26
SIR 9/6
MRR 1/8
LRR FOR 1/9
ORR 1/14
2/8
CAR/PLAR 5/11
Key Decision Points (KDPs)
KDP B
ICR 9/23
KDP C
MCR 12/15
KDP D 11/8
TIRS Instrument
Development
SCR 10/17
ISRR 2/3
IPDR 5/26
ICDR 4/27
IPER 10/7
PSR-Ship 2/6 2/7
OLI Instrument
Procurement
RFP Rel 1/9
Award 7/20
Development
ATP 7/20
ISRR 11/6
IIBR 11/13
IPDR 3/4
ICDR 10/27
IPER 1/5
IPSR 8/3
Ship 10/3
Spacecraft
Draft RFO 10/31
RFO 12/7
Award 4/24
Procurement
Development
ATP
S/C SRR 9/3
S/C PDR 3/30
S/C CDR 10/19
Start SC I&T 1/17
IIRR 9/6
Solar Array 5/24
Observatory
Instrument Integration & Environmental Testing
OLI Integ 10/17
PER 4/10
TV CPT 11/26
Ship 12/20
Launch Vehicle
ATP 12/15
PLA at S/C 9/19
P/L Start 12/21
LRD 2/11
IOC 2/12
5/11
Commissioning
Mission Operations Element
Procurement
Draft RFP 12/14
RFP 2/29
Award 9/19
Development
SRR 10/15
OTS 10/30
PDR 4/16
B2 CDR 10/19 11/4
B3 4/30
B4 5/25
B5 8/31
B6 2/22
Ground System Development
GS CPR 2/21
GS SRR 9/25
GS PDR 9/15
GS CDR 3/16
GRTs Begin 7/14
GRTs Complete 8/17
DPAS Operational Releases and Testing
6/1
3/11

Operational Land Imager (OLI)

LDCM Operational Land Imager (OLI)

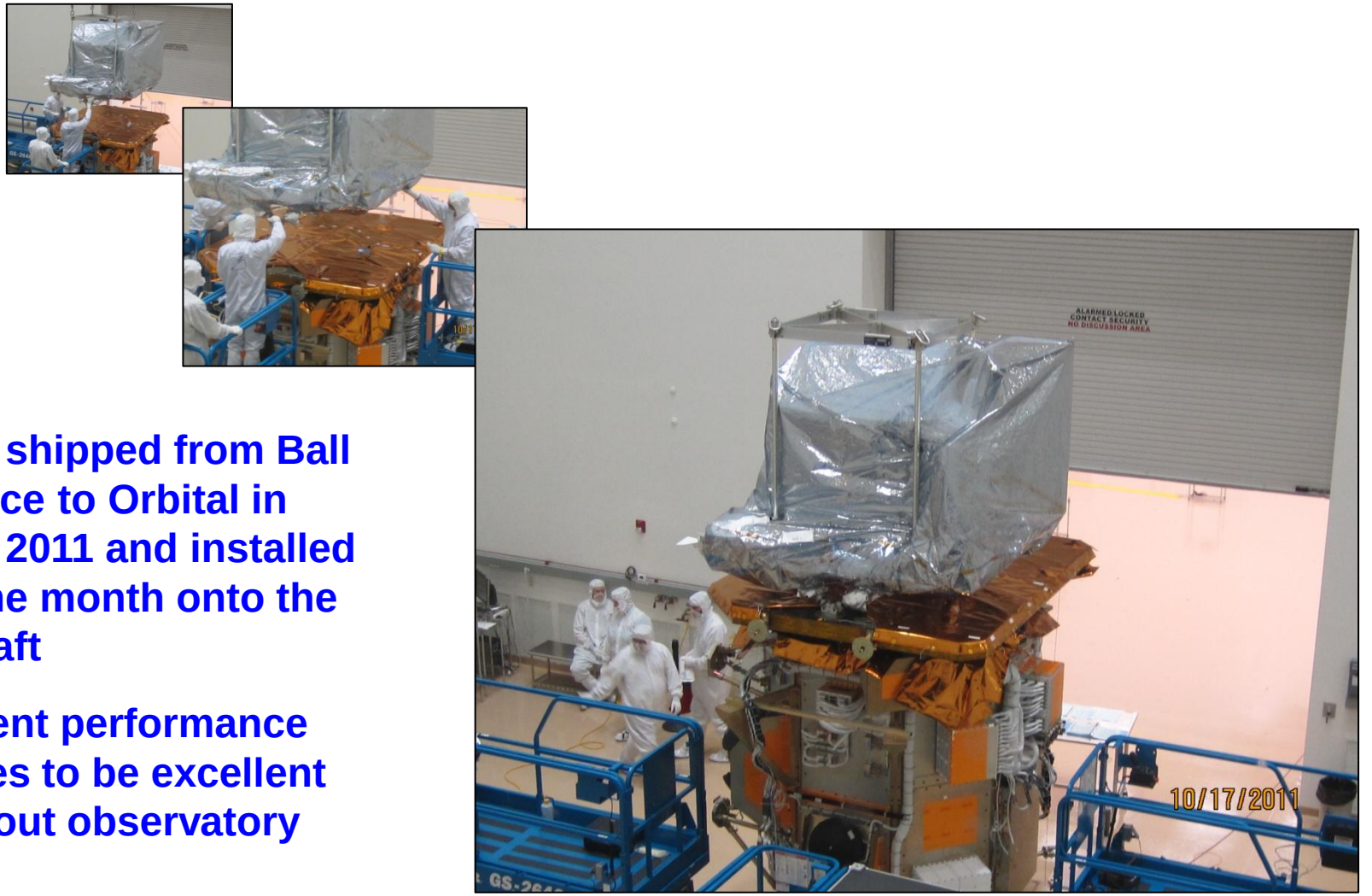
- **A reflective-band multi-channel earth-imaging instrument**
  - **provides imagery to detect and quantitatively characterize changes on the global land surface at a scale where natural and man-made causes of change can be detected and differentiated.**
  - **OLI design draws on 40 years of Landsat imaging experience plus Worldview/Quickbird and ALI heritage**



- **Instrument description**
  - **eight multi-spectral bands ranging in wavelength from 433 nm to 2200 nm with spatial resolutions of 30 meters**
  - **one panchromatic visible band with a spatial resolution of 15 meters**
  - **Pushbroom VIS/SWIR sensor**
  - **Four-mirror telescope with front aperture stop**
  - **Focal Plane Assembly (FPA) consisting of 14 sensor chip assemblies, passively cooled**
  - **Absolute radiometric accuracy < 4%**
  - **Mass: 450Kg**
  - **Operational Power: 160 W**
  - **Size: 1.8 m x 2 m x 1 8 m**

OLI Significant Progress

- **Operational Land Imager (OLI)**

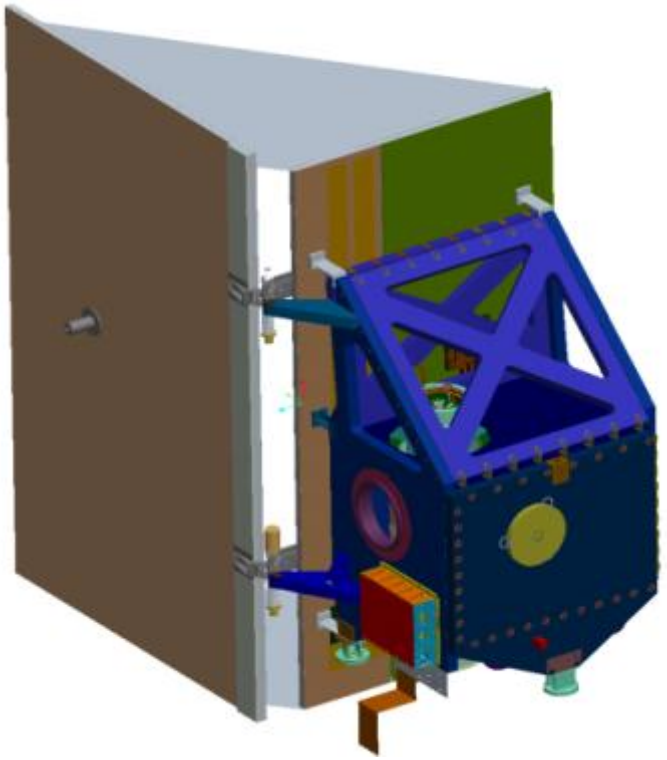


- **OLI was shipped from Ball Aerospace to Orbital in October 2011 and installed that same month onto the spacecraft**
- **Instrument performance continues to be excellent throughout observatory testing**

Thermal Infrared Sensor (TIRS)

LDCM Thermal InfraRed Sensor (TIRS)

- **A thermal infrared earth-imaging instrument**
  - **complementary to the reflective bands sensed by OLI for detecting and quantitatively characterizing land surface change**
  - **continues the record of earth monitoring in the thermal portion of the electromagnetic spectrum currently sensed by Landsats 5 and 7**



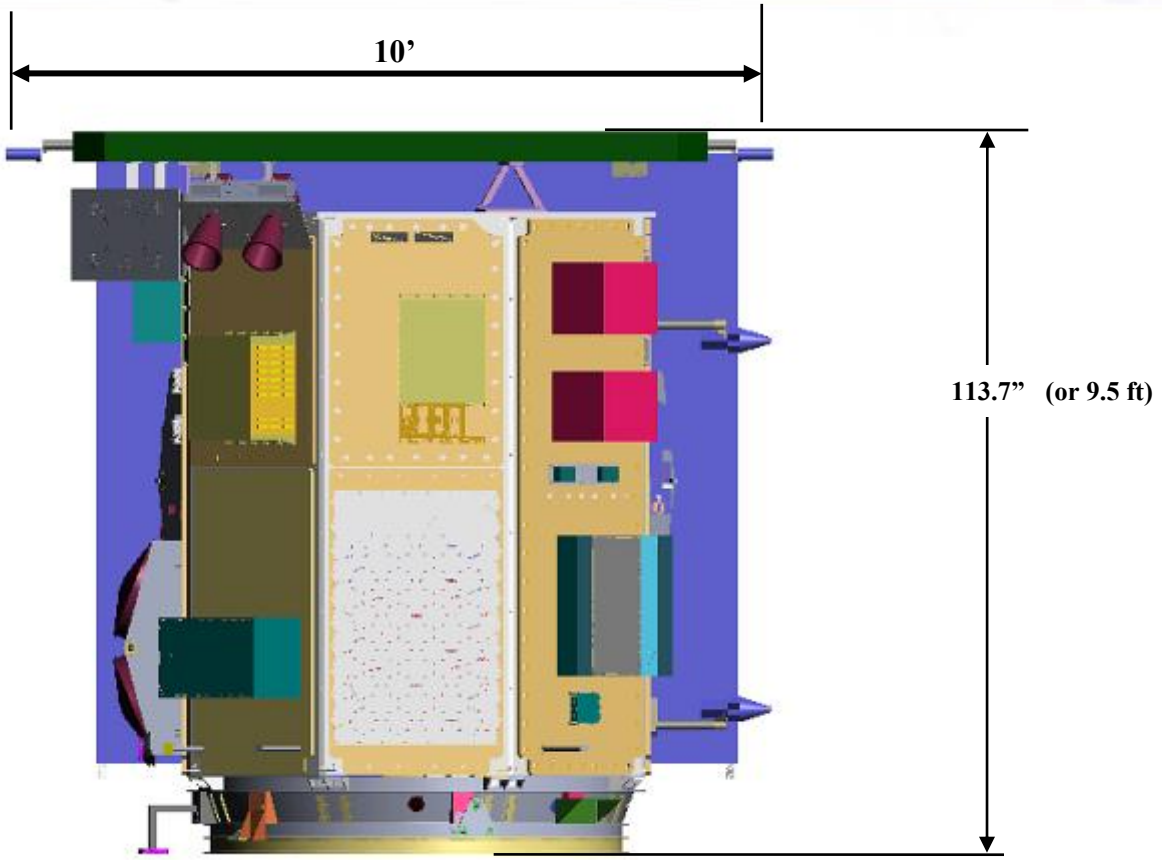
- **Instrument description**
  - GSFC In House Build
  - Two spectral bands at 10.8 and 12 micrometers
  - Ground sampling distance, both in-track and cross track, of 100m.
  - Pushbroom LWIR sensor
  - Four-lens telescope
  - FPA consisting of three 2-dimensional QWIP sensor chip assemblies
  - Mechanically cooled focal plane; BATC provided cryo cooler
  - NEdT @ 300K < 0.4
  - Mass: 240 Kg
  - Operational Power: 380 W
  - Size: 80 cm x 76 cm x 43 cm (with earth shield deployed)

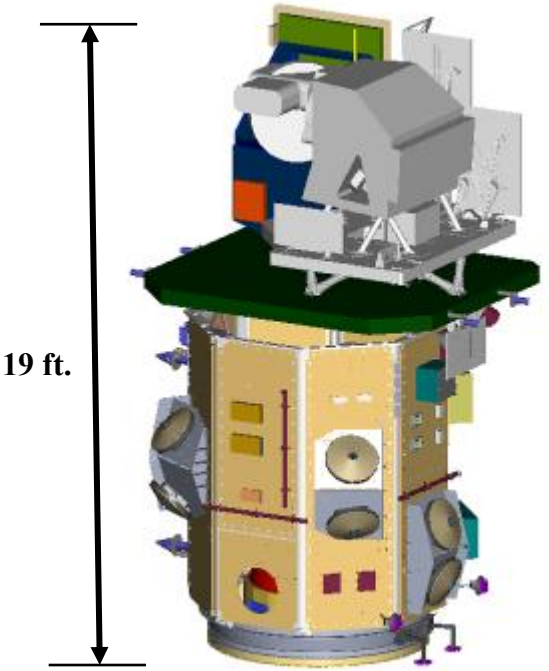
TIRS Significant Progress

- TIRS completed testing in January 2012 and was shipped from NASA/GSFC to Orbital in February 2012
- During initial testing at Orbital, it was discovered that pressurized helium within the cryocooler had leaked out
  - Investigation revealed a pinch seal on the fill tube had failed
- The cryocooler was repaired by May and reinstalled onto the spacecraft in July
- Since that time, TIRS performance has been excellent throughout observatory testing

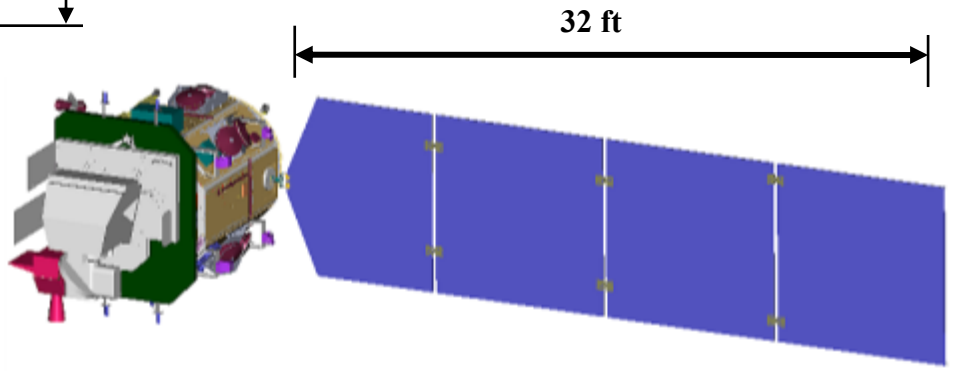
Spacecraft/Observatory

Spacecraft/Observatory Size





S/C Assembly Mass - 4556 lbs



Spacecraft/Observatory Significant Progress

- **Spacecraft bus integration was completed by Orbital Sciences Corporation (Orbital) in early 2012**
  - **Both OLI and TIRS are now fully integrated**
- **A power short anomaly occurred in April 2012 that damaged components in three spacecraft electrical boxes**
  - **An intensive investigation and recovery effort took place**
  - **OLI, TIRS, and the other spacecraft components were shown to be undamaged by the short**
  - **The three spacecraft boxes were repaired and reinstalled onto the spacecraft in July**
- **The integrated observatory successfully completed functional testing in July and then entered environmental testing**
  - **Observatory has now successfully completed all environmental testing**
    - Electromagnetic Interference / Electromagnetic Compatibility (EMI/EMC)
    - Dynamics (vibration, shock, and acoustics)
    - Thermal Vacuum
- **Observatory Transporter Complete**
  - **The transporter that will carry the observatory to the launch site is complete and was tested through a "Pathfinder" trip to VAFB**

Fully Integrated LDCM Observatory

LDCM Observatory Entering EMI/EMC Testing

LDCM Observatory After Thermal Vacuum Testing

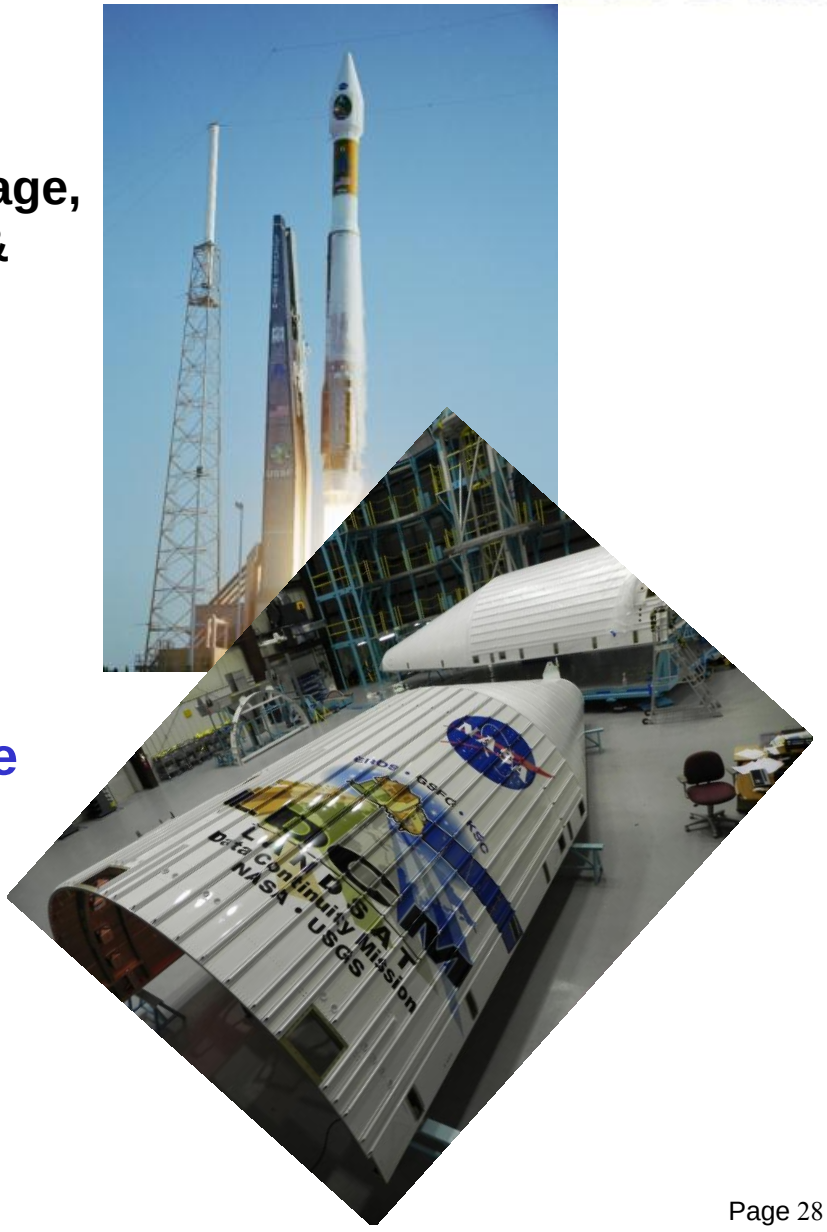
LDCM Transporter

- LDCM Transporter completed fabrication in July 2012 by Nelson Manufacturing in Ohio
- A successful “Pathfinder” dry-run trip was made from Orbital to VAFB in August

Launch Vehicle
&
Launch Site Processing

Launch Vehicle and Launch Site Processing

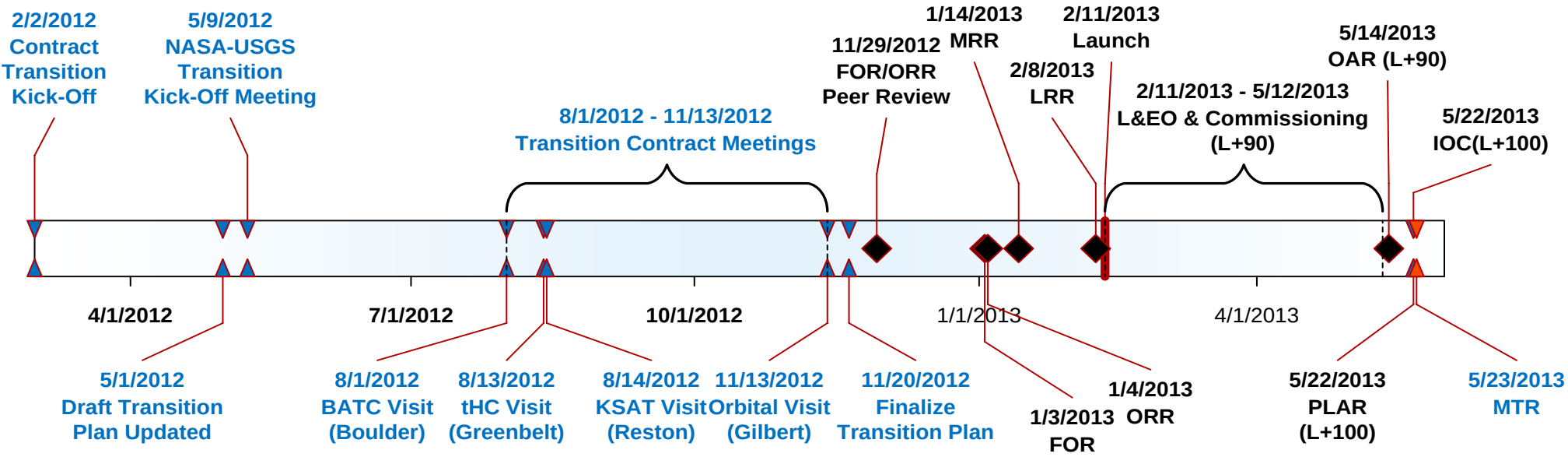
- **Atlas V 401 Launch Vehicle**
  - **United Launch Alliance (ULA)**
  - **LDCM rocket (booster, Centaur second stage, and fairing) delivered to VAFB in August & September 2012**
    - Rocket was stacked on pad in October
  - **Excellent coordination between ULA and LDCM through NASA/KSC**
  - **Successful interface testing has verified mechanical and electrical interfaces to spacecraft**
- **Astrotech selected in summer 2011 as the LDCM spacecraft processing facility at VAFB**
  - **Preparations on track to take delivery of LDCM observatory**
  - **Astrotech participated in Transporter pathfinder activities at VAFB**



Preparations for Mission Transition to USGS

Transition Timeline

Transition Timeline (as of 9/19/12)



- **Transition dates assume launch date of 2/11/2013**
- **IOC occurs in conjunction with successful PLAR**
- **Mission Transition occurs in conjunction with successful MTR**
- **Will have many transition actions complete before PLAR**

- **FOR: Flight Operations Review**
- **ORR: Operations Readiness Review**
- **MRR: Mission Readiness Review**
- **LRR: Launch Readiness Review**
- **L&EO: Launch & Early Orbit**
- **PLAR: Post Launch Assessment Review**
- **OAR: On-Orbit Acceptance Review**
- **IOC: Initial Operating Capability**
- **MTR: Mission Transition Review**

On To Launch!

The Path Ahead

- Observatory is currently being packed for shipment to VAFB
- Recovery from spacecraft power anomaly reduced schedule margin and challenged team
  - Outstanding effort by Orbital and whole team to keep launch date viable

• Observatory Pre-Ship Review	Dec 14-15
• Observatory Shipment to Launch Site	Dec 18
• Flight Operations Review / Operations Readiness Review	Jan 3-4
• Mission Readiness Review	Jan 17
• Safety & Mission Success Review	Jan 22
• KDP-E	Jan 31
• Flight Readiness Review	Feb 6
• Launch Readiness Review	Feb 8
• Launch!	Feb 11, 2013

Project Summary

Project Summary

- Launch Readiness Date is February 11, 2013 with 10 days of schedule reserve
- Integrated Observatory has completed environmental testing
  - Currently being packed for shipment next Tuesday to VAFB!
- OLI, TIRS, and spacecraft are performing excellently
- Observatory Transporter is ready to ship the observatory in December to VAFB
- Extensive Mission Readiness Testing (MRT) and mission simulations continue to ensure flight, ground, and operations segments work together as a system and are ready for successful launch and on-orbit operations
- Launch vehicle and launch site processing activities are on track to support a February 11, 2013 LRD
- Mission transition preparations are on track to enable “Landsat 8” to begin routine operations three months after launch