Systems Engineering when the Stakes are High and Time is Short: Lessons from the Lunar Reconnaissance Orbiter

INCOSE Presentation at APL

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David Everett, NASA GSFC

Abstract

- ***Engineering a Successful Mission: Lessons from the Lunar Reconnaissance Orbiter***
- Schedule pressure is common in the commercial world, where late delivery of a product means delayed income and loss of profit. Research spacecraft developed by the government, on the other hand, tend to be driven by the high cost of launch vehicles and the public scrutiny of failure--the primary driver is ensuring proper operation in space for a system that cannot be retrieved for repair. The Lunar Reconnaissance Orbiter (LRO) development faced both schedule pressure and high visibility. Originally conceived as one of many small, annual robotic missions to explore the moon in advance of the next human campaign, LRO became the only NASA mission to the moon for the next few years, but NASA was already committed to launch this 7-payload spacecraft within 2-1/2 years of confirmation. The team had to balance the strong push to meet a 2008 launch against the need to ensure that this first mission for Exploration succeeded. In the end, national launch priorities delayed LRO and reinforced the emphasis on mission success, an outcome ensured by the team's diligence along the way. This presentation will provide an overview of the mission from concept through commissioning and explore some of the challenges the systems engineering team faced taking a mission from preliminary design review to pre-ship review in 3 years.

Topics

- Lunar Facts
- LRO Objectives
- LRO Results to Date
- Programmatic Environment During Development
- Challenges and Approaches
- I&T Overview
- Observations and Lessons Learned

How far away is the moon?

9.1 um IR image from Mars Odyssey on April 19, 2001

Scale distance and size

- Earth = 12 inches in diameter
- Moon = 3-1/4 inches in diameter
- Moon distance = 30 feet
- Sun diameter = 108 feet
- Sun distance = 2-1/4 **miles**
- Pluto distance = 88 miles from sun

Moon Facts

- Diameter: 3476 km (27% of earth)
- Land area: 38 x 10^6 sq km (25% of earth)
  - More than North America and Europe combined
  - A little less than Asia
- Distance from earth: ~30 earth diameters
  - Minimum: 356,375 km
  - Maximum: 406,720 km

Earth Rise, December 1968

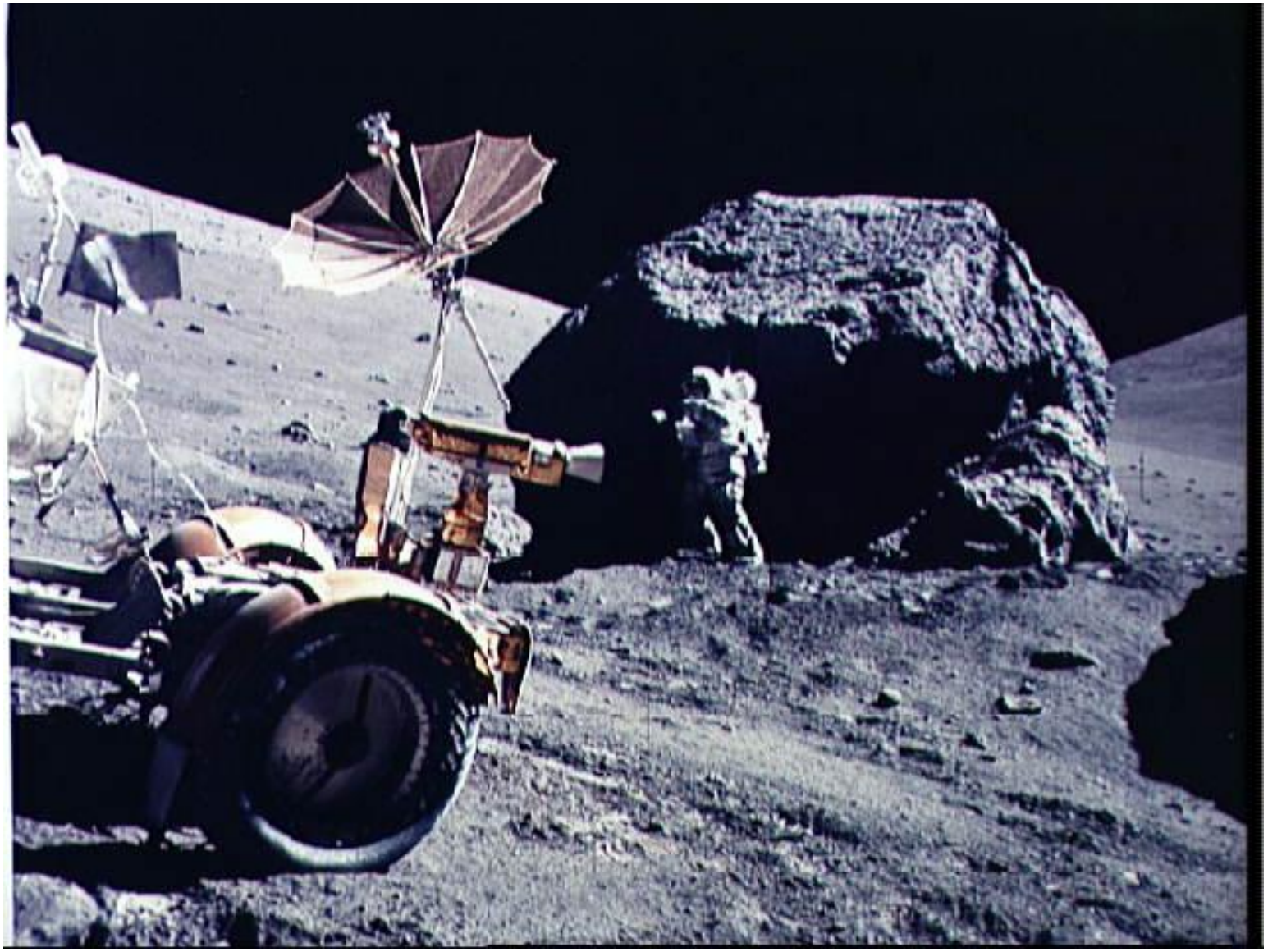
LRO Beginning

- January 2004, the President announced the "Vision for Space Exploration", sending a "series of robotic missions" to the moon "beginning no later than 2008".
- Announcement of Opportunity for LRO instruments released in June 2004; target launch October 2008.
- **Six** instruments selected in December 2004.
  - Selected instruments had strong relationship to recently-flown instruments
- Funding started in early 2005.
- Technology demonstration payload added in April 2005:
  - Mini-RF development significantly behind other instruments
  - Data rate and power consumption are significant

LRO Objectives, Polar Focus

- Characterize landing sites
  - High-resolution mapping
  - Surface characterization (slope, roughness)
- Identify resources
  - Water
  - Minerals
  - Sunlight
- Characterize radiation environment
  - Energy deposited in tissue-equivalent plastic
  - Neutron albedo

Lunar Rover, Schmidt, Big Boulder



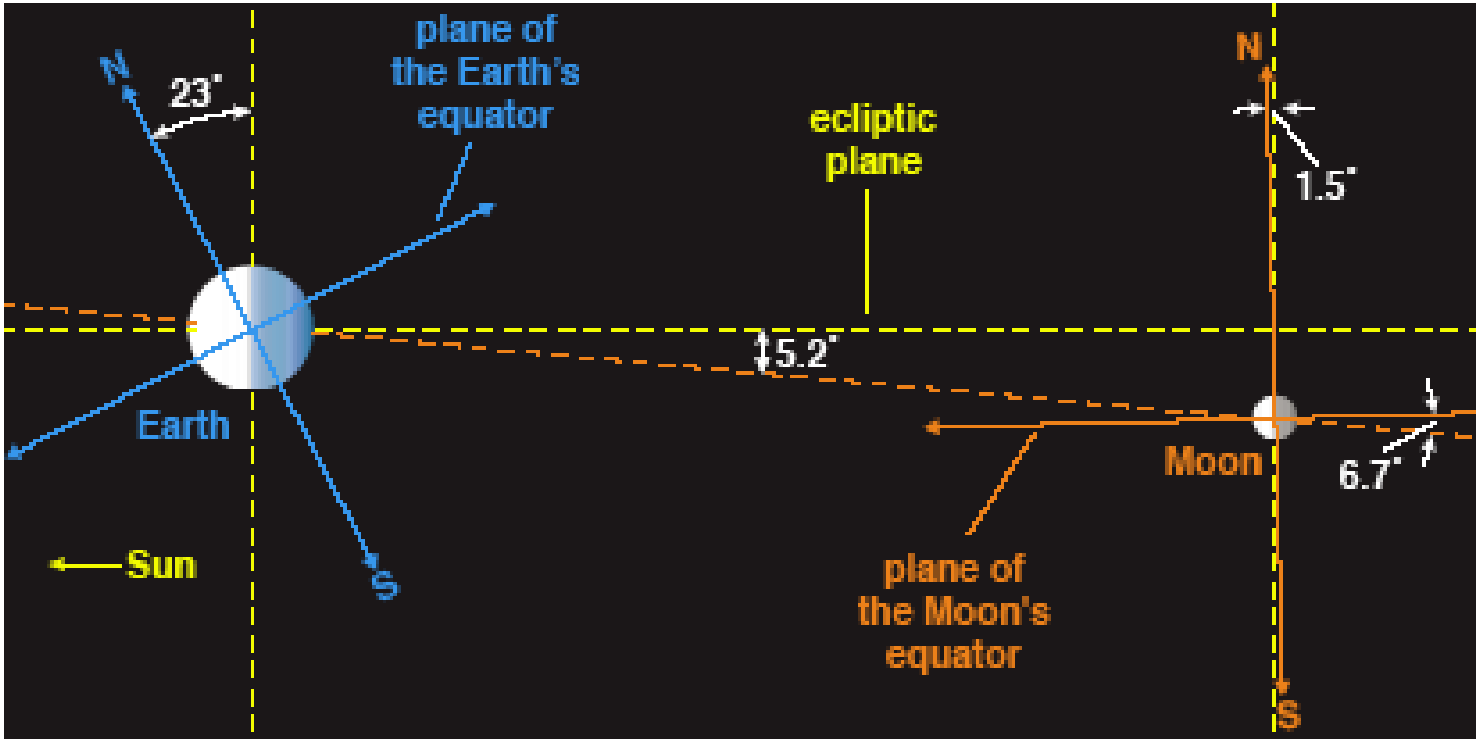
Dangers of Poor Reconnaissance

"The Apollo 15 Lunar Module accidentally set down on the rim of a crater such that its engine bell was damaged, and with one of the legs in the crater, at a tilt of 10 , just 5 below the maximum acceptable angle [Baker, 1982; Harland 1999]. Hazards from craters of this size are best detected with meter scale topography and high incidence angel (80) images - both provided with the LROC NAC."

(LROC web site: http://lroc.sese.asu.edu/objectives.html)

Why the Poles and Where?

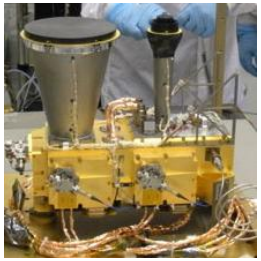
- Cold traps exist near the lunar poles (Watson et al., 1961)
  - Low obliquity of Moon affords permanent shadow in depressions at high latitude.
  - Temperatures are low enough to retain volatiles for $t > \tau_{Moon}$.



LRO Instruments and Investigations

LOLA: Lunar Orbiter Laser Altimeter

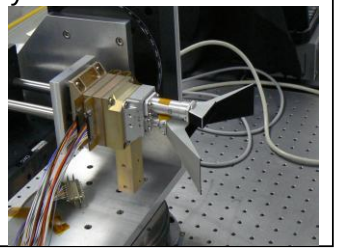
- Topography
- Slopes
- Roughness



Full Orbit
Autonomous

LROC/WAC: Wide-Angle Camera

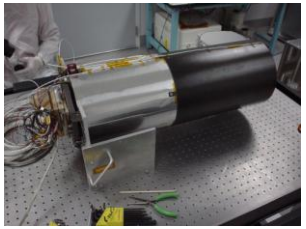
- Global Imagery
- Lighting
- Resources



Day Side
Autonomous

LROC/NACs: Narrow-Angle Cameras

- Targeted Imagery
- Hazards
- Topography



Day Side
Timeline Driven

LR: Laser Ranging

- Topography
- Gravity

GSFC LOS
Autonomous

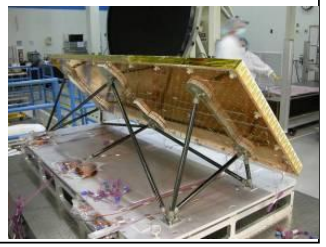
DLRE: Diviner Lunar Radiometer Exp.

- Temperature
- Lighting
- Hazards
- Resources

Full Orbit
Autonomous

Mini-RF: Synthetic Aperture Radar

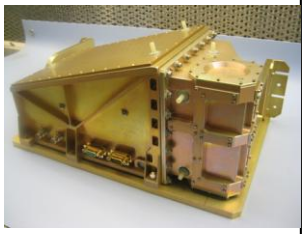
- Tech Demonstration
- Resources
- Topography



Polar Regions
Timeline Driven

CRaTER: Cosmic Ray Telescope…

- Radiation Spectra
- Tissue Effects



Full Orbit
Autonomous

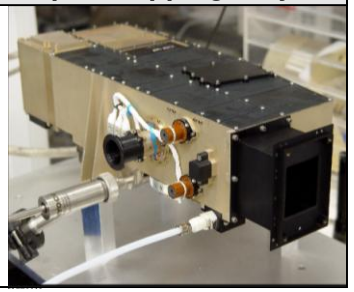
LEND: Lunar Explr. Neutron Detector

- Neutron Albedo
- Hydrogen Maps

Full Orbit
Autonomous

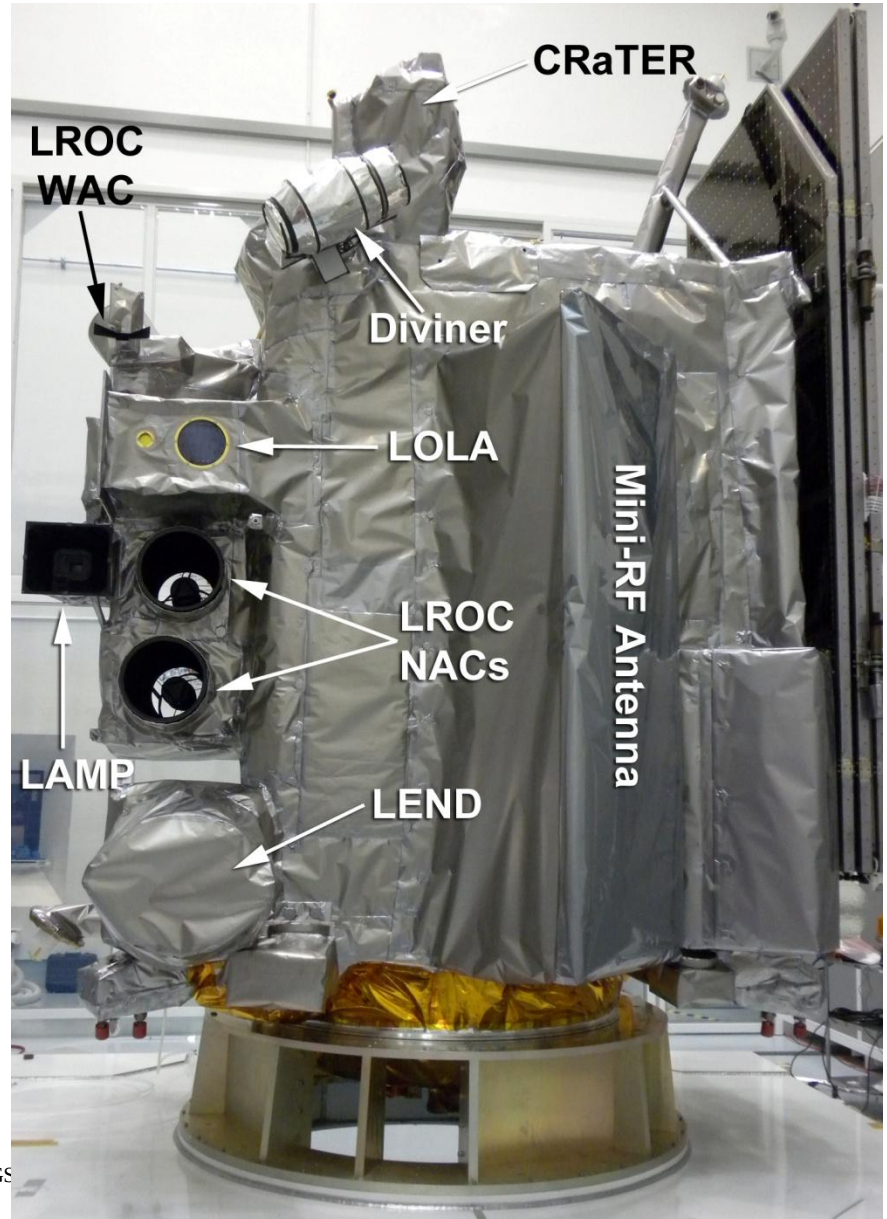
LAMP: Lyman-Alpha Mapping Project

- Water-Frost
- PSR Maps

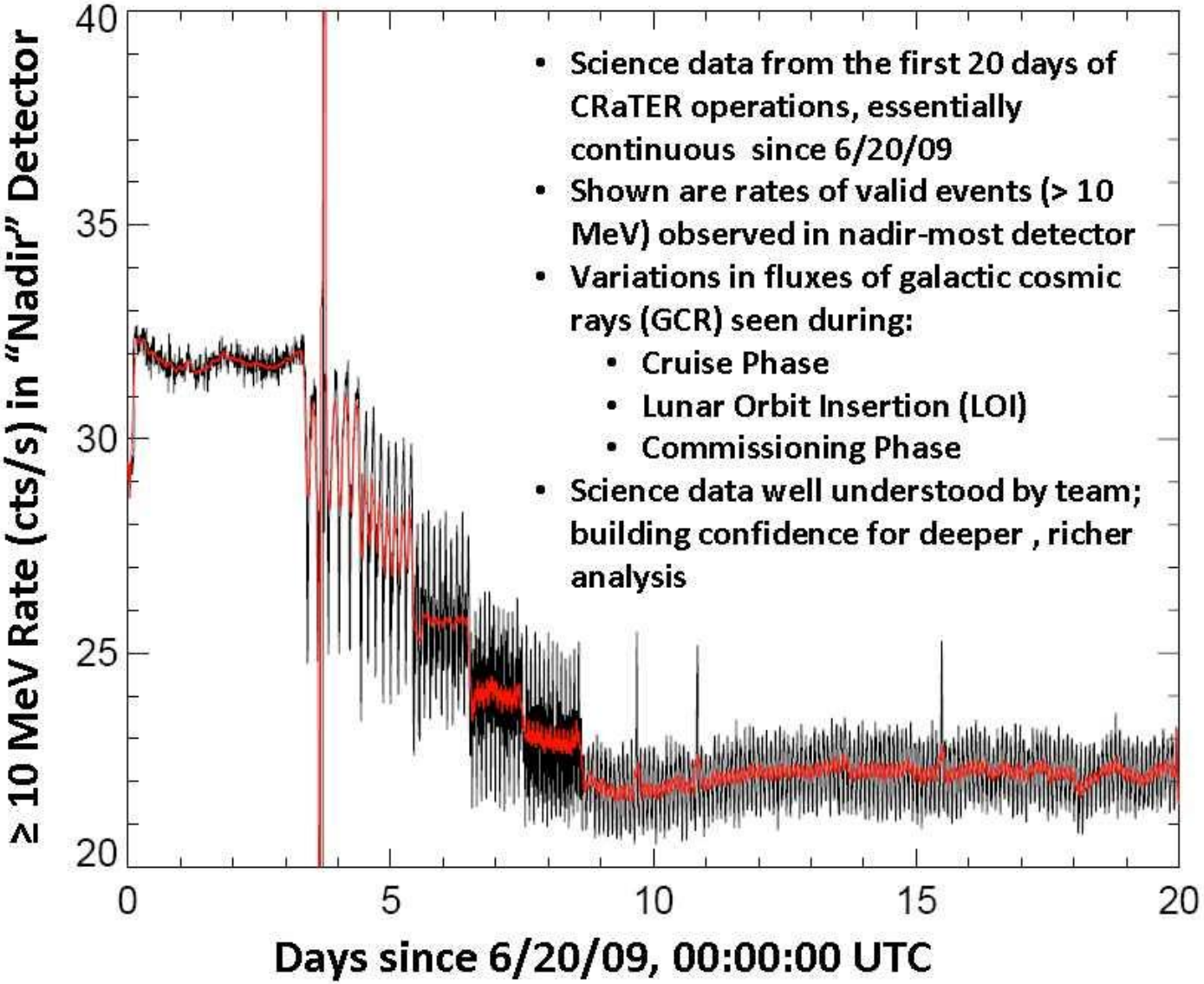


Night Side
Autonomous

LRO Payload Layout

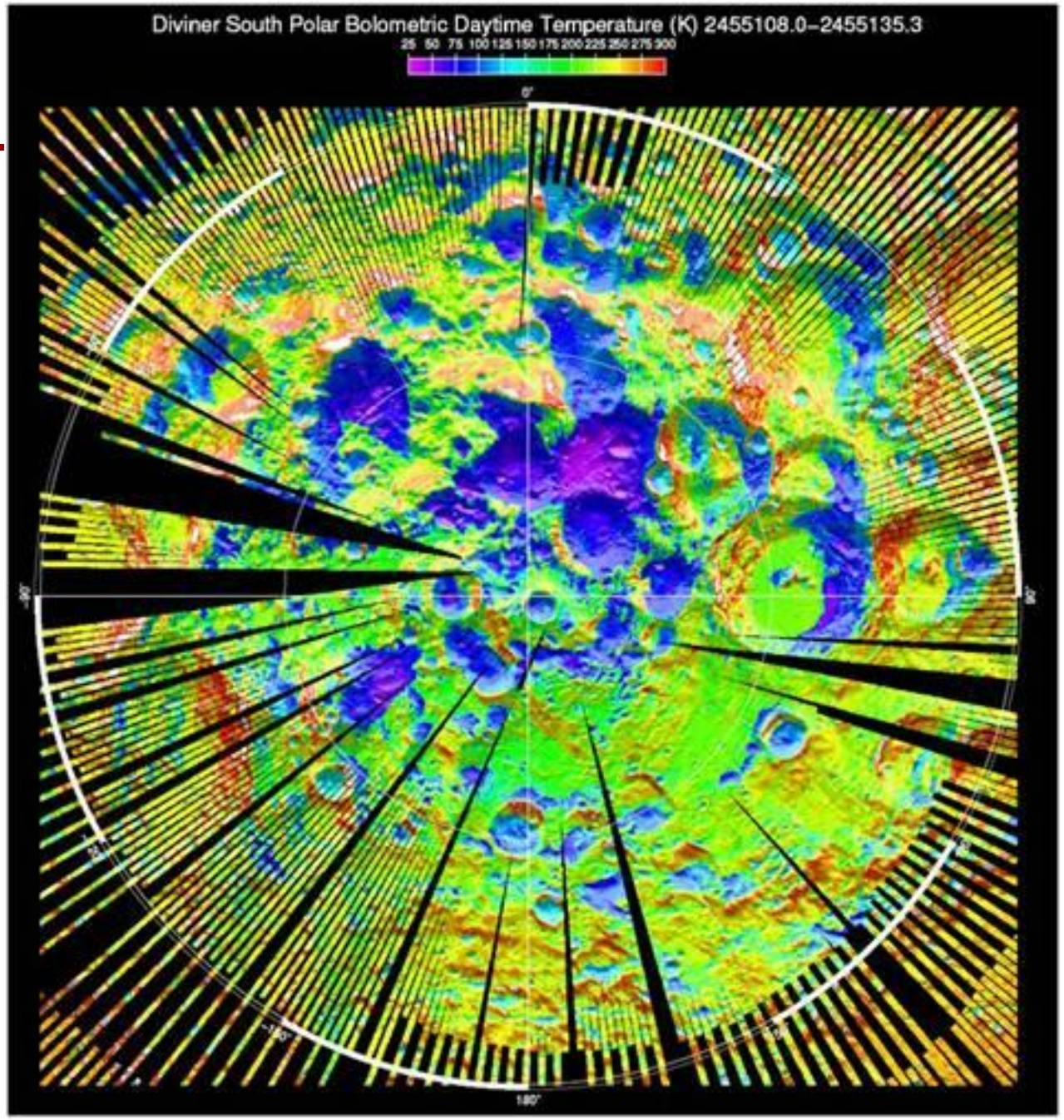


CRaTER

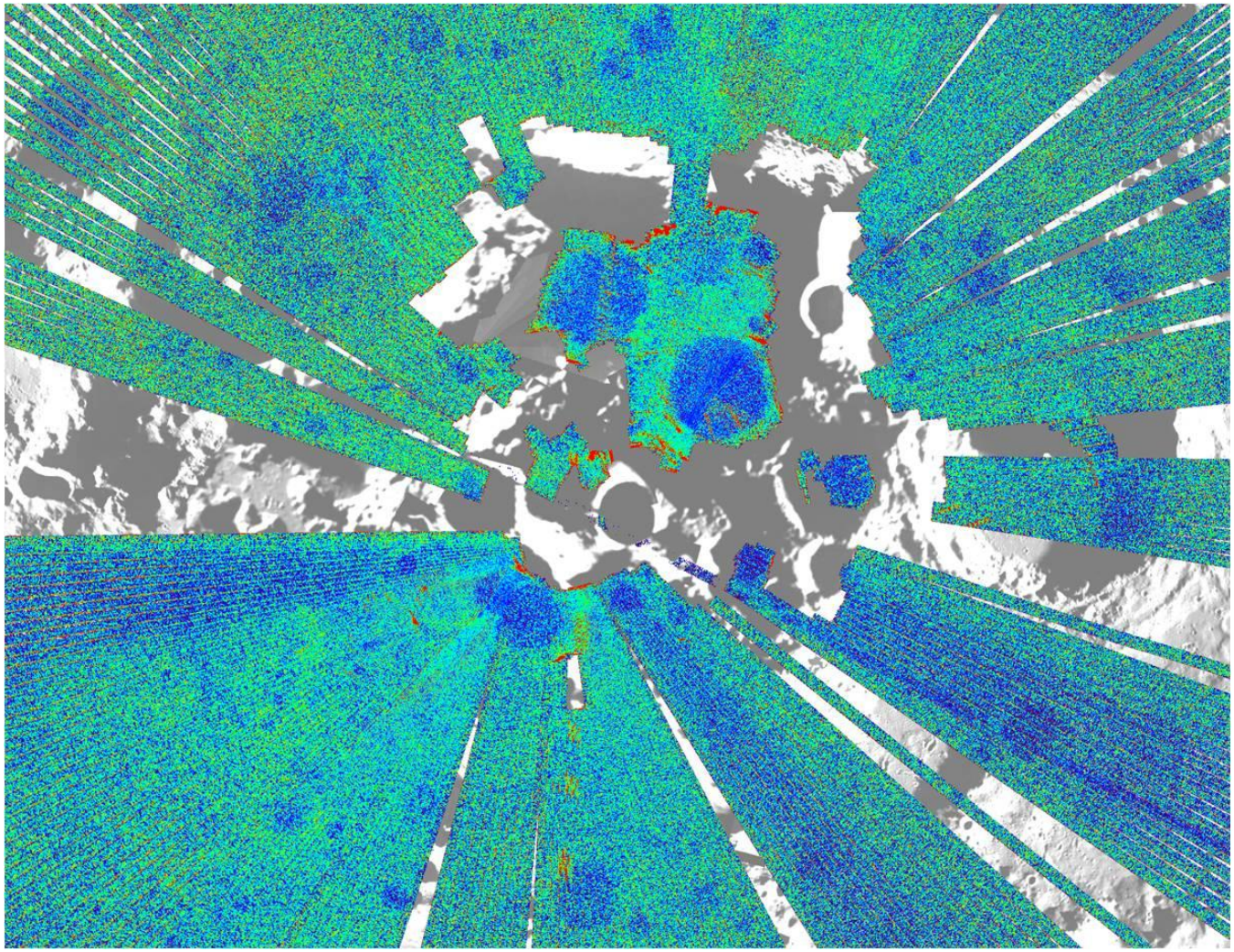

≥ 10 MeV Rate (cts/s) in "Nadir" Detector
40
35
30
25
20
0
5
10
15
20
Days since 6/20/09, 00:00:00 UTC
• Science data from the first 20 days of CRaTER operations, essentially continuous since 6/20/09
• Shown are rates of valid events (> 10 MeV) observed in nadir-most detector
• Variations in fluxes of galactic cosmic rays (GCR) seen during:
  • Cruise Phase
  • Lunar Orbit Insertion (LOI)
  • Commissioning Phase
• Science data well understood by team; building confidence for deeper , richer analysis

Diviner

Temperatures down to ~35 K!



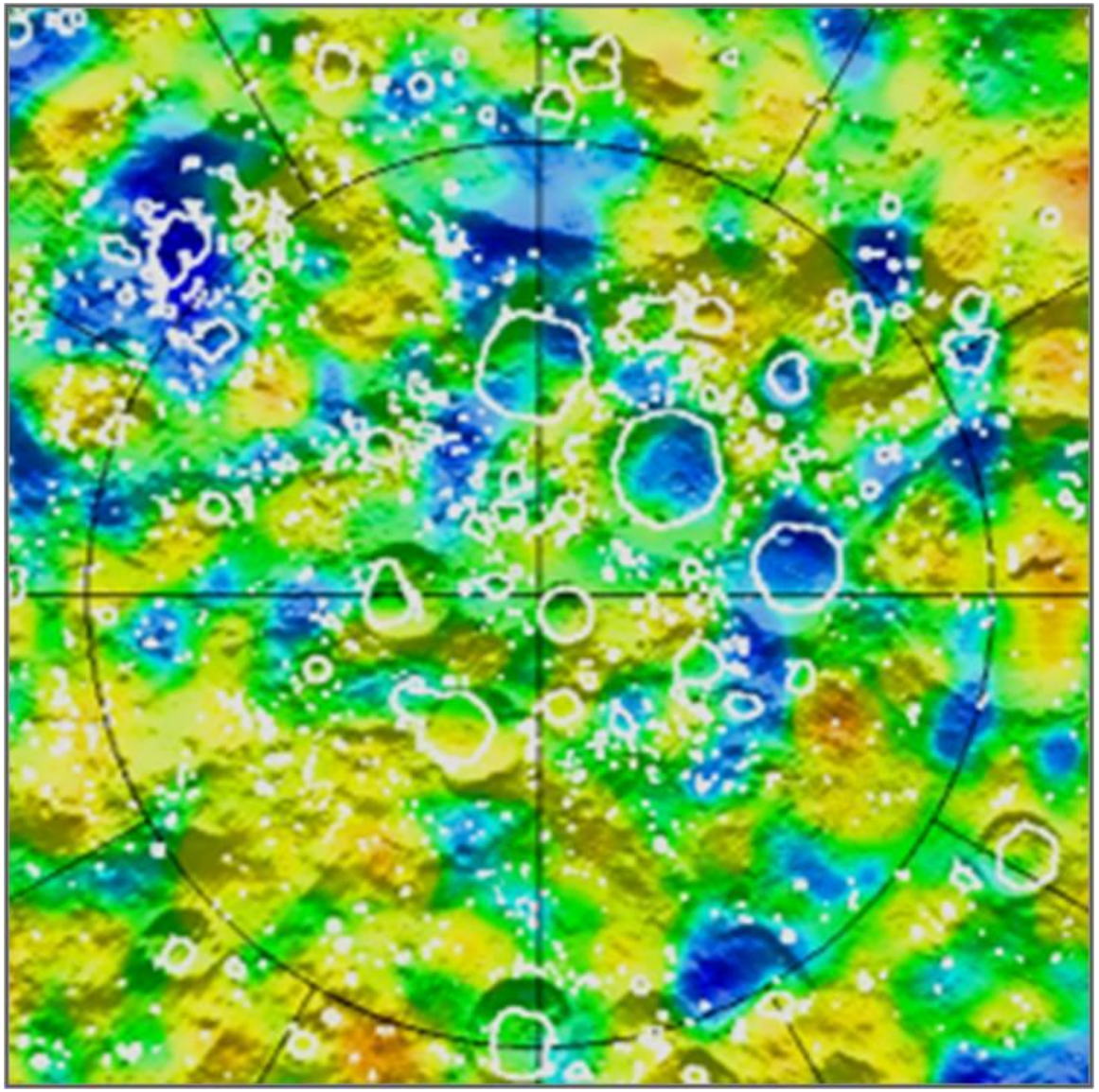
LAMP



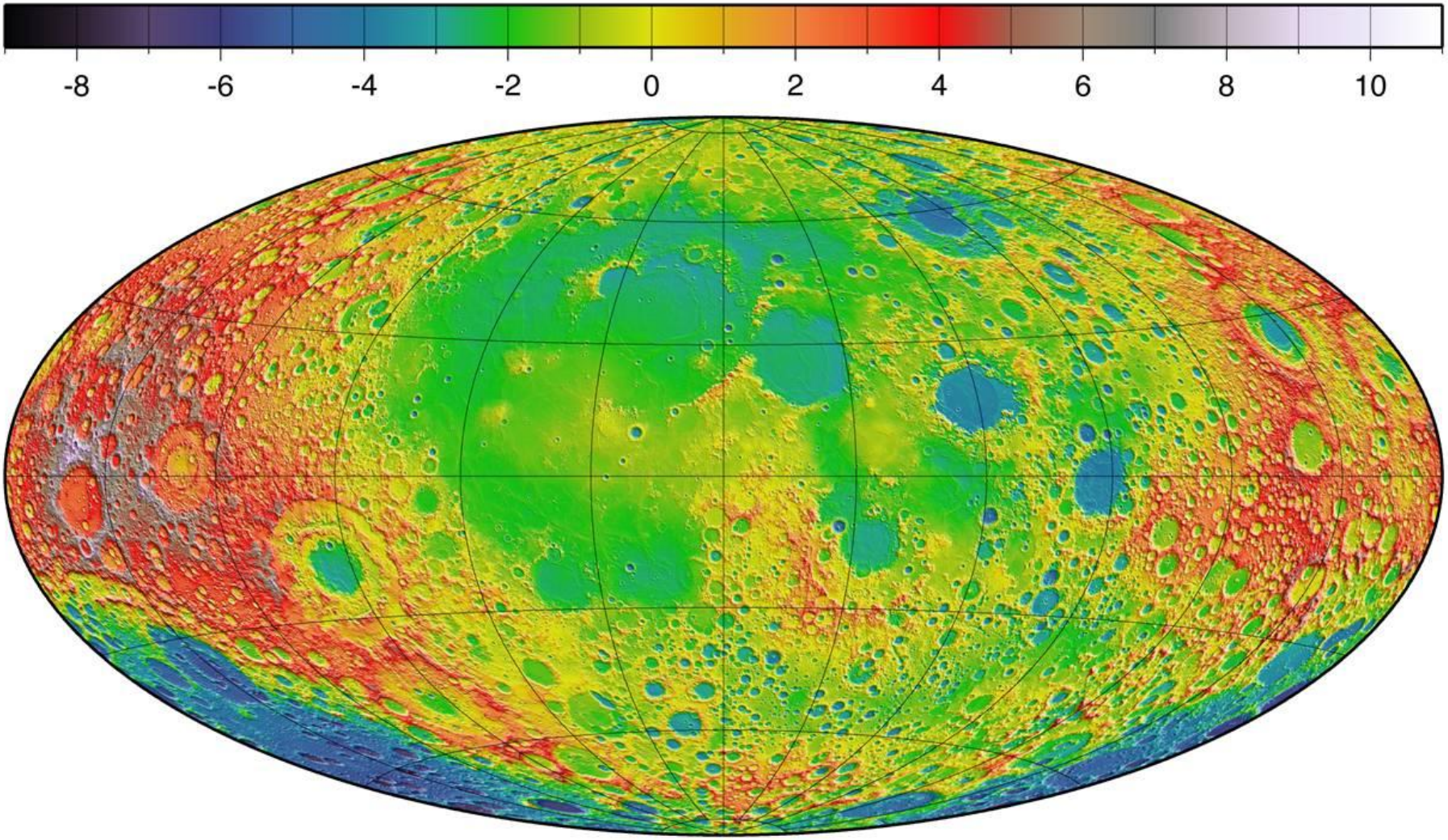
Shadowed craters are dark under ultaviolet illumination

LEND

Neutron absorption does not always correlate with permanent shadows

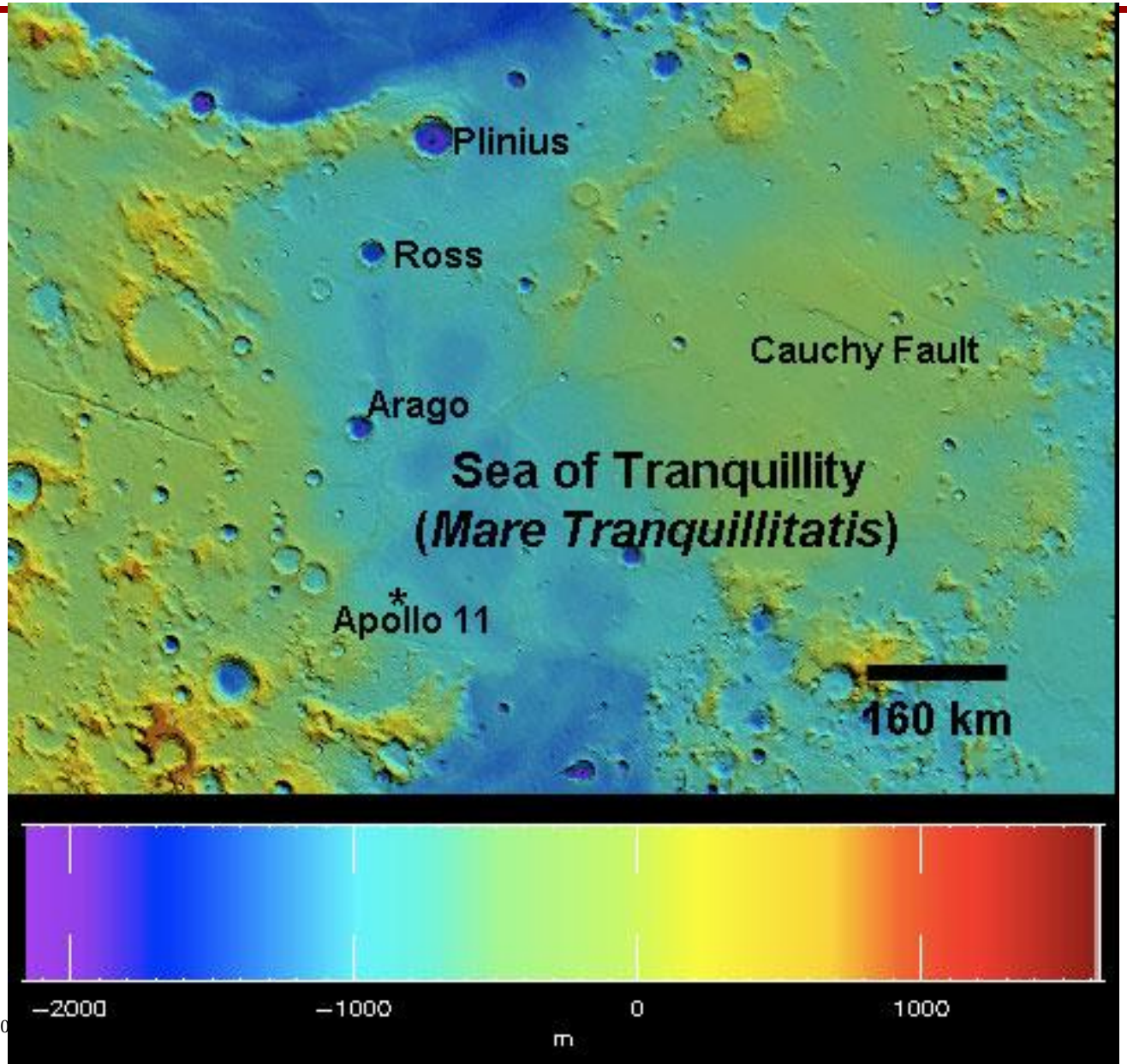


LOLA Global Topography



Lunar Far Side Altitudes

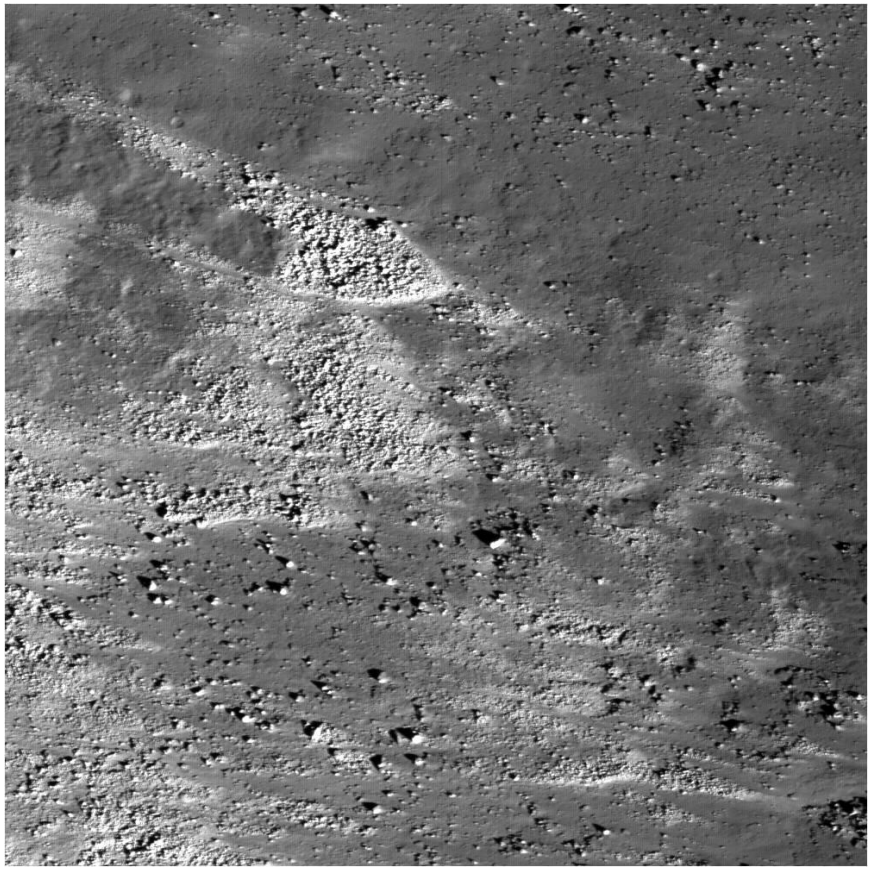
LOLA Laser Altimetry Data



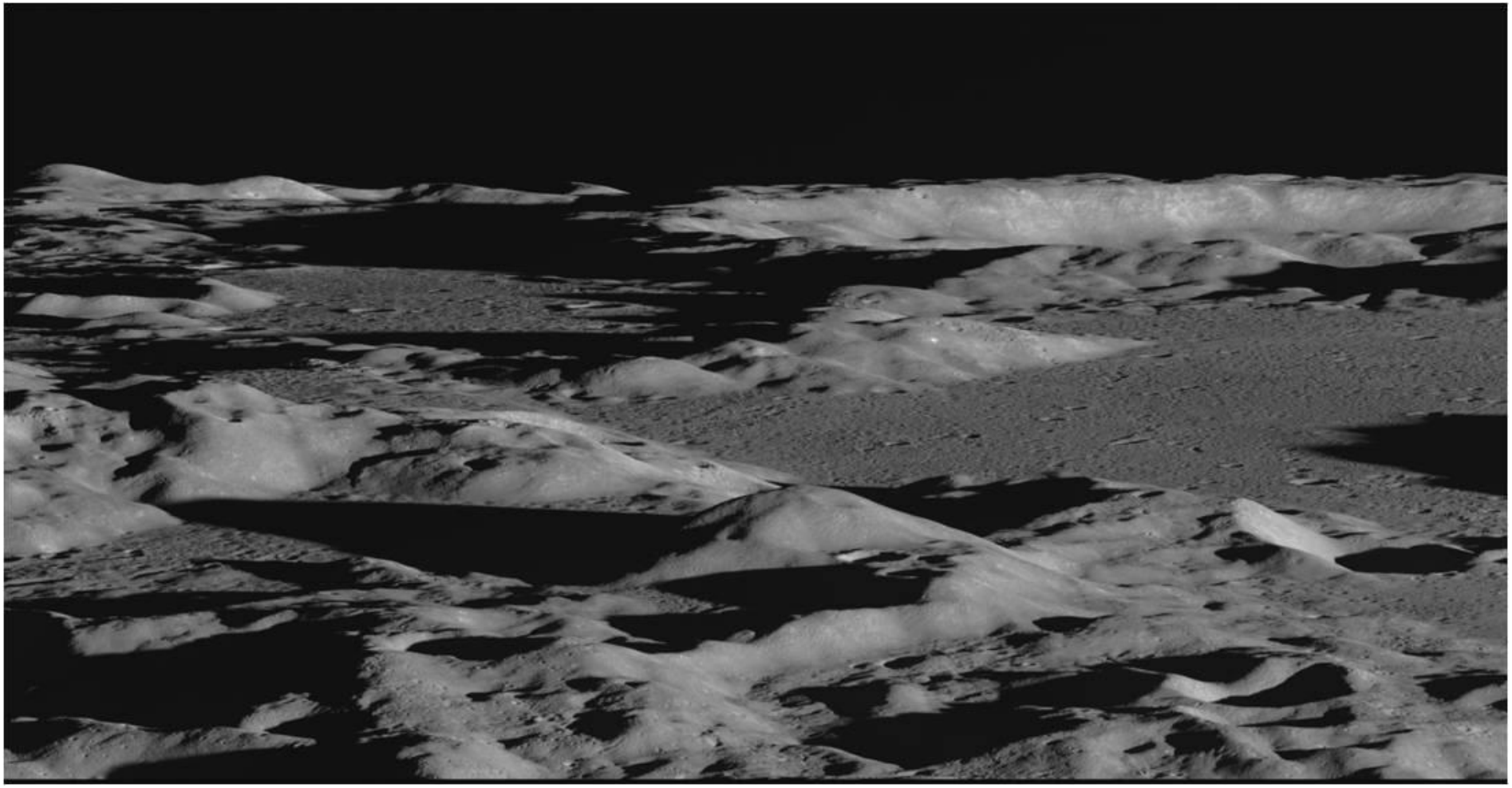
LROC—Wide and Narrow Angles

WAC Mosaic of “Cobra Head”
*Image width: 55 km

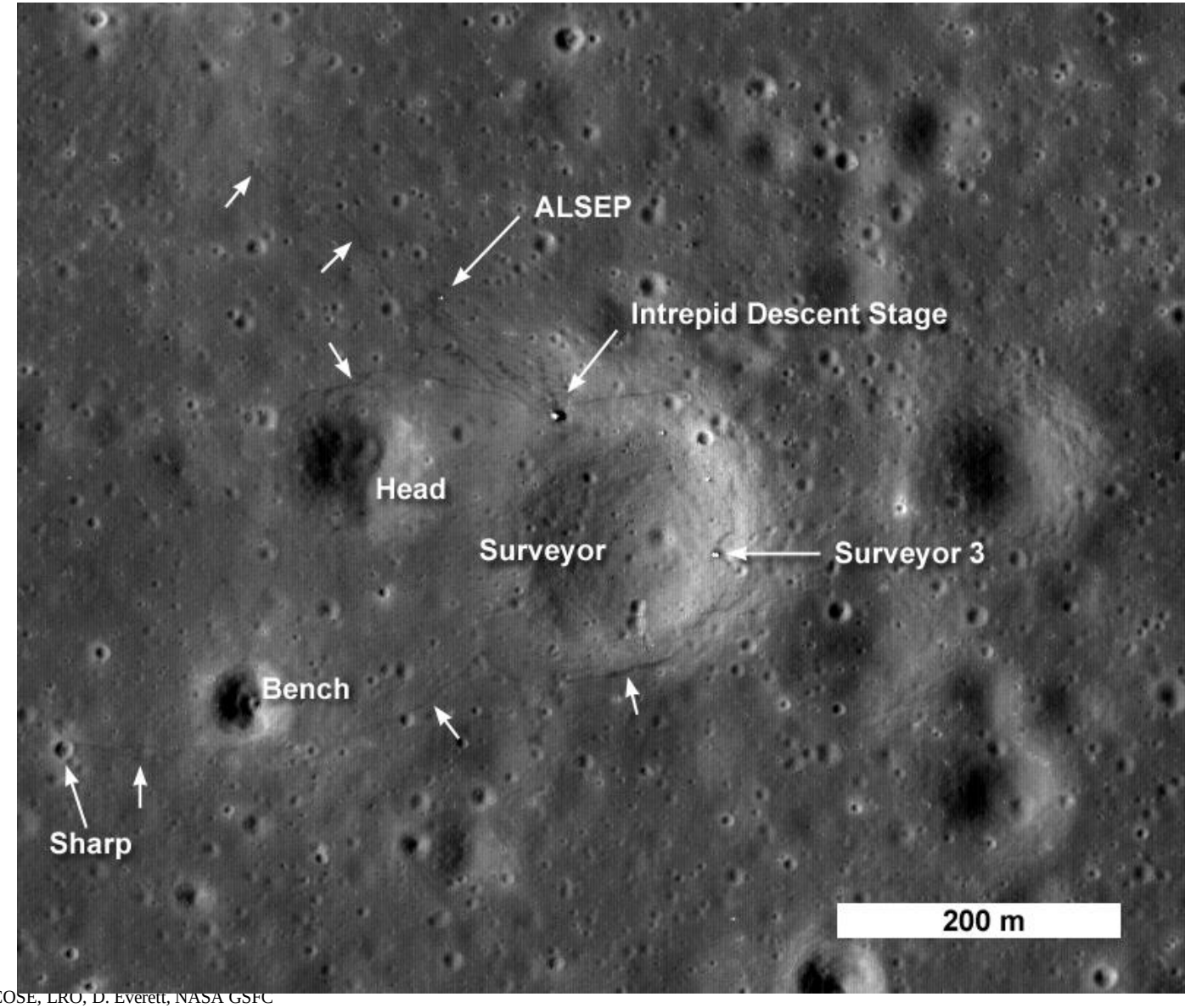
NAC closeup of WAC region marked by arrow *Image width: 500 m



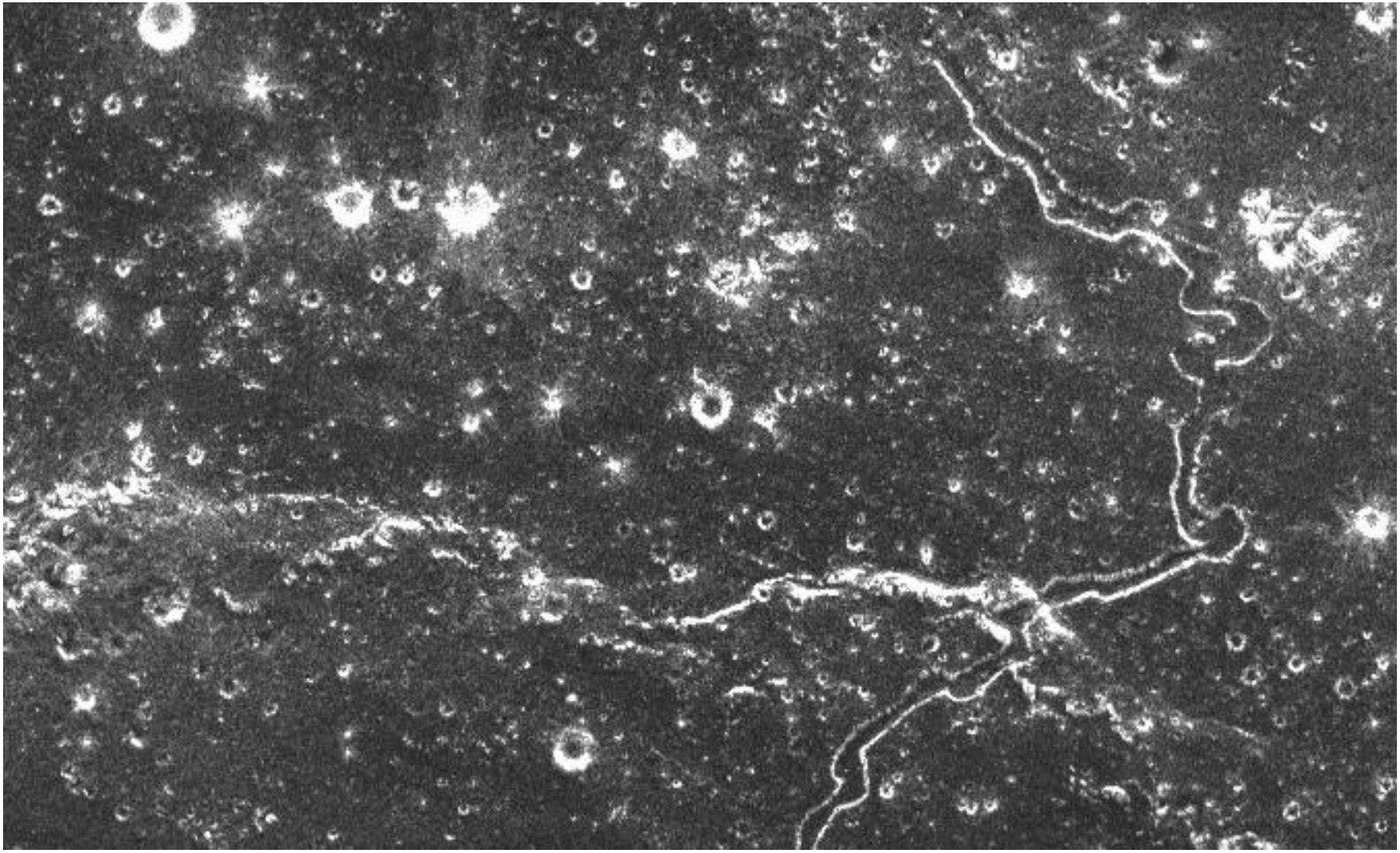
LROC—Limb View



LROC—Apollo 12 site



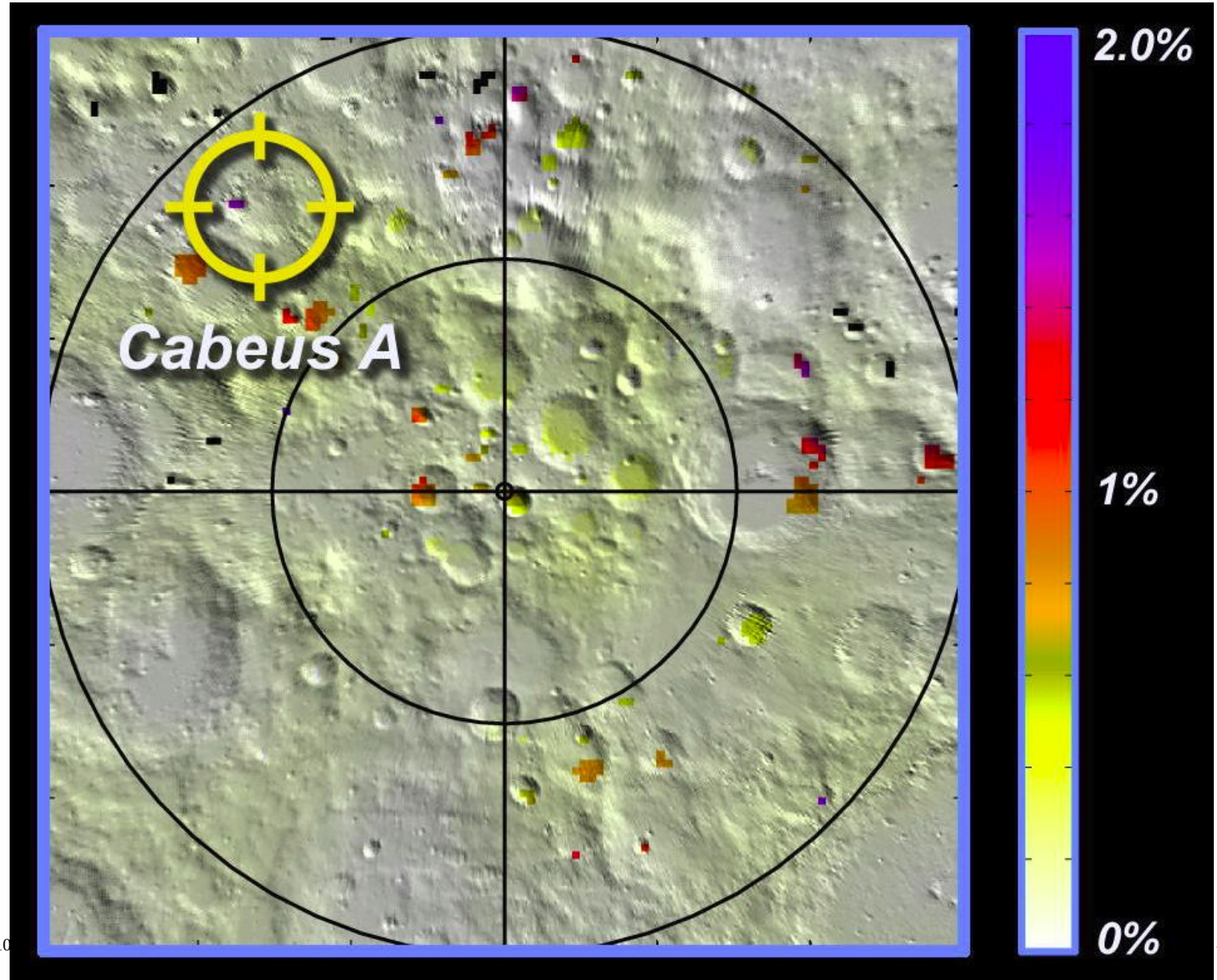
Mini-RF—Herodetus



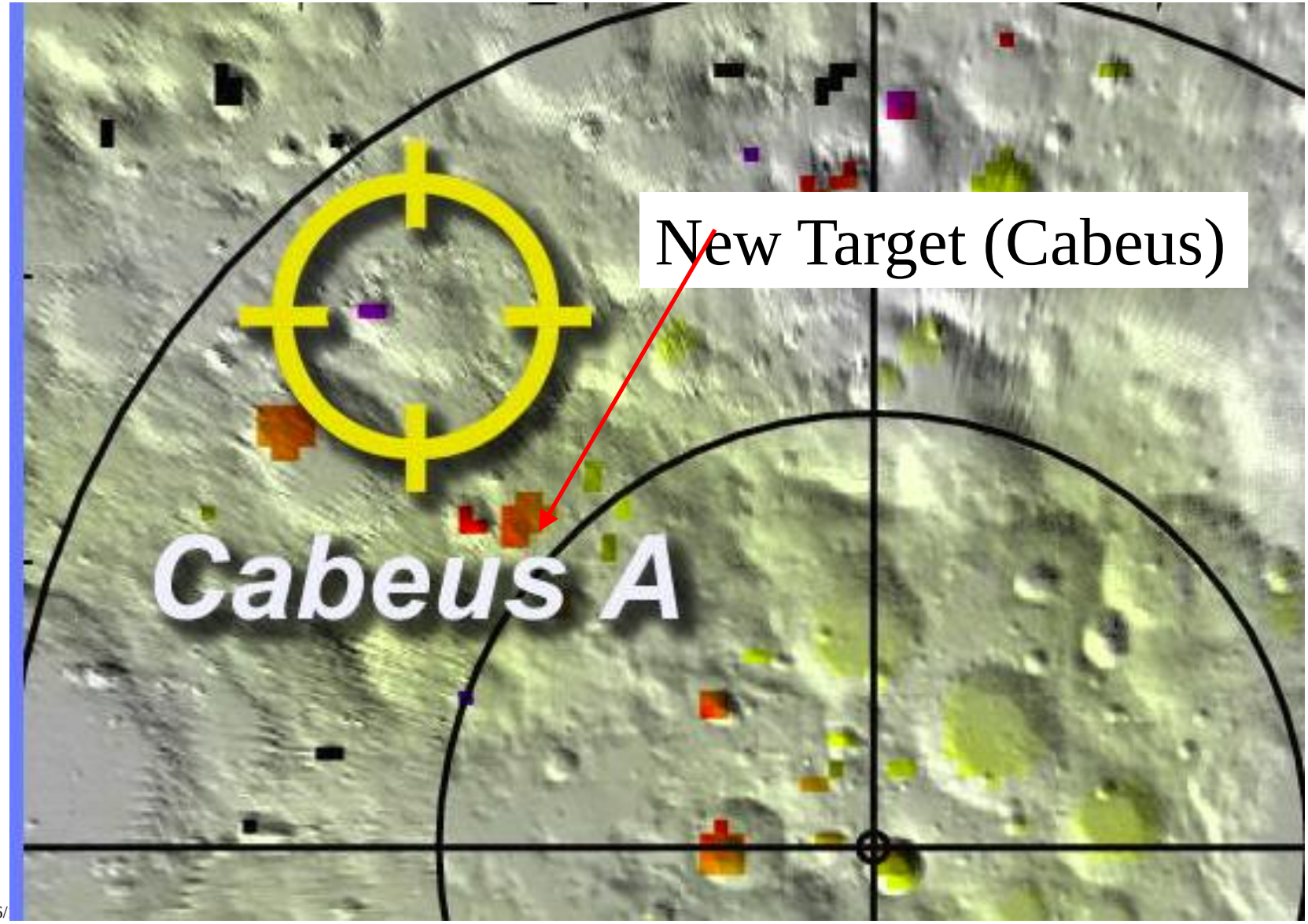
LCROSS Target as Viewed by LRO

- Lunar Crater Observation and Sensing Satellite flew with LRO as secondary payload
  - Designed to shepherd the launch vehicle upper stage into a polar crater
  - Impact on October 9, 2009
- LRO data from various instruments collected prior to LCROSS impact aided target selection

Original LCROSS Target

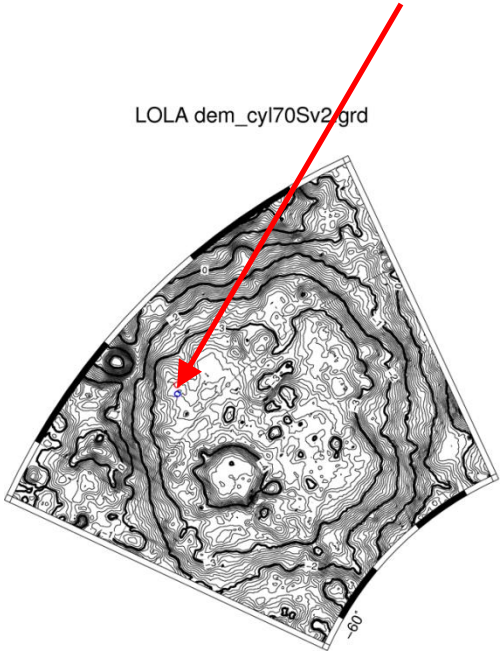


Closer View of Target (old and new)

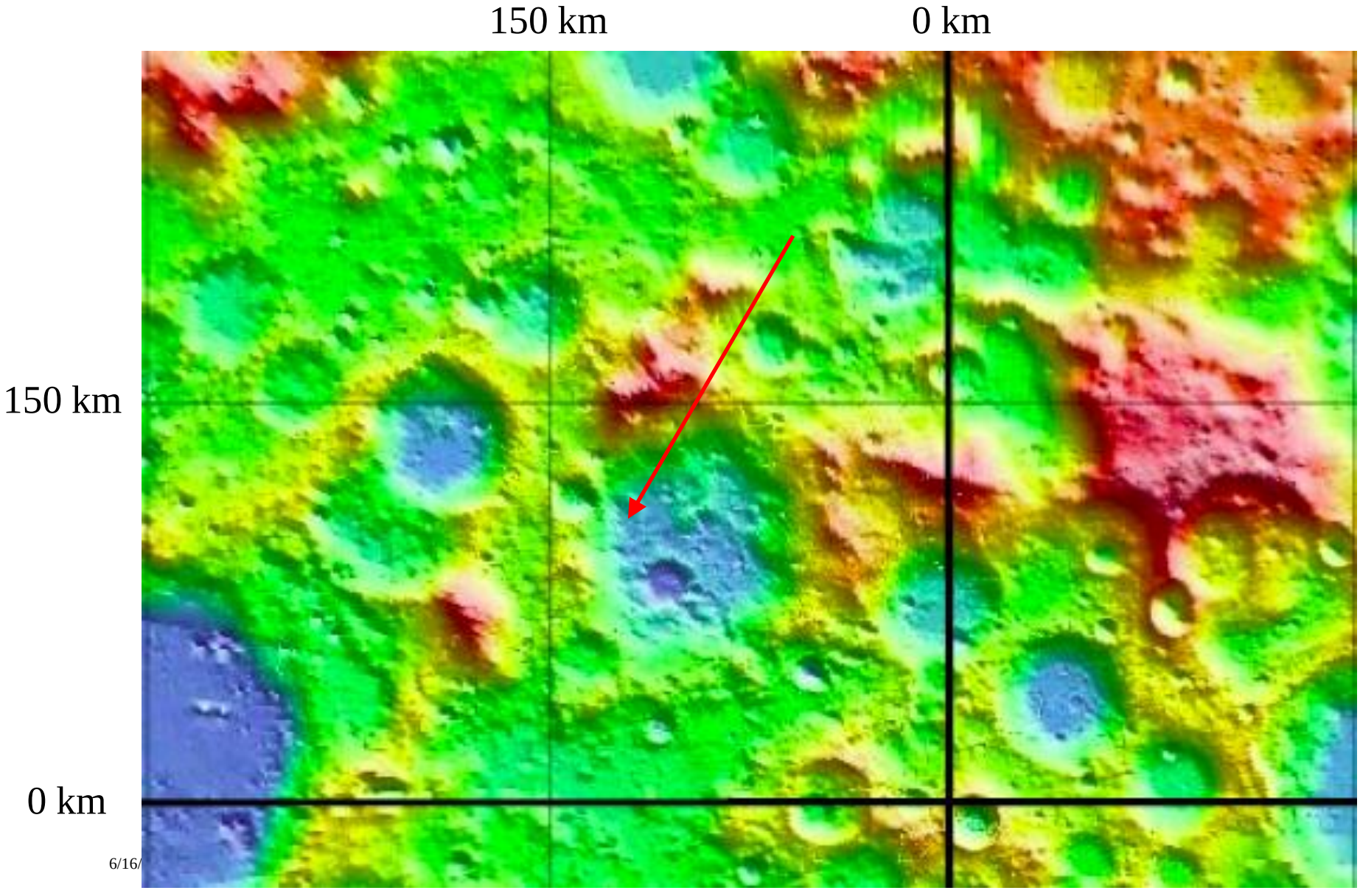


LCROSS Target

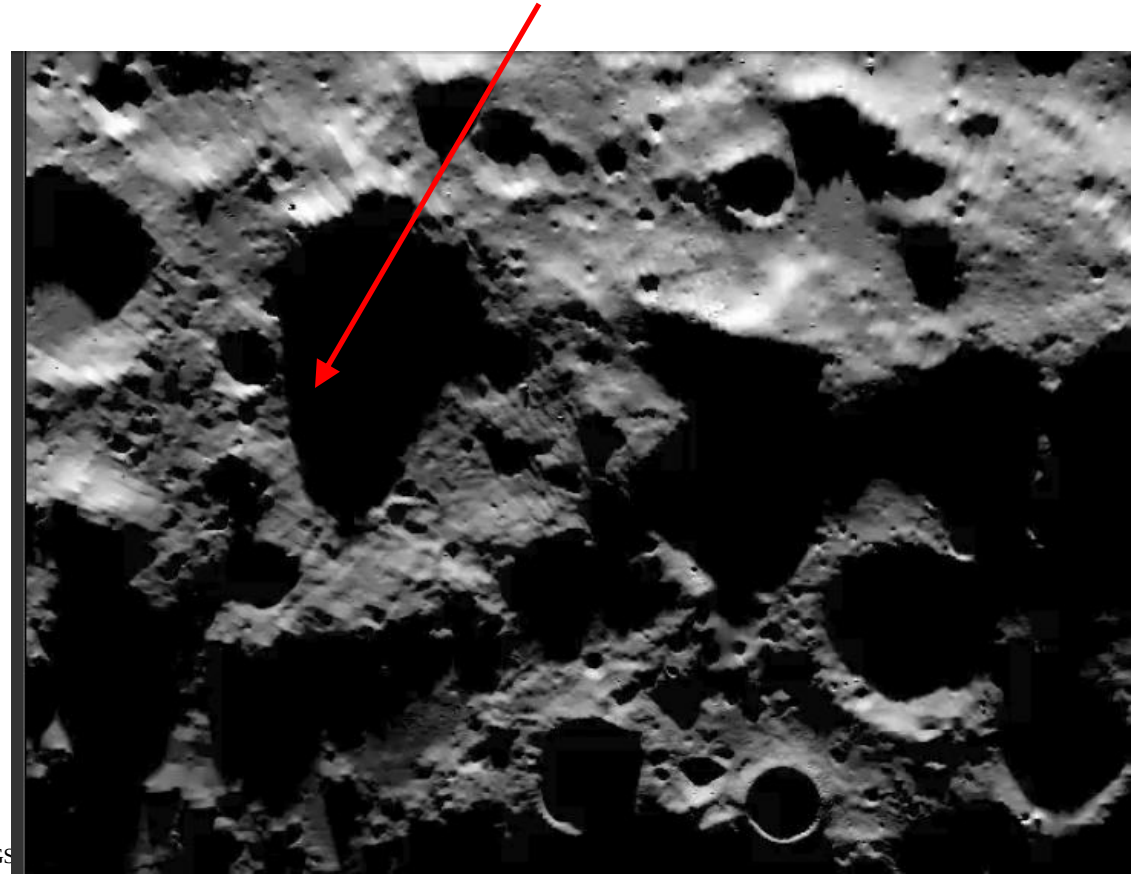
Centaur Impact indicated by **Red** circle
SSC impact indicated by **Blue** circle



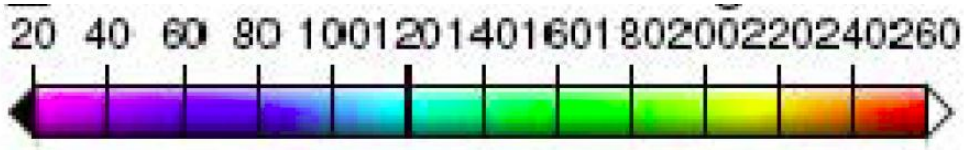
LOLA Data

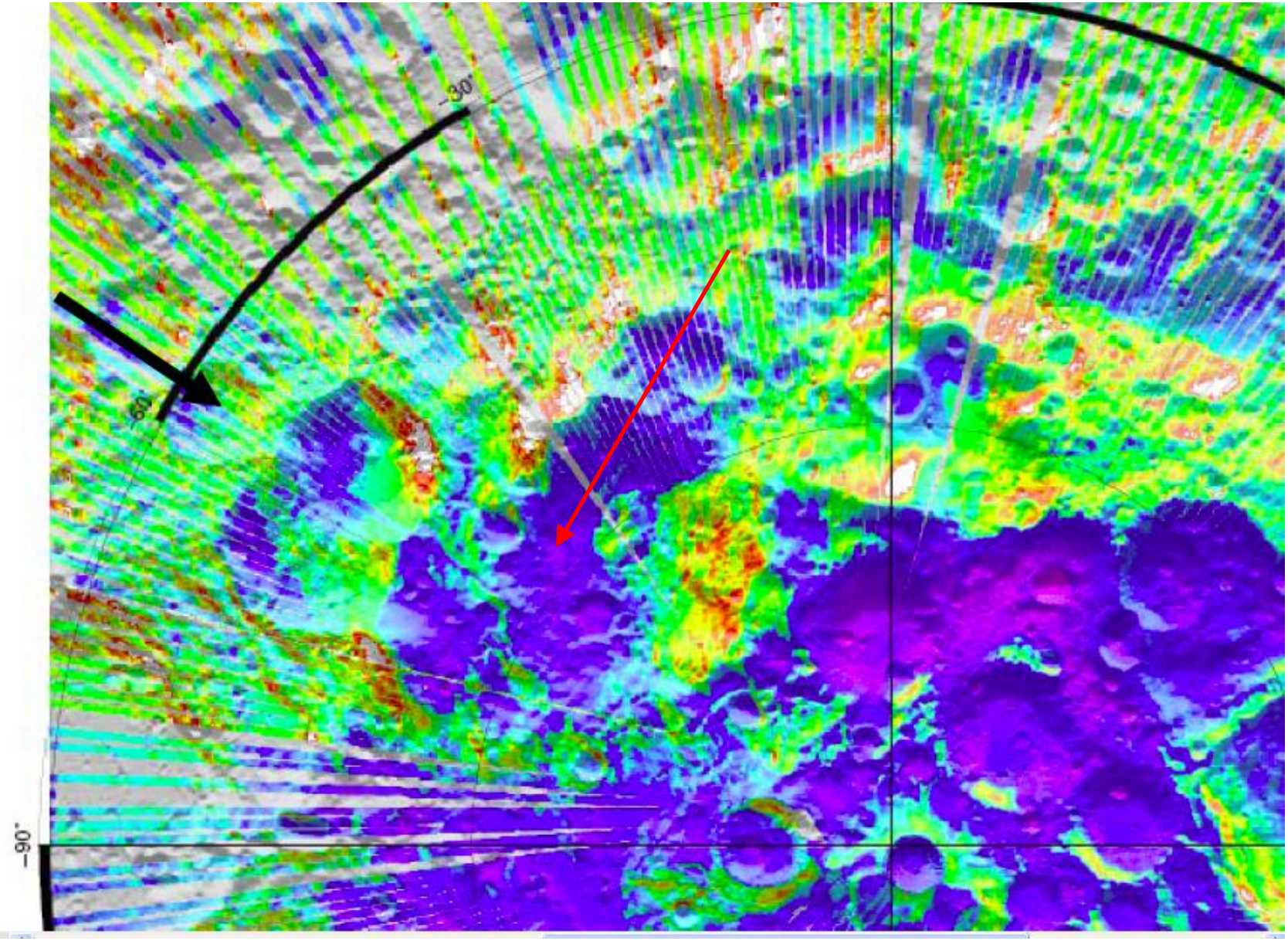


LOLA Data, Simulated Lighting

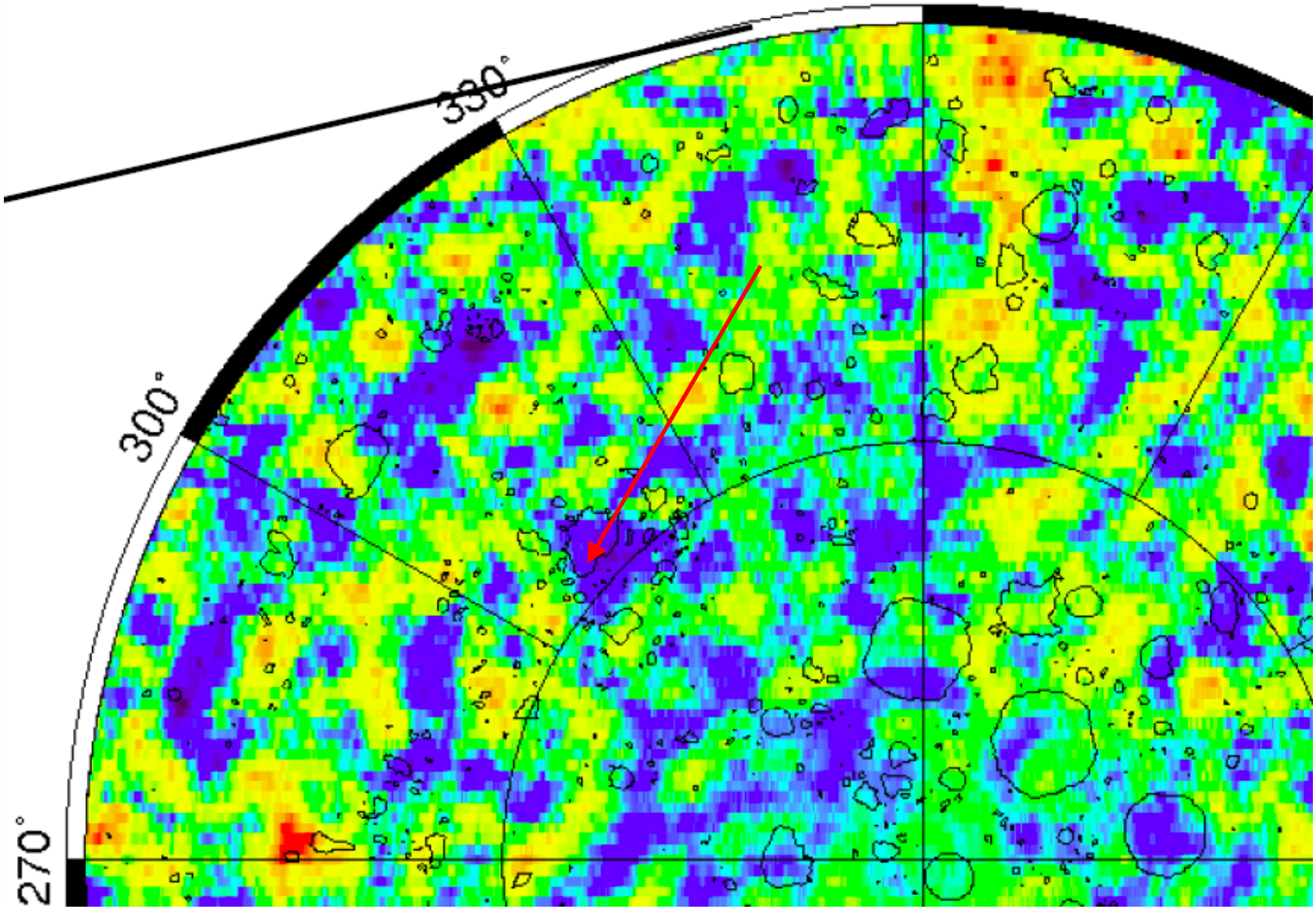


Diviner Data

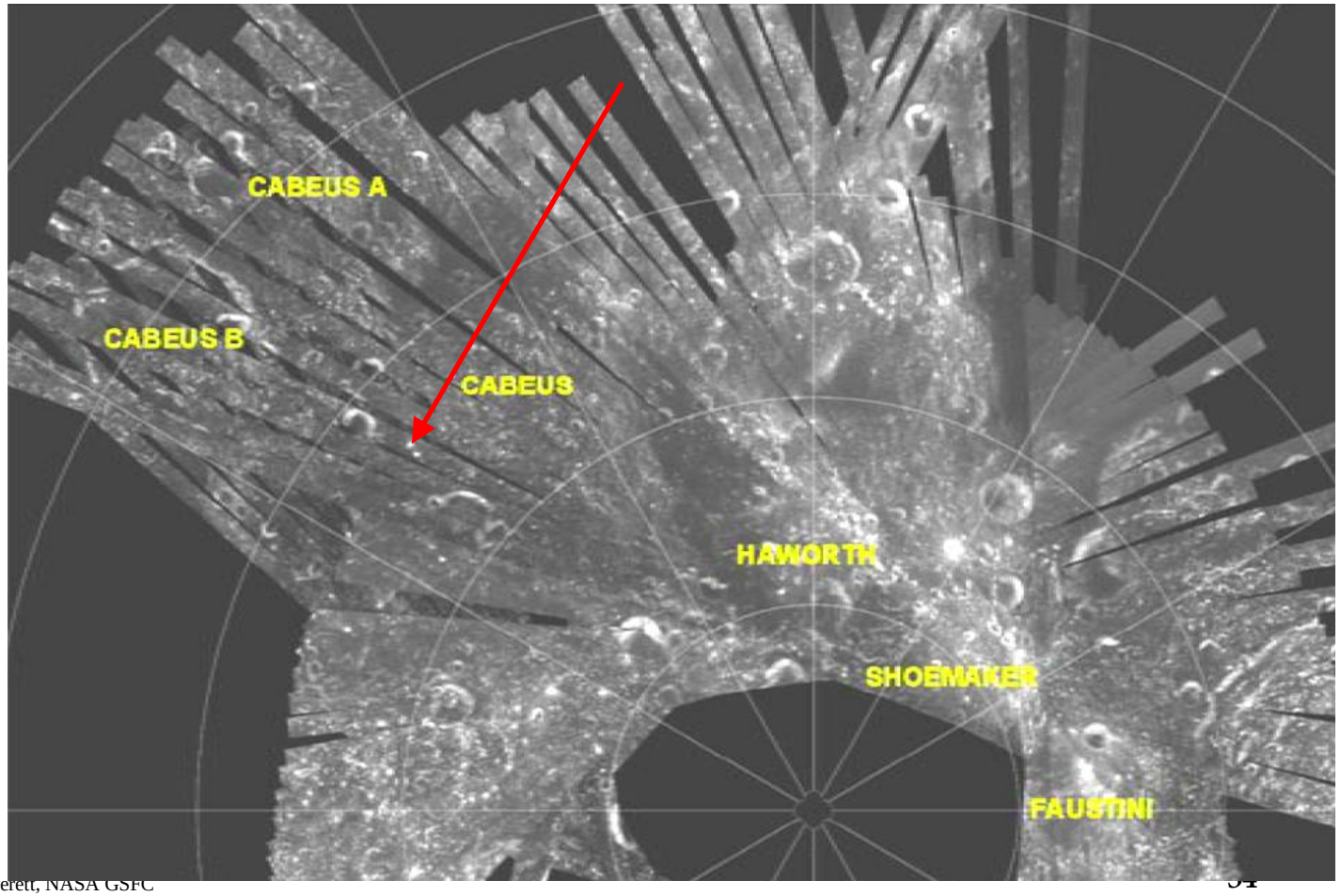




LEND Data

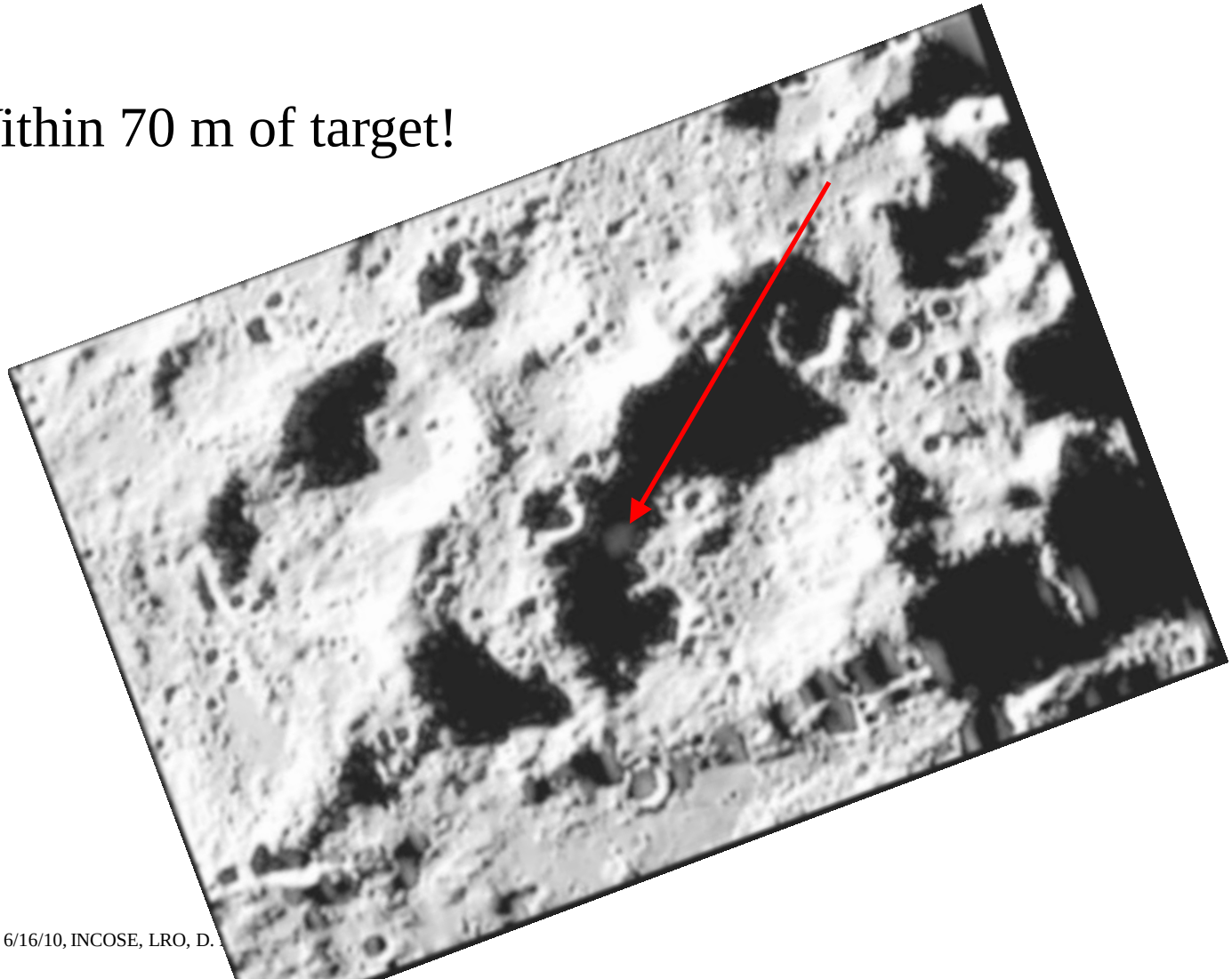


Mini-RF

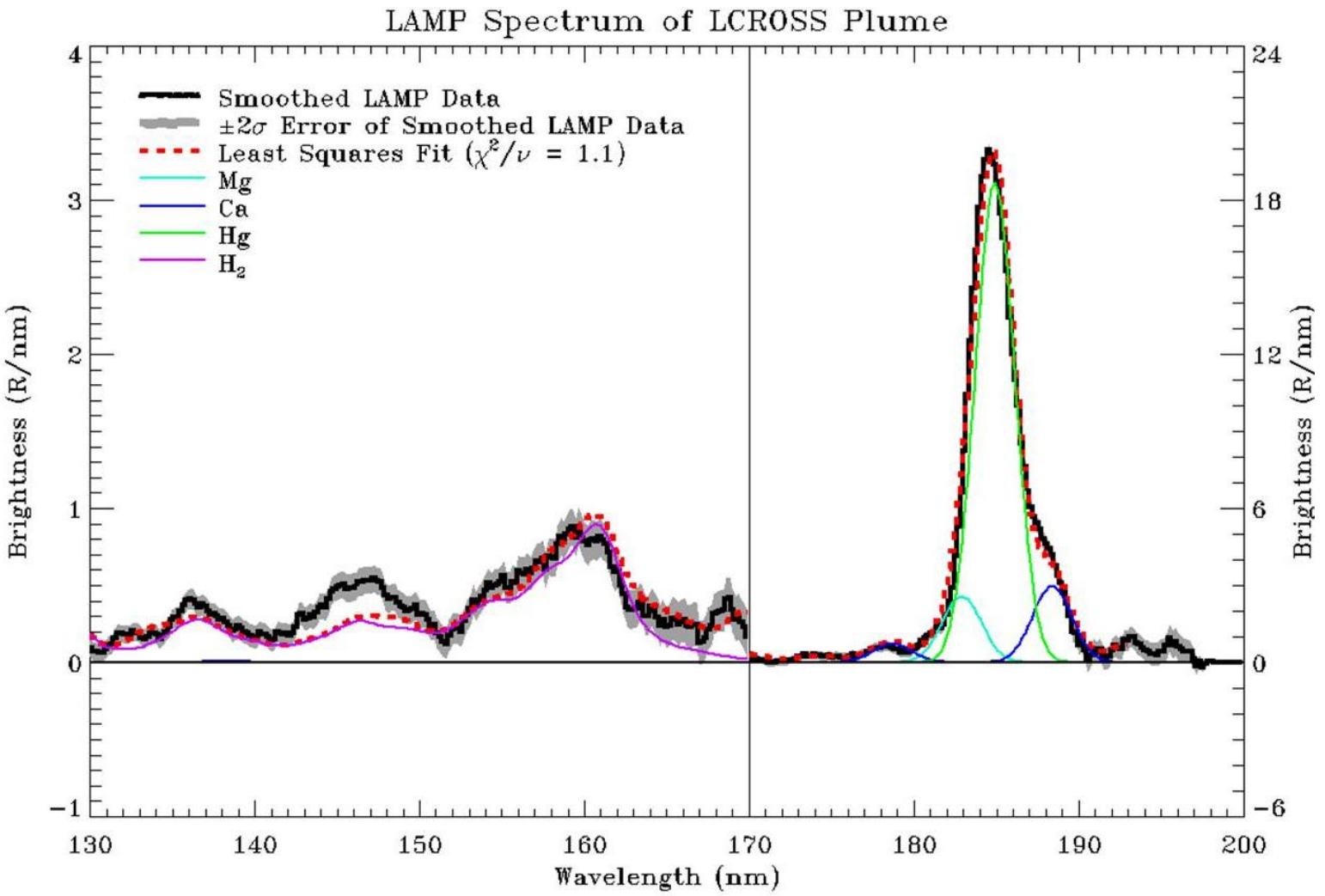


Centaur Impact from LCROSS

Within 70 m of target!



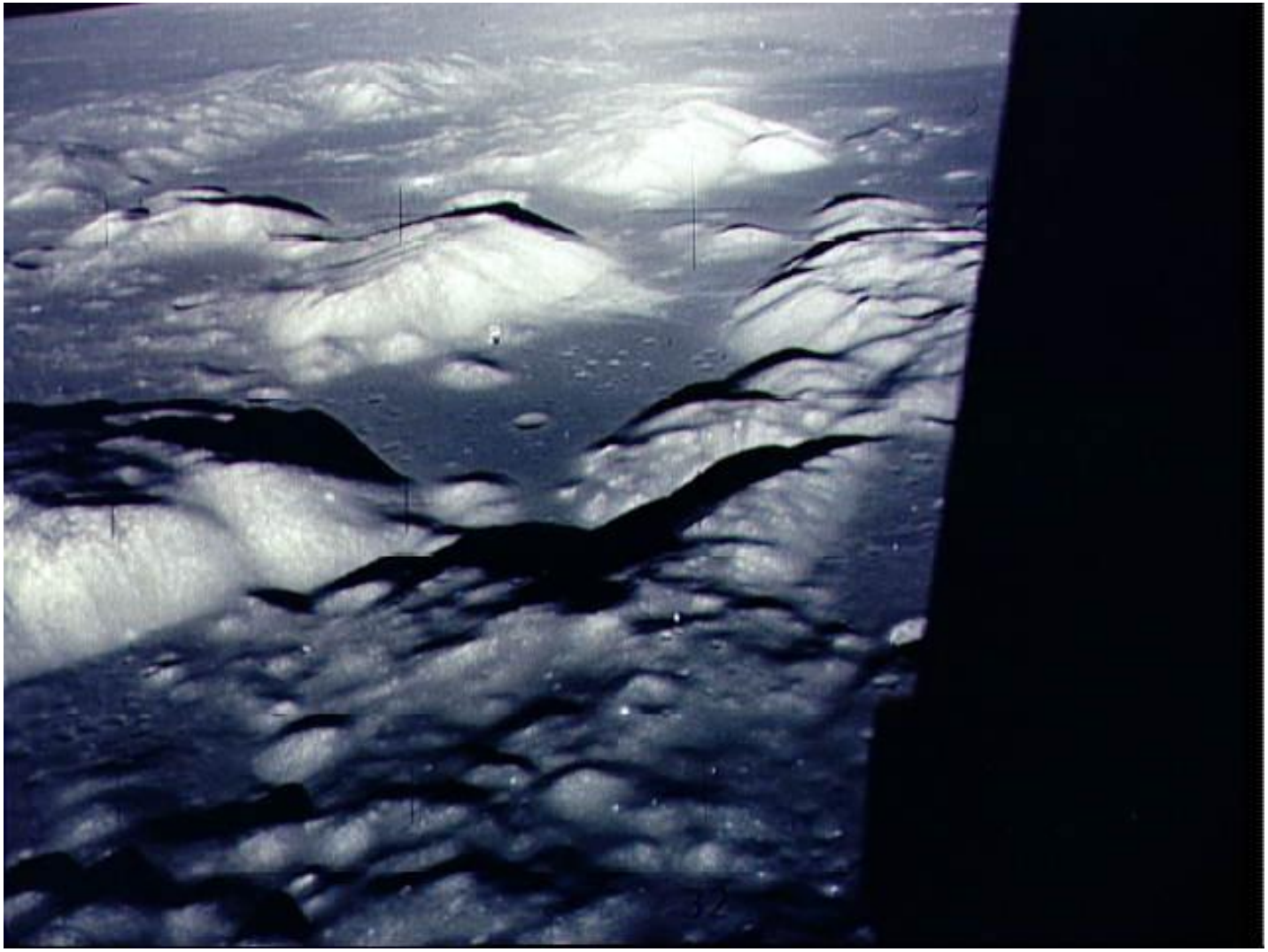
LAMP Detects the LCROSS Plume



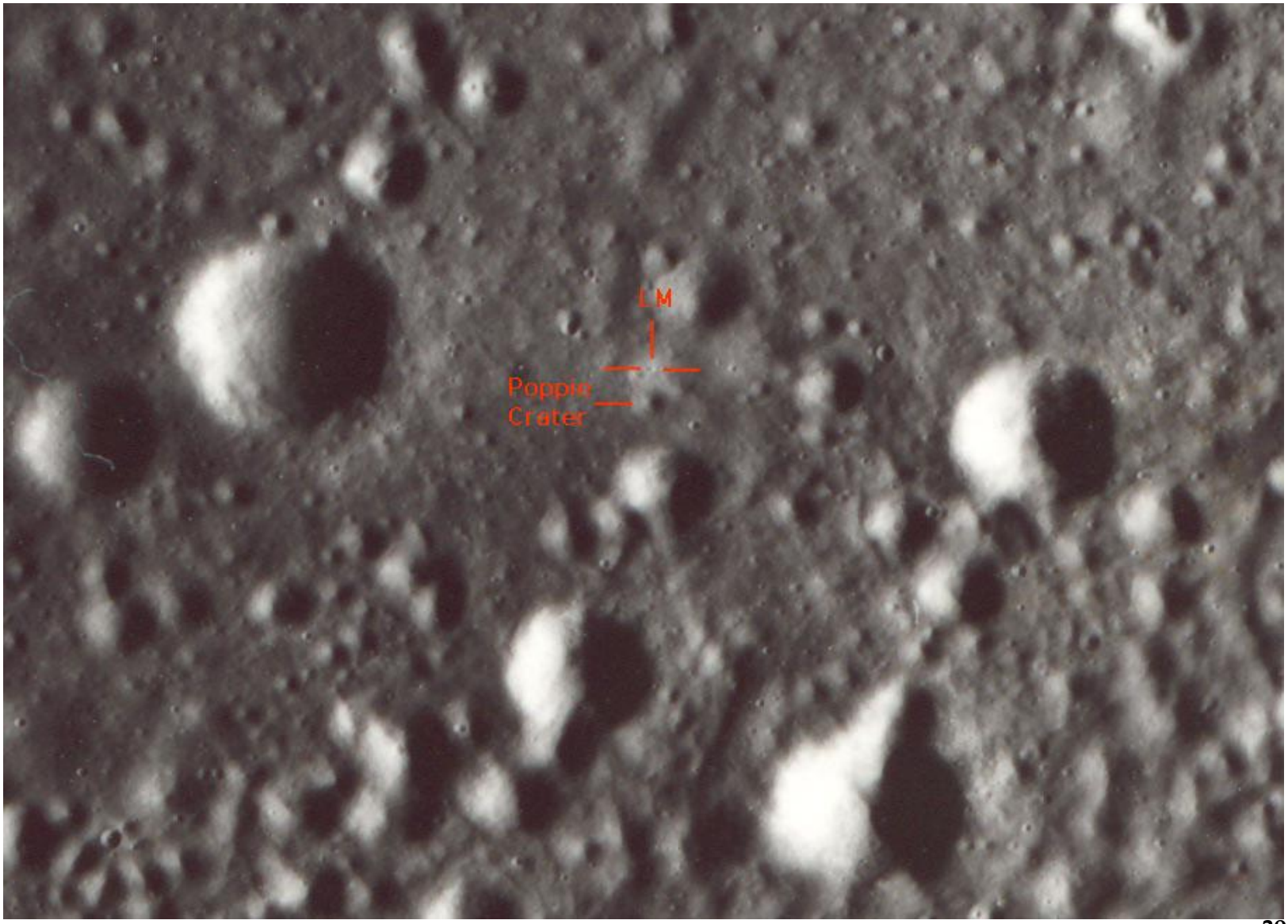
LCROSS Summary

- **The impact appears to have occurred in a volatile rich area:**
- **Water** …and other compounds (e.g., CH4, CO2, SO2, NH3, H2S) *likely* observed…more work needed to get unique identification
- Estimates of total water from band depths and OH emission strengths indicate significant amounts of water (>100 kg vapor and ice)
- The amount and types of volatiles suggest:
  - The very cold temperatures sequester all sorts of volatiles
  - May be difficult to explain with a single source model

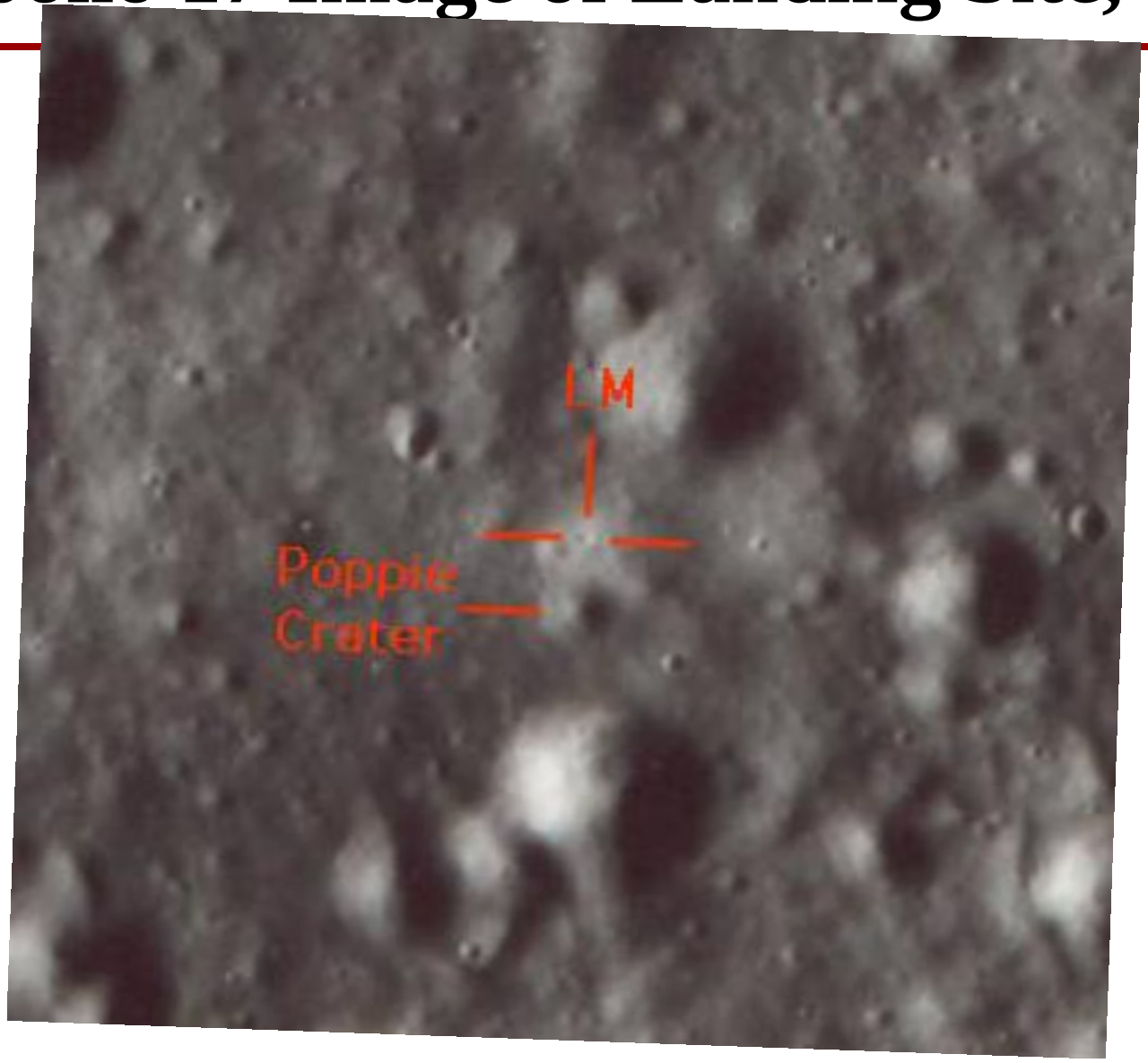
Apollo 17 Site from Orbit, 1972



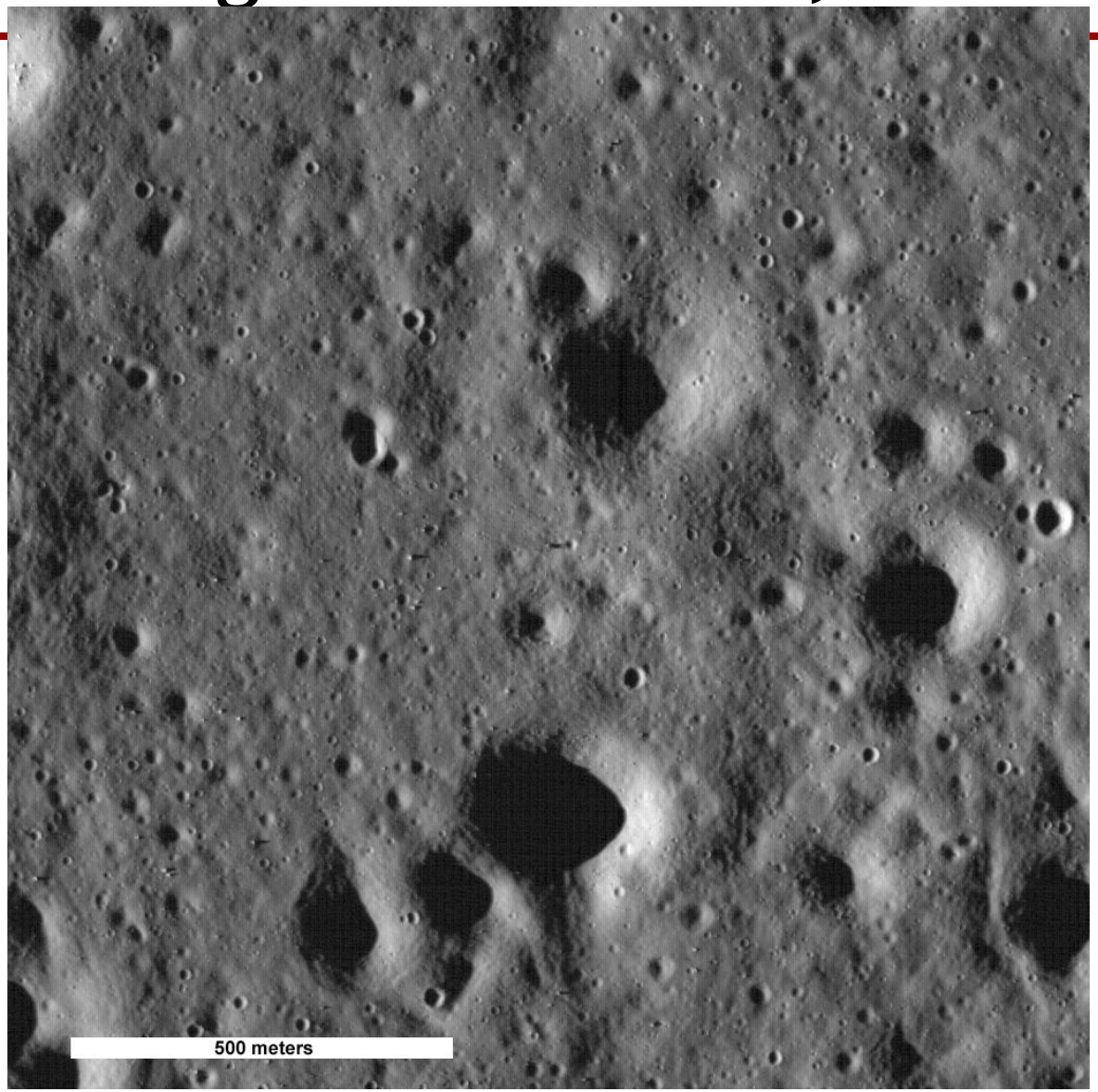
Apollo 17 Site After Departure, 1972



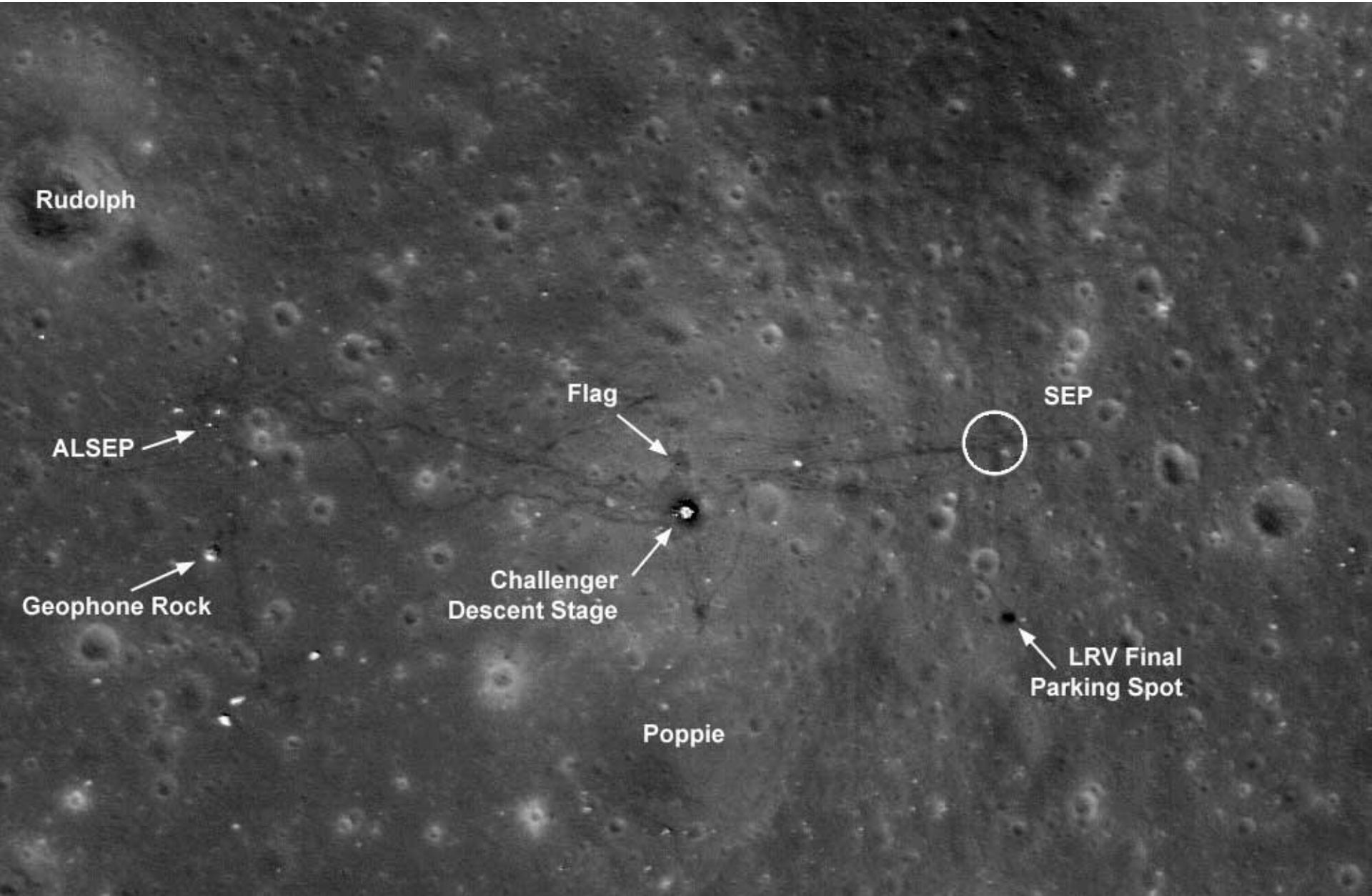
Apollo 17 Image of Landing Site, 1972



LRO Image from 100 km, 2009



LRO Image from 50 km



LRO Design Constraints (per AO)

- Polar, 50 km circular orbit
  - Harsh thermal environment (-140 to +140 deg C surface temperatures)
  - High-resolution imagery
  - All sun angles
- Delta II launch vehicle (launched on Atlas V)
  - Spinning upper stage
  - Tight mass constraint
- 14-month mission
- Class “C” reliability (largely single-string) with grade “B” parts and strong test program
- 2008 launch (launched June 18, 2009)

Programmatic Environment

- Robotic Lunar Exploration Program (RLEP) office originally at GSFC under Science Mission Directorate
  - LRO the first of a series of small, annual missions assigned to GSFC in May 2004
  - LRO philosophy was "design to cost"
- RLEP moved under Exploration Systems Mission Directorate in May 2005
  - LRO Philosophy became "design to requirements": little desire by HQ to descope requirements; strong desire to fly Mini-RF
- RLEP moved to Ames Research Center in November 2005
  - Second mission began to slip past 2009
- **LRO asked to re-focus on cost as confirmation review approached**
- RLEP renamed Lunar Precursor Robotic Program (LPRP) and moved to Marshall Space Flight Center in May 2006
- Due to Exploration budget concerns, RLEP program office closed in early 2007, LRO reported directly to HQ
- RLEP re-opened by FY2008 appropriations

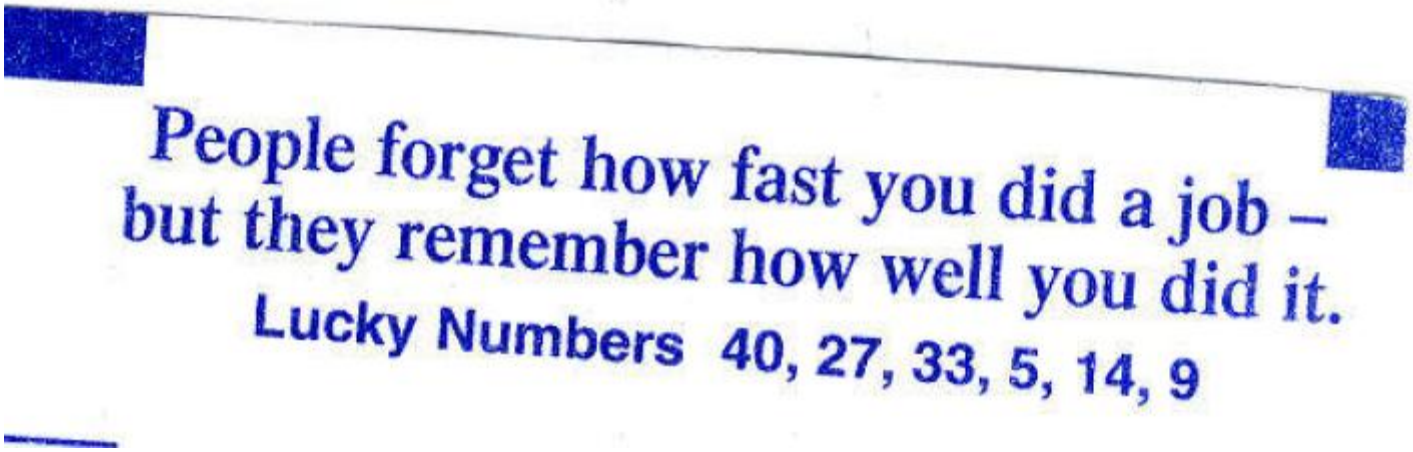
Milestones

- AO June 2004
- Funding start in January 2005
- System Requirement Review in August 2005
- Launch vehicle changed to EELV in November 2005
- Preliminary Design Review in February 2006
- Confirmation Review in May 2006
- Critical Design Review in November 2006
- Start of spacecraft integration in January 2008
- Pre-Environmental Review in June 2008
- In July 2008, national launch priorities slip LRO to 2009 launch
- Thermal Vacuum start in October 2008
- Environmental testing and CPT complete January 2009
- Pre-Ship Review in February 2009
- Launch on June 18, 2009

Schedule

- We had a Level 1 requirement to launch in 2008
- HQ continued to emphasize this requirement
  - Exploration Systems Mission Directorate's (ESMD) credibility with Congress and OMB was tied to getting this first mission done on time
  - HQ offered extra funding after CDR in order to hold schedule
    - Some money was applied in key areas
    - Overall effect reduced cost by saving schedule: one component can hold up the entire development
- Independent Review Team expressed concern with LRO's schedule at each review
- LRO engineers frequently expressed concern with schedule
- LRO established a budget at confirmation which did not overly constrain the mission
- Project management and systems team needed to balance schedule against technical risk

LRO Fortune Cookie



The Constant Challenge

- Find ways to get things done faster without compromising the technical integrity
  - Work harder (we all did this—good team spirit)
  - Add more people (mechanical team)
  - Design for parallel development
  - Test early
  - Manage risk
  - Challenge the standard way of doing business
  - Focus on the people
  - Make decisions and move on
- All of the above were necessary!

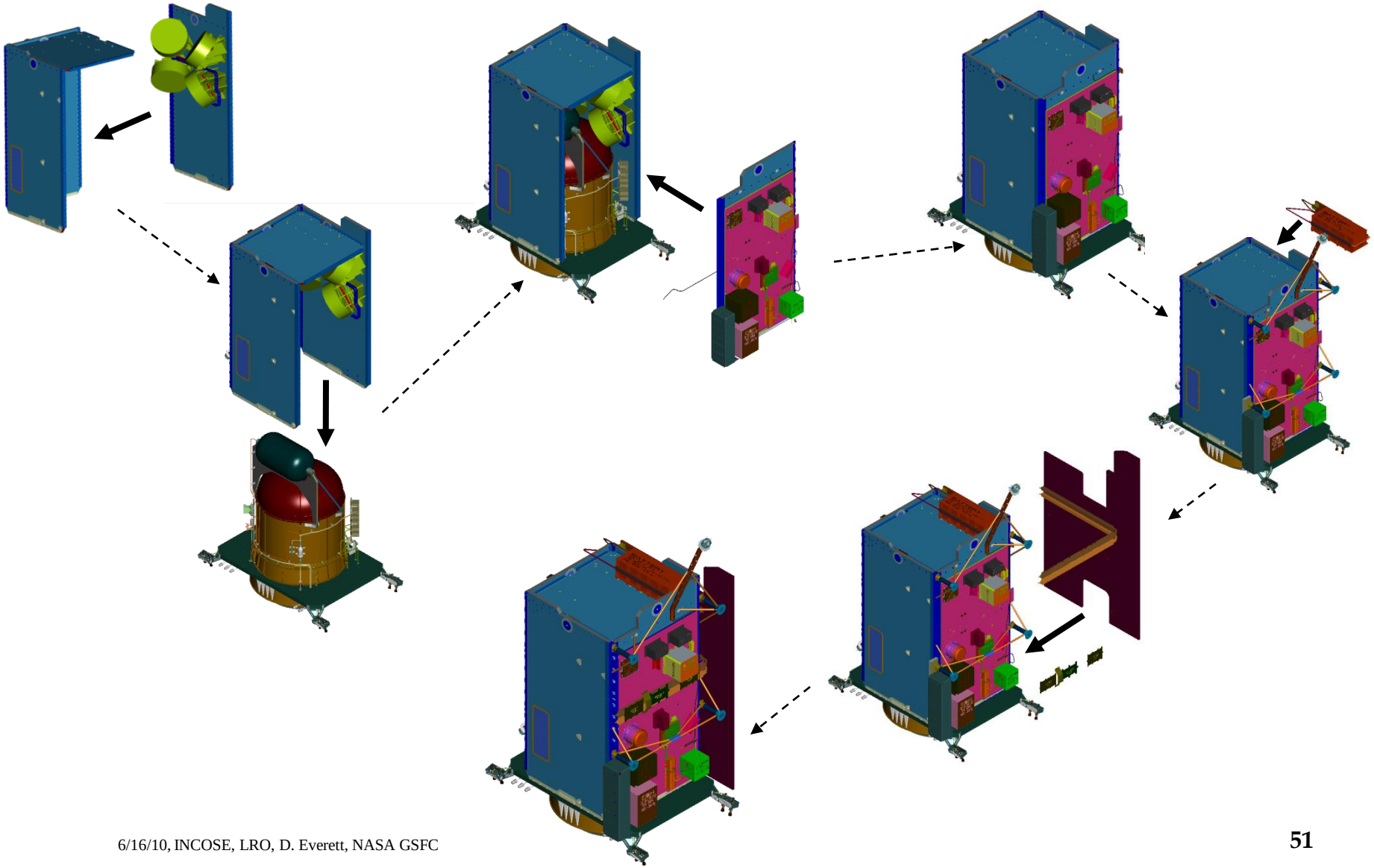
Launch Vehicle Change

- In September 2005, the propulsion team identified a risk associated with the nutation time constant of LRO's propellant tank.
  - Almost half of the Orbiter's mass is liquid fuel
  - Delta II upper stage is spin stabilized
  - We would not know until spring of 2006 (after drop-tower testing) whether LRO could meet launch vehicle requirement for NTC
- Conducted trade of options:
  - Accept risk and proceed with current design: too risky to schedule
  - Redesign with bi-propellant: too much schedule impact
  - Redesign for Evolved Expendable Launch Vehicle: beyond project's scope to make this decision
  - Redesign with solid rocket motor: impact on mechanical and thermal
- Briefed HQ in November 2005

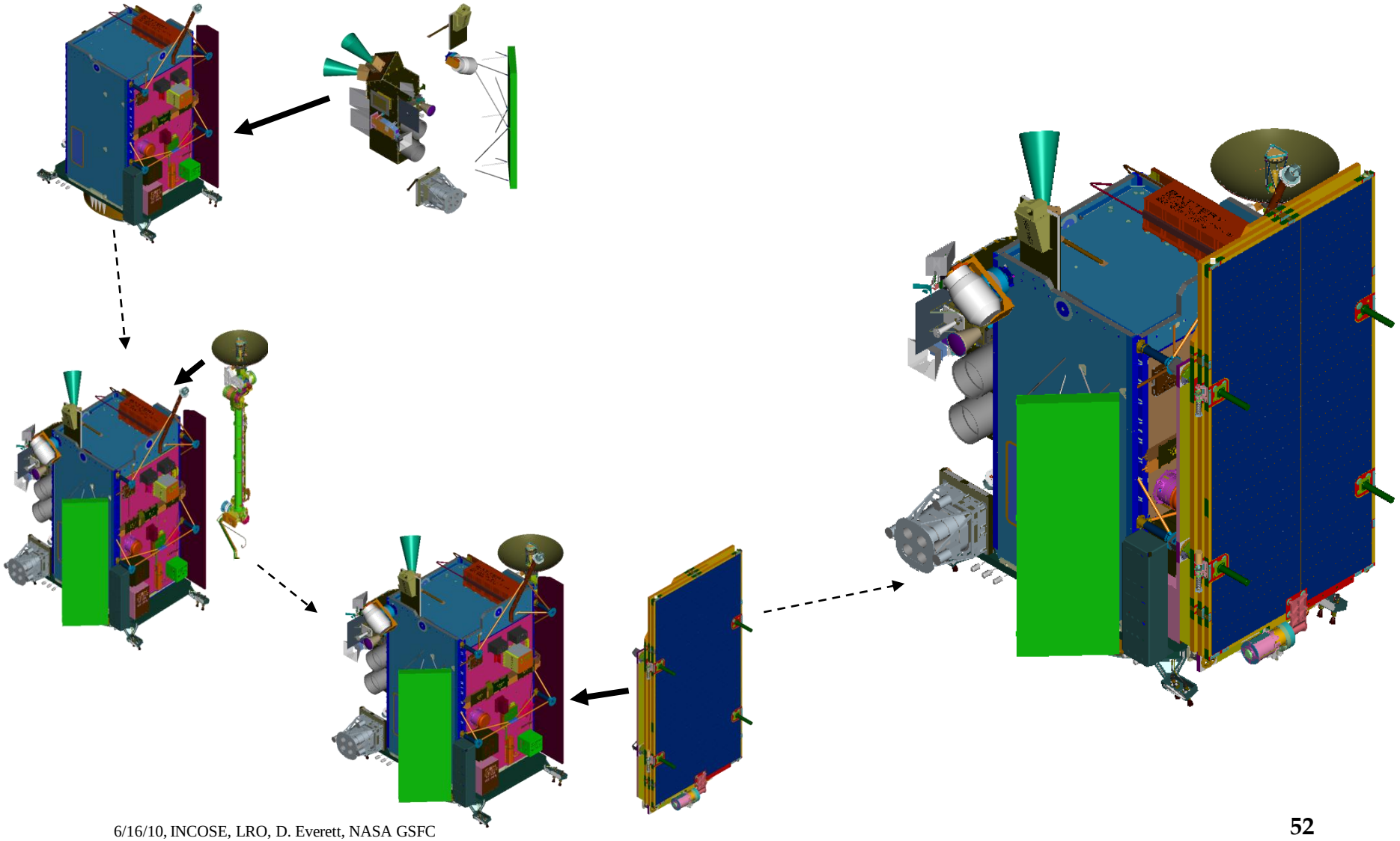
Launch Vehicle Change (cont.)

- Associate Administrator decided during the briefing to move LRO from Delta II to EELV
  - Solved NTC problem
  - Allowed use of surplus propulsion components from X-38
  - Provided additional launch capability for secondary payload
- LRO Mechanical team re-started system design with the following guiding principles:
  - Set mass limit with capability of two fuel tanks from X-38
  - Create modular design for parallel assembly
  - Couple significant mass to minimize thermal transients
- Mechanical and thermal teams were significantly behind at mission PDR in February 2006
- PDR-level peer reviews for mechanical and thermal in May 2006

Orbiter Modular Integration (1)



Orbiter Modular Integration (2)



Test Early: Interface Tests

- We conducted interface tests with each instrument and with most other components as soon as breadboards were available
- We discovered problems at nearly every interface test: reversed polarity signals, timing issues, etc.
- All problems were easy to correct, since the tests were early
- We only experienced one interface problem during Orbiter-level integration (1553 transformer reversed)
- Time saved with interface testing easily exceeded time spent on the tests
- Example: transponder
  - Added scope to contract to implement interface test in July 2007
  - Detector lock and rcvr clock signals swapped, soft reset not implemented, spacecraft software error caused repeated strobing of hardware reset, telemetry database updated, GSE aux command changed to a square wave
  - Integration of flight unit in February 2008 found no issues

Risk Management

- Monthly meetings with each of the subsystem leads provided input to our risk management process
  - One-on-one atmosphere was good for identifying potential issues at the system level
  - Kept the subsystem leads thinking about risk
  - Kept the database up-to-date
- Monthly risk management board meetings provided:
  - Insight to project management
  - Forum for project-level decisions about risks
- The LRO team did not wait for monthly meetings to address critical risks
- Example: propulsion tank NTC issue
- Example: hard drive radiation test failure
- Example: C&DH power converter delayed delivery
  - Built flight spare card with slightly lower quality part
  - Started investigating risk associated with flying this part
  - Bought time while we worked with the vendor to get flight part delivered

Improved Process: Procurements

- The LRO team executed a number of procurements, including:
  - Inertial Measurement Unit
  - Star Trackers
  - Coarse Sun Sensors
  - Transponder
  - Modulator
  - Traveling-Wave Tube Amplifier
  - Solar Array
  - Battery
- We had significant **systems support** for each of these:
  - Ensuring the proper environmental requirements
  - Ensuring good interfaces
- Our **manufacturing engineer** worked with each vendor after selection:
  - Tailor SOW and specifications to use vendor processes as much as possible without sacrificing quality
  - Check preliminary parts list for issues
  - Ensure proper testing was part of the vendor's plans
- Example: Few problems with procured components at time of delivery
- Example: transponder parts issue avoided

Focus on the People

- We solved problems quickly by bringing our full talent to bear
  - Diverse perspectives
  - Minority opinions
- Constant effort to get people to voice their concerns
  - Some people don't want to be a bother
  - Some people don't realize the full impact of their concern
  - Some people don't think their voice will make a difference
- Some people require more effort
  - Maybe their style doesn't match your style
  - Perhaps they have less experience
  - Perhaps they worry too much
  - Or maybe they just think differently
- Example: propulsion trade to solve NTC problem
- Example: coarse sun sensor circuit design issue
  - Small discrepancy bothered engineers performing test
  - Pursued source (with systems support) until flaw was discovered

Decision Making

- There is no fool-proof method to make multi-parameter decisions with high-stakes risks
- LRO's formula:
  - Take input from multiple people (diverse perspectives)
  - Analyze what can be analyzed
  - Pick a path using **engineering judgement**
  - Follow the chosen path unless you hit an obstacle
- We did not spend a lot of time looking for other options if we found one that met schedule, cost, and performance requirements
- Challenges with this approach:
  - Viable solution is not always the "optimal" solution
  - Review teams like to see evidence of careful, exhaustive trade studies, with clear, analytic rationale
- Example: comm system redundancy
- Example: direct orbit insertion
- Examples: reaction wheel board layout issue, Diviner actuator damage
  - Band-aid fix to save schedule or significant delay to implement "clean" fix

Over 50 Issues Between CDR and I&T!

- Nearly every component had some sort of ***unforeseeable*** problem during the build phase, with technical risk-vs.-schedule or subsystem-vs.-subsystem decisions required:
  - C&DH:
    - Assembly issues—rework
    - SBC noise problem—rearrange spacewire ports
    - Power supply parts delays—build extra unit
  - Comm
    - Transponder Software design flaw—change ground stations
    - Transponder Hardware design flaw—replace part, jumpers
    - Modulator assembly problems—bring in-house
    - Modulator performance at cold—modify circuit
    - TWTA design error in ground protection circuit—fly as-is
  - GN&C
    - Wheel board layout problem—redo
    - Star Tracker resets—change part
    - MIMU part failure—replace part

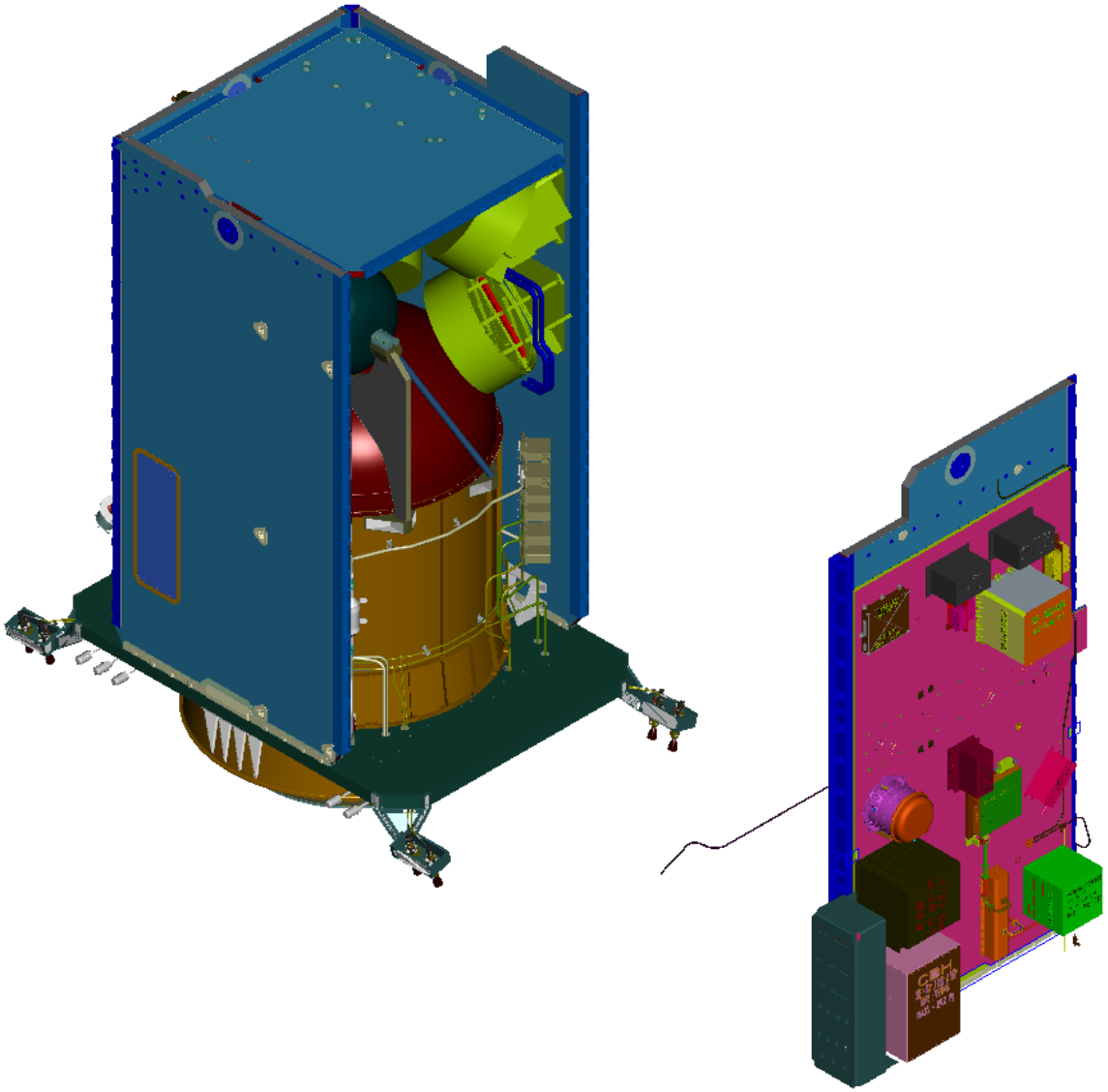
Over 50 Issues (cont.)!

- Nearly every component had some sort of ***unforeseeable*** problem during the build phase, with technical risk-vs.-schedule or subsystem-vs.-subsystem decisions required:
  - Software performance problems—update code
  - Power: PSE frequency shift during vibe—tighten and retest
  - Payloads
    - CRaTER ETU part failure—flight parts OK
    - Diviner actuator damaged during test by long screw—re-work
    - LAMP board damaged by long screw—replace board
    - LEND power surge during thermal vacuum—replace unit (flight spare)
    - LOLA housing corrosion—fly as is
    - LOLA overtest during sine burst—no damage
    - LOLA corona during thermal vacuum—no damage
    - LROC NAC vibration failure—redesign mount for secondary
    - Mini-RF strut failure during thermal vac—redesign strut

Flight Integration Begins, Jan 2008

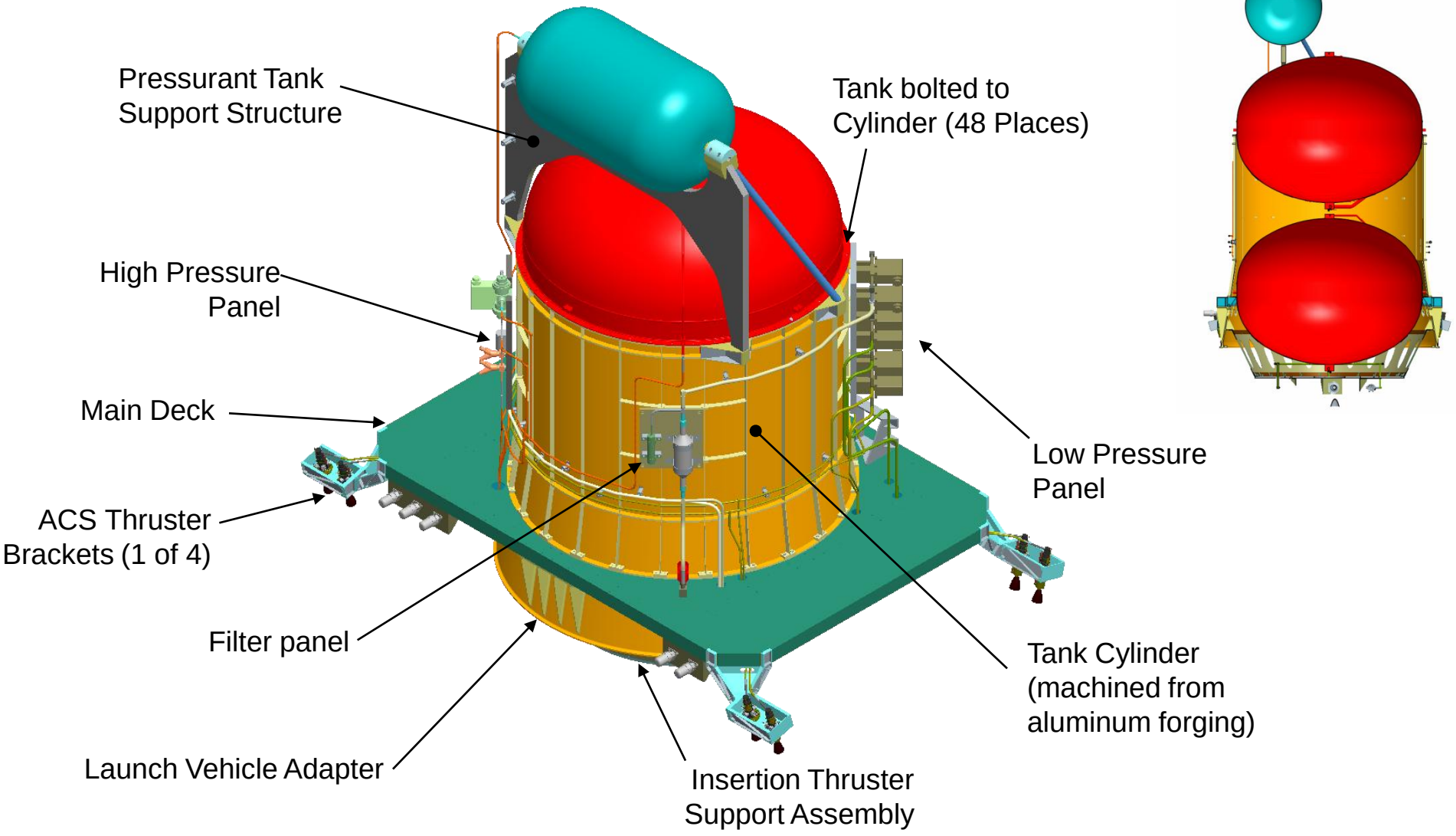
PDE Safe-to-Mate, January 2008

Propulsion Tank and Wheel Locations

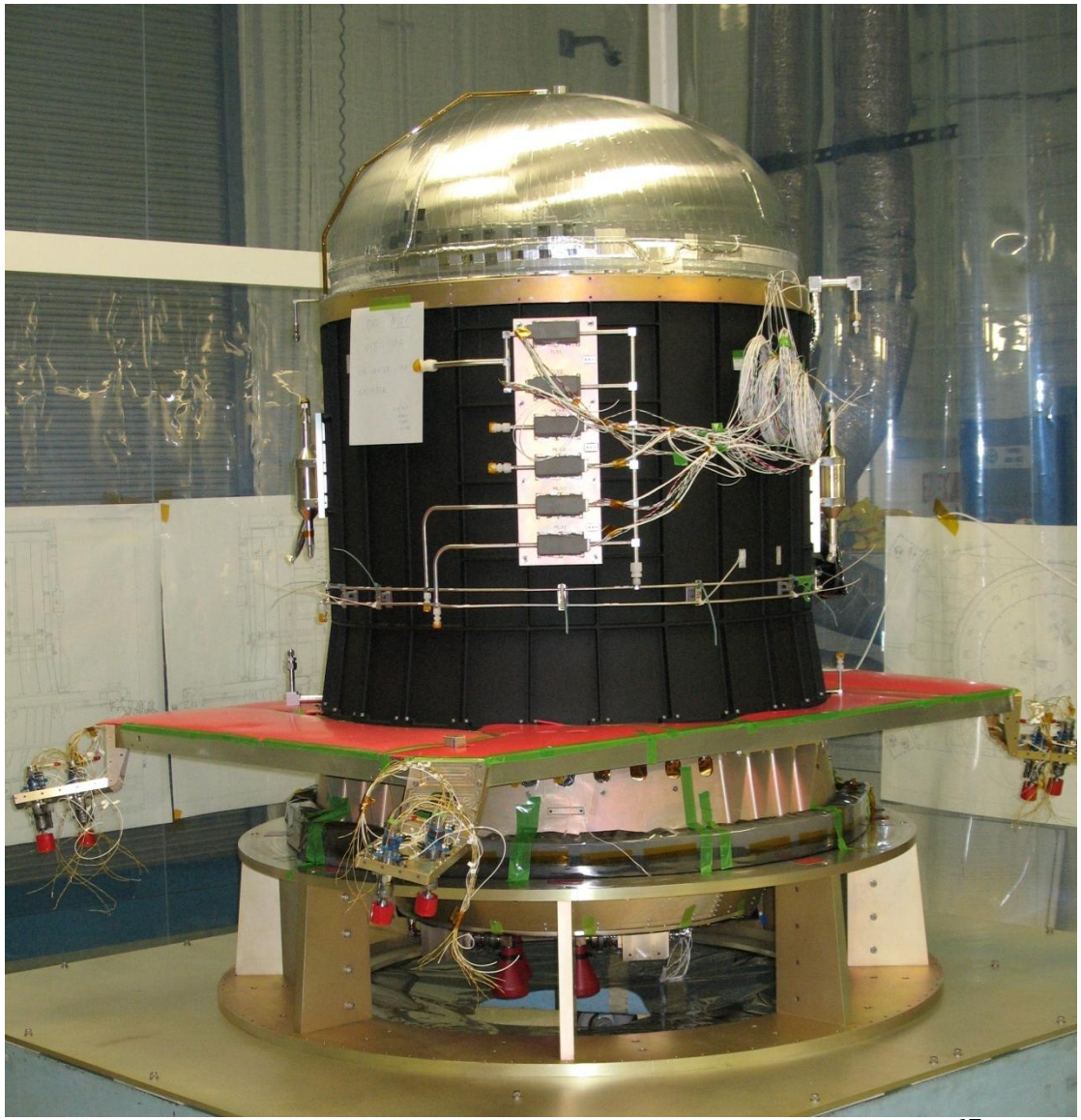


Reaction Wheels, January 2008

LRO Propulsion Module

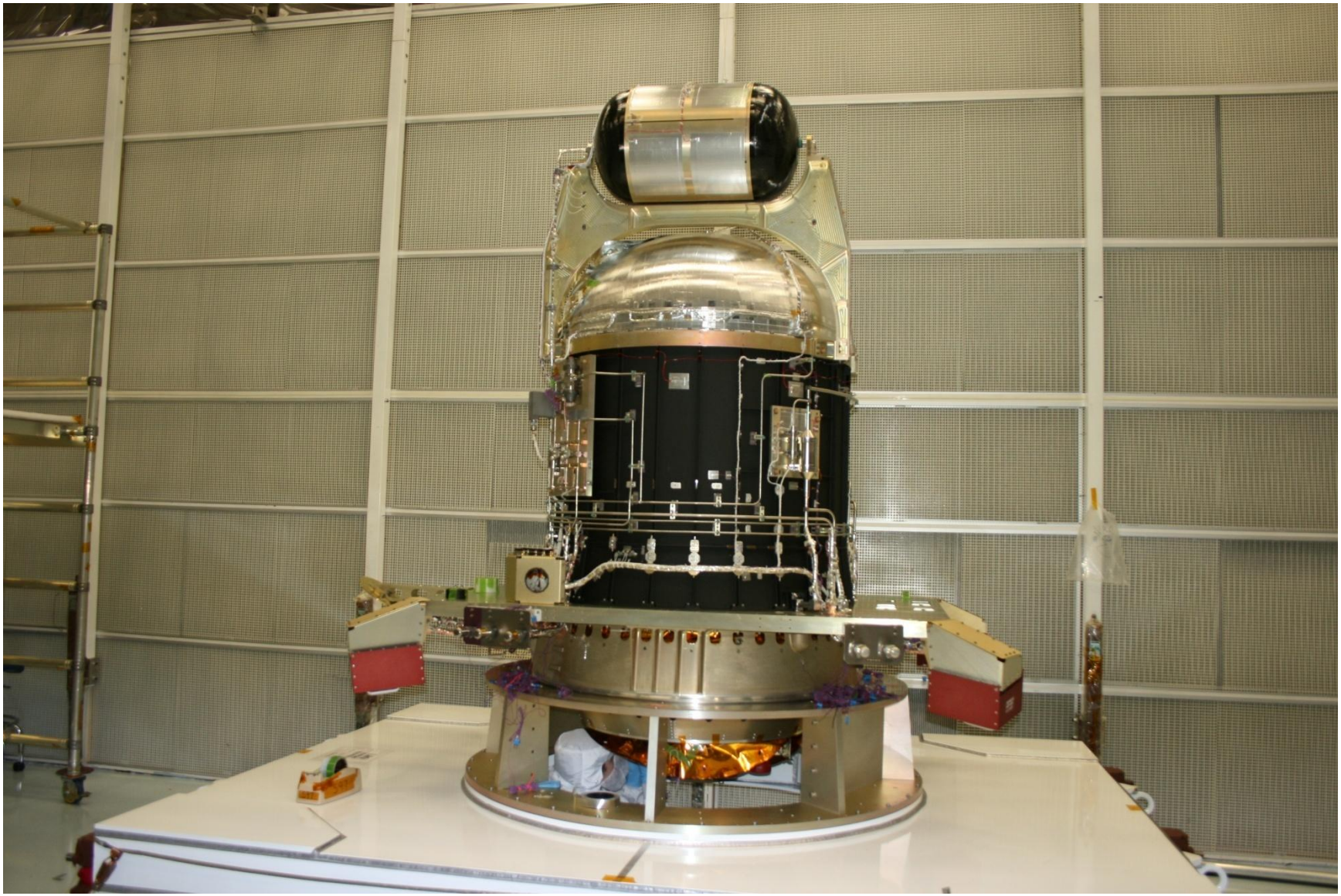


Propulsion Module

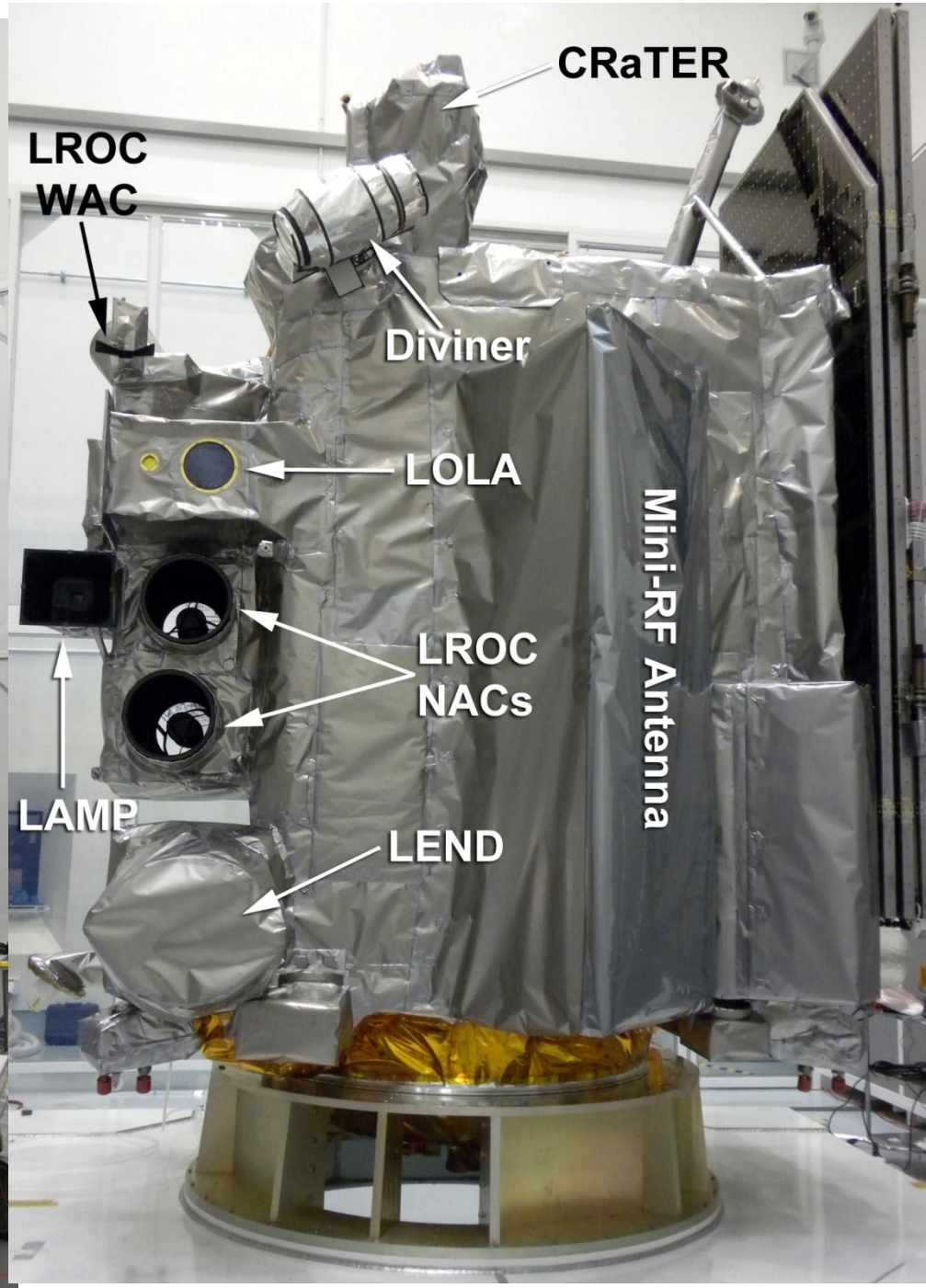


Assembly Team

Propulsion Module, January 2008

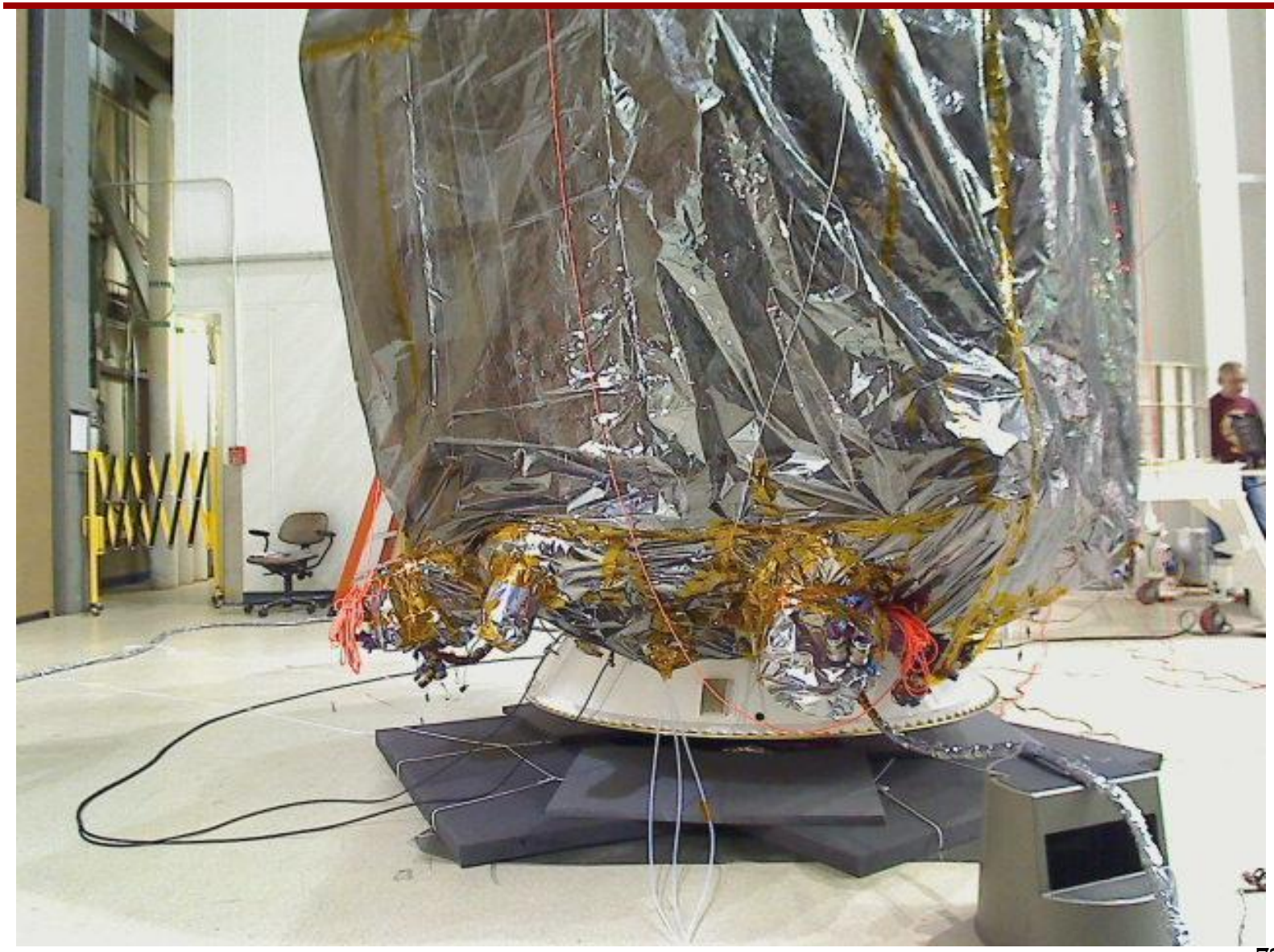


+Y Panel Integration, 3/13/08

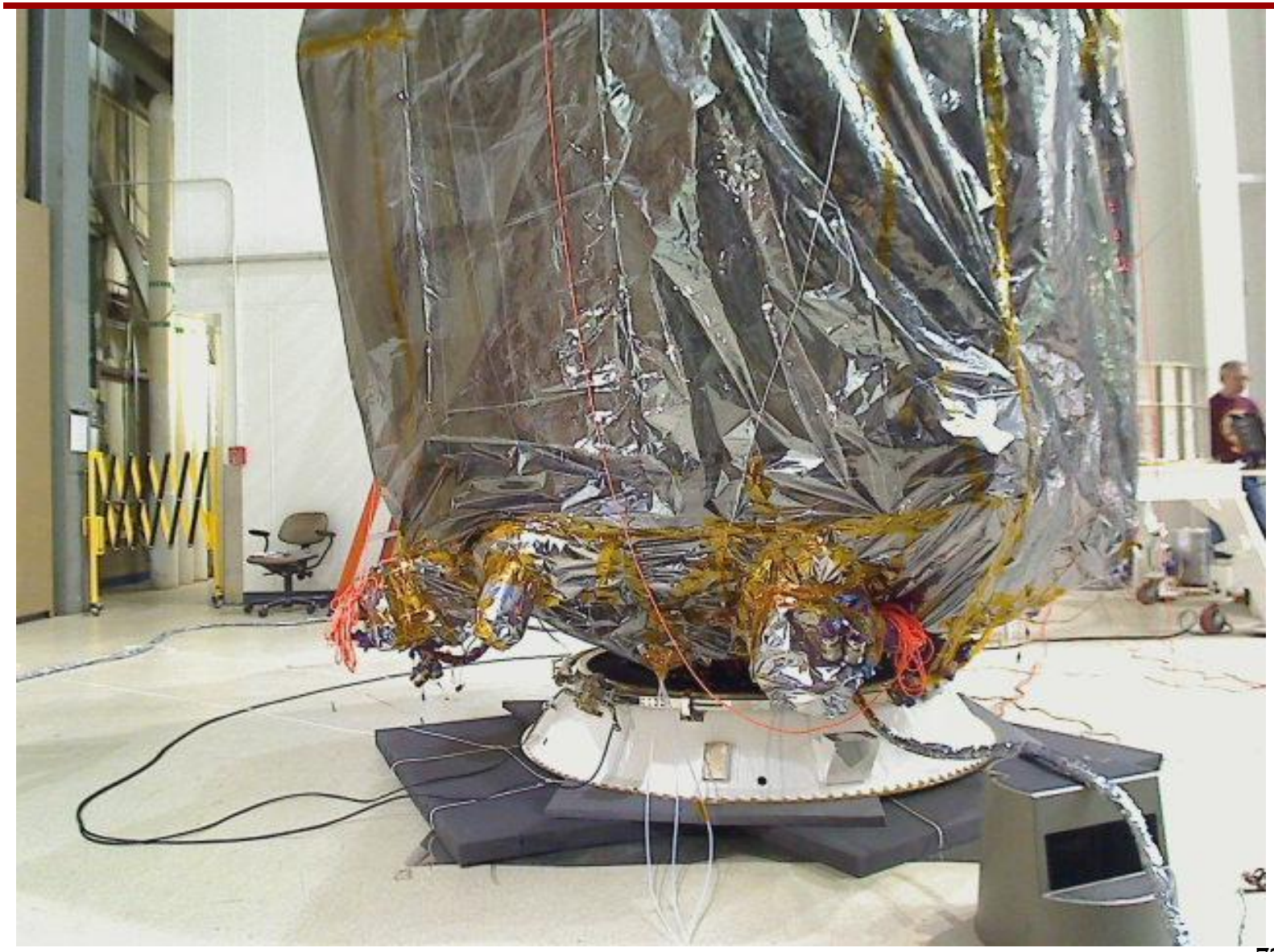

CRaTER
LROC
WAC
Diviner
LOLA
Mini-RF Antenna
LROC
NACs
LAMP
LEND

WS1 Antenna Assembly at White Sands

Shock Test (before)

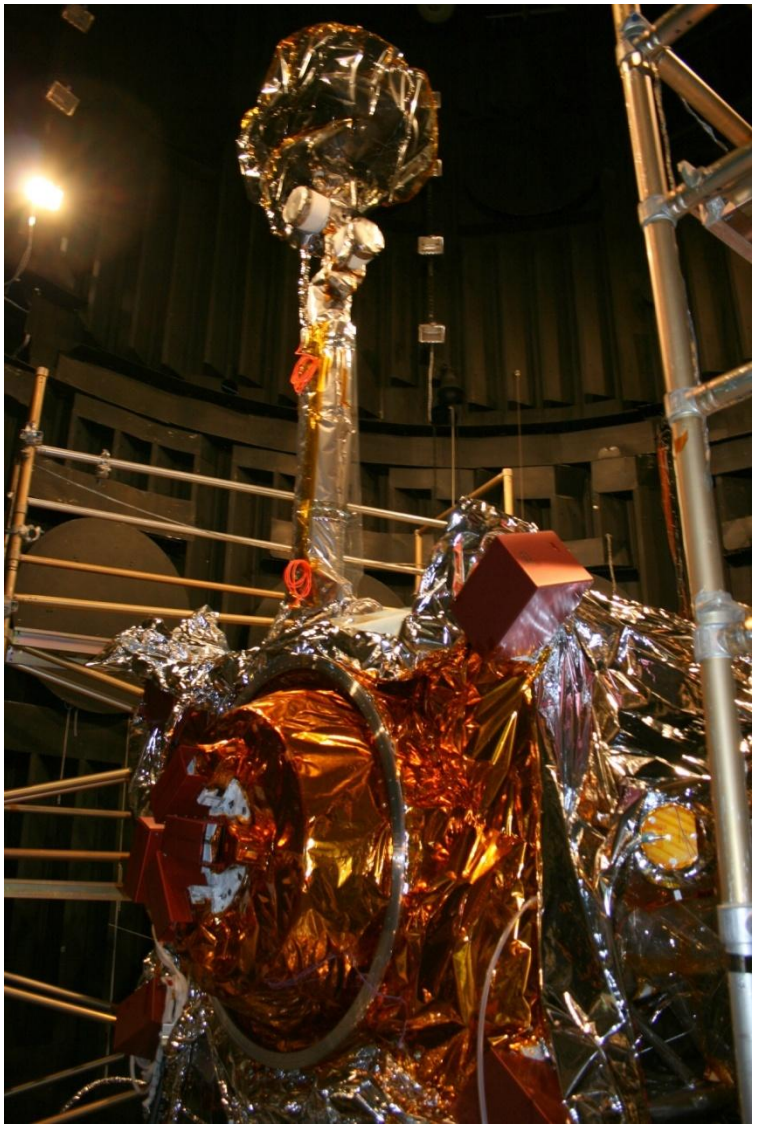


Shock Test (after)



EMI

Thermal Vacuum



Final Preparation for Ship

- Systems and Mission Assurance worked together to ensure clear and complete documentation
- Acceptance Reports for components
  - Pointer to all documentation
  - Signoff by component owner, subsystem lead, and cross-cutting systems (mechanical systems, avionics systems, thermal systems)
- Work Order Authorizations were not closed until:
  - Associated PR's were closed
  - All paperwork was complete and in the database
- Requirements were not considered "verified" until:
  - WOA was closed
  - Reports were in the configuration management system

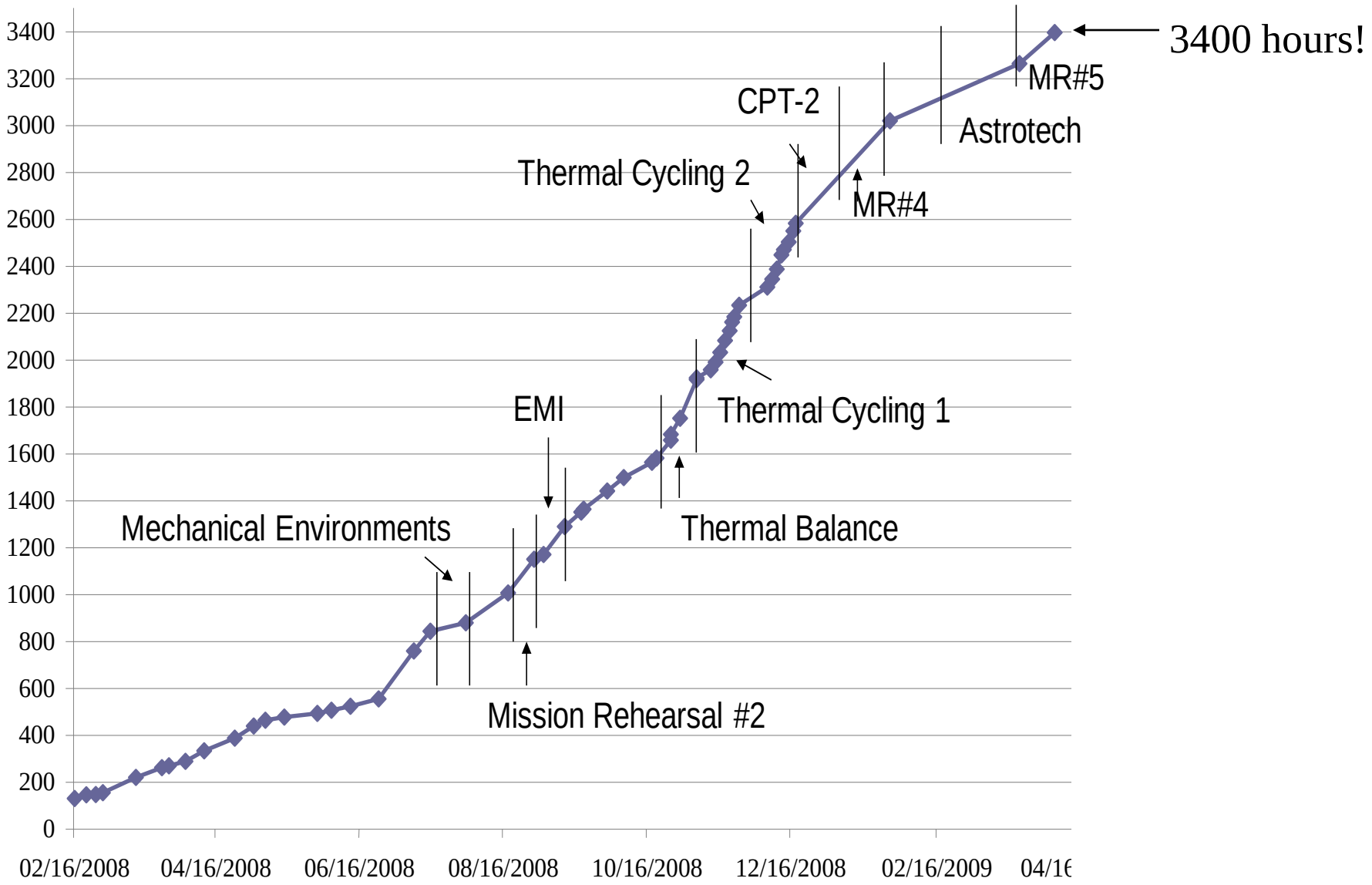
On the Truck

LRO Crew at Astrotech

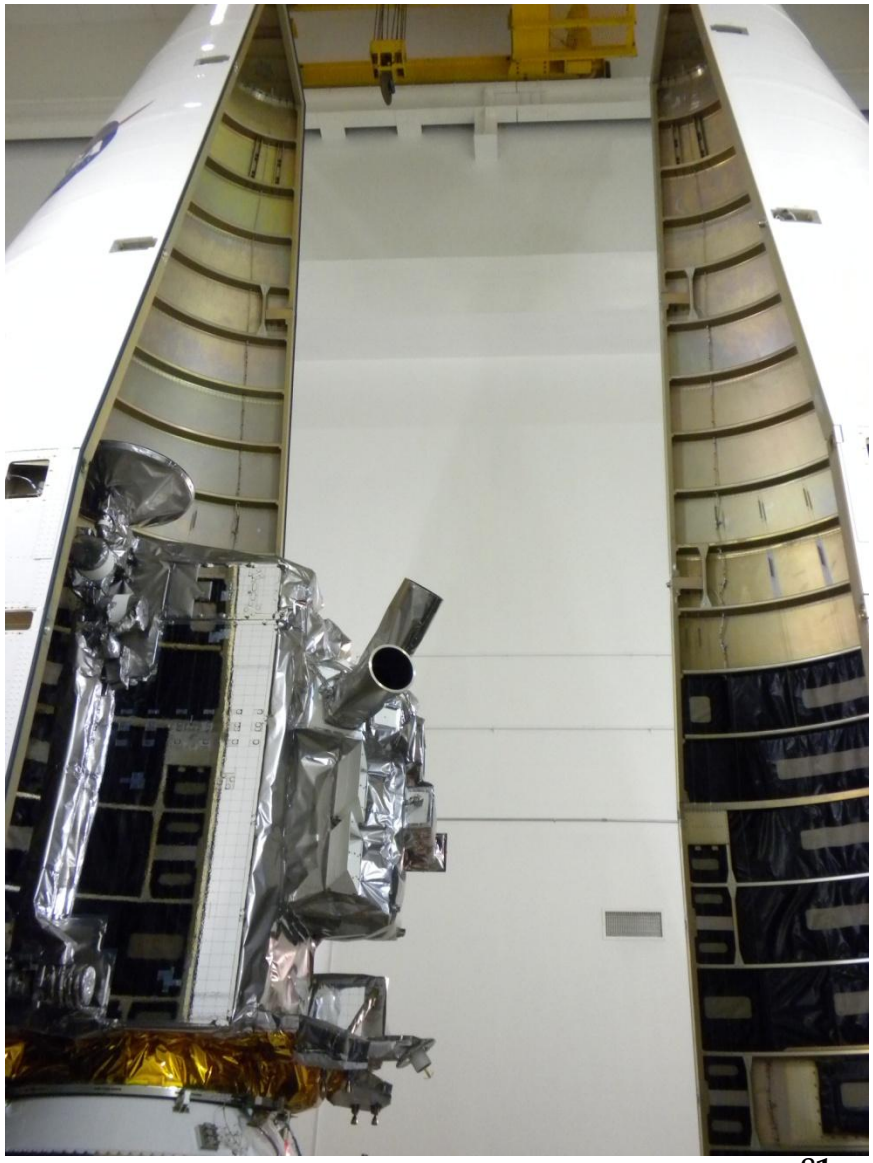
Launch Site Operations

- The end is in sight—don't stumble now!
- Shipped in February 2009 for April launch
- Vehicle issues pushed launch into June
  - Used extra time for additional operations testing
- Extra attention at launch site
  - Upper-level management gets very interested
  - Engineers become hyper-vigilant
- Project loses control of the schedule
  - Launch vehicle and range issues dominate
  - Spacecraft team must stay flexible
- Lots of fun and lots of stress!

Cumulative Orbiter Hours



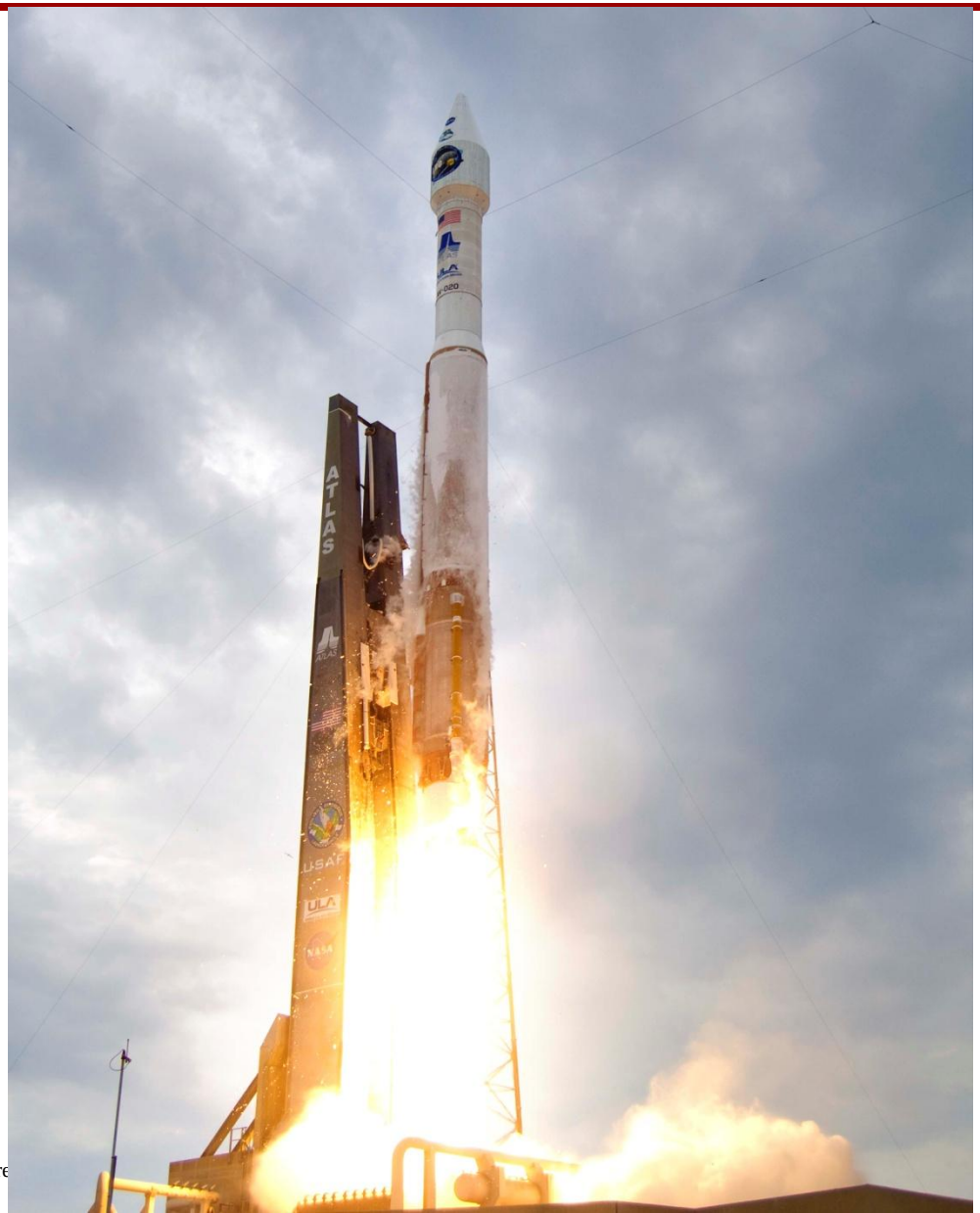
Stacked and Ready for the Fairing



Onto the Rocket!


ATLAS
USAF
NASA

June 18, 2009



Post Launch

- 5 Days to the moon
  - Mid-course correction after 24 hours only 1.3 m/s: great ride from Atlas!
  - Lunar Orbit Insertion on June 23: 555 m/s (40-minute burn)
- Rehearsals paid off with generally smooth operations
- Safehold transitions
  - Early mission due to tight safing limits
  - Early lunar orbit due to unexpected tracker behavior on transition from lunar occultation
  - Couple of operator errors later in the mission
  - Spacecraft took care of itself as designed
- Instrument commissioning took a bit longer than planned
  - We consciously put less attention on this phase pre-launch in order to ensure full readiness in all other areas
- There is much to learn in the first few weeks of the mission; 24/7 staffing is essential

Mistakes

- Expect mistakes!
  - We all make mistakes; the challenge is to avoid the fatal ones
  - Treat mistakes and failures as a normal part of the job—keep things out in the open, clean up, and move on
- Some of our biggest mistakes:
  - Underestimated the system-level complexity of the High-Gain Antenna System and the Solar Array System
    - Interplay of thermal with RF and with actuator electronics
    - Gimbal blankets
    - Resistive losses in solar array cables
  - Failed to anticipate the impact of the change in the center's engineering services contract
    - Major contract change right in the middle of the build phase
    - Created uncertainty, impacted workforce, delayed harness
  - Underestimated some warning signs on overloaded engineers
    - High performers don't always take a break when they should, and sometimes take on more than they can handle
    - Extended schedule created extra stress—working hard for longer than expected
    - Impacted efficiency rather than integrity of the system

Failures and Flaws

- Coarse Sun Sensor interface circuit—wrong resistance
  - Found during ACS testing before environmental testing
  - Removed C&DH and replaced resistors
- Solar array gimbal power dissipation—14x higher than planned in thermal design
  - Found during thermal balance testing
  - Added radiator and removed blankets
- LEND high voltage arcing—damaged detectors
  - Found during thermal vacuum testing
  - Replaced instrument with flight spare after final Orbiter CPT
  - Further issues on one detector after operating for 5 months in space—instrument still meeting performance requirements
- LOLA blanket too tight—causing alignment issues
  - Found shortly after instrument activation
  - Only impacts some measurements over cold surfaces—instrument still achieving objectives

Observations and Lessons Learned

Observations on motivation (inspired by Daniel Pink):

- Autonomy
  - Team members at all levels were invited to promote their best ideas in support of the mission as a whole—ownership of solutions
  - Systems engineering held the big picture view, facilitated communication, documented design decisions, verified system-level performance
  - Team members understood their control over mission success and were, therefore, motivated to excel
- Mastery
  - We challenged our experts in a constructive way
    - Used basic physics, expected explanations in those terms
    - Encouraged a discipline lead to represent their own perspective, but with an eye to the system impact
  - We expected ownership and probing inquiry of anomalies and design issues
- Purpose
  - Headed to the moon, paving the way for the new exploration
  - We tried to make sure everyone realized the criticality of every piece of the system
  - We held regular get-togethers and we celebrated our victories along the way, encouraging a sense of team

Observations and Lessons Learned

- Don’t be afraid to point out to stakeholders decisions that can be made to relieve your problems (launch vehicle example)
- Programmatic constraints affect the development:
  - Tight schedules force decisions
  - Tight budget approaching confirmation forces optimization
  - Extra money after CDR can save schedule and probably save money in the long run
- Even if the schedule is tight, make sound technical choices (remember the fortune cookie)

Observations and Lessons (cont.)

- Interface tests save money in the long run—test early and often
- Plan early for parallel development and assembly
- Decouple delivery events so that integration can move forward even if one item is late
- Systems engineering is all about the team
  - Success depends on the performance of the entire team
  - Some people on the team will require more effort, but the extra effort is required to get different perspectives
  - Watch for overloading, especially in those requiring little effort, and definitely in yourself
  - Be flexible and optimistic

Credits

LRO Credits compilied by David Everett, 9/22/09

Project Office

Craig Tooley	Project Manager	GSFC code 451
Cathy Peddie	Deputy Project Manager	GSFC code 451
Bill Sluder	Deputy Project Mgr/Resources	GSFC code 451
Keith Opperhauser	Project Support Mgr	GSFC code 451
Deanna Adamczyk	Financial Manager	GSFC code 451
Tricia Gregory	Admin/Project Support	
Julie Janus	Contracting Officer	
Amy Aqueche	Contract Specialist	
Jim Smith	Mission Business Mgr	
Mary Bernhard	General Business (-2007)	
Vanessa Hernandez-Martinez	Resource Analyst	
Linnette Morales	Resource Analyst	
Bob Hesenperger	EVM	
Andy Eaker	Scheduling Lead	
Marty Campbell	Scheduling	
Debbie Dusterwald	CM/DM Manager	
Dorothy Hall	CM/DM	
Warren Shultzaberger	CM/DM	
Angela Hess	MIS	
Jen Brill	MIS	
Kristina Safdie	Risk Management (2006-present)	
Adrian Rad	Risk Management (2004-2006)	
LaShonda Jacobs-Terry	Procurement (CSS, Star Tracker)	

GSFC Science Team

Rich Vondrak	Project Scientist (2008)	GSFC code 690
Gordon Chin	Project Scientist (2004-2007)	GSFC code 693
Tom Morgan	Project Scientist (2007)	NASA HQ
John Keller	Deputy Project Scientist	GSFC code 691

Payload Team

Arlin Bartels	Payload Systems Manager	
Mary Reden	Payload Systems Engr	
Joe Cerullo	Payload Systems Engr	
Stan Scott	Science Data Mgmt	

Systems Engineering Team

Dave Everett	Mission Systems Engineer	GSFC code 599
Martin Houghton	Deputy MSE, Mission Design	GSFC code 599
Rick Saylor	Deputy MSE, I&T	Honeywell
Phil Luers	Avionics Systems	GSFC code 561
Tom Ajluni	Spacecraft Bus & LV Systems	ATK
Steve Andrews	Safing Engineer, HGAS Systems Lead	GSFC code 599
Mark Beckman	Flight Dynamics	GSFC code 595
Rivers Lamb	Flight Dynamics	GSFC code 595
Leslie Hartz	Systems Analysis	GSFC code 599
Eric Holmes	GN&C Systems	GSFC code 591
Mike Pryzby	Orbiter Systems	ATK
Steve Wasserzug	Mechanical/Thermal Systems	ATK
Charlie Wildermann	SW/HW Systems	GSFC code 580
Joe Novotka	Electrical Systems, EMI/EMC	QSS
Judy Brannen	Requirements Database Manager	Constellation Software Engineering
Tom Jones	Launch Vehicle Mgr	GSFC code 429

EEE Parts Team

Rich Williams	EEE Parts Lead	GSFC code 562
Chris Greenwell	EEE Parts Support	QSS
Bruno Munoz	EEE Parts Support	Ball Aerospace and Technologies Corporation
Maxine Windhausen	LRO Parts Storage & Procurement	MEI Technologies
Henning Leidecker	EEE Parts Expert Consultant	GSFC code 562

Contamination Control

Chris Lorentson	Contamination Control Lead	GSFC code 546
Rachel Rivera	Contamination Engineering	GSFC code 546
Joe Hammerbacher	Contamination I&T	SGT
Glenn Rosecrans	Contamination Analyst	SGT
Patsy Dickens	Contamination support and Documentation	SGT
Marcello Rodriguez	Purge Systems and contamination support	GSFC code 546
Alfred Wong	Cleanroom Support Systems	SGT
Leon Bailey	Contamination Control Technician	ManTech
Karrie Houston	Contamination Engineering	GSFC code 546

I&T Team

Joanne Baker	Orbiter I&T Lead	GSFC code 568
Mike Wright	Deputy I&T Manager	GSFC code 568
Kevin Blahut	GSE Systems Engineer	ATK
Harold "Rex" Richardson	I&T Engineer	ATK
Massoud Ainloo	Senior Test Engineer	MEI
Joshua Grodin	I&T Engineer	MEI
Gary Lepore	I&T Engineer	MEI
Marsha Shanahan	FlatSat Manager	MEI
Carroll Trickey	Senior Electrical Technician	OSC
Patrick Kilroy	I&T Engineer	GSFC Code 568
George Moore	I&T Engineer	GSFC Code 568
Greg Greer	ITOS Lead Engineer	Hammers
Warren Thompson	Front End Processor Developer	Hammers
Michael Smit	Spacecraft Simulator Developer	Hammers
Matt Lew	Spacecraft Simulator Developer	Hammers
Karen Calvert	ITOS Developer	Hammers

Matilda Ewancio	Electrical Technician	OSC
Brenda Wallace	Electrical Technician	SGT
Deneen Ferro	Electrical Technician	SGT
Kim Cousler	Environmental Project Engineer	GSFC Code 549
Janet Thomas	Environmental Project Engineer	GSFC Code 549
EMI Testing Laboratory at GSFC		
Mark Branch	EMC Environmental Test Engineer	GSFC Code 549
Vaughn Nelson		
Rick Jones		
Robert Houle		
Nathan Block		
Greg Jamroz		
Andrew Mentges		
Vibration Test Group		
Timothy Schwartz	Vibroacoustic Environmental Test Engineer	GSFC Code 549
Thermal Vac test Group		
Ana-Mellina Espiritu	Thermal Vacuum Environmental Test Engineer	GSFC Code 549
Optical Alignment Team		
Henry Sampler	Optical Alignment Lead	code 551
Dr. Samuel Hetherington	Optics Support Engineer	code 551
Carlos Aviado	Optics Support Engineer	Analex
James Gill	Optics Support Engineer	Analex
Nicholas Spartana	Optics Support Technician	Analex
Dean Osgood	Optics Support Technician	Analex

Safety and Mission Assurance Team

Ron Kolecki	System Assurance Mgr (SAM)
Lydia Lee	Deputy SAM
Jana Rezac	Safety Lead
Chuck Peterson	Safety
Cindy Taylor	Software Quality Engineer
Nick Virmani	Manufacturing Engineer
Al Lacks	Quality Assurance
Joe Calabrese	Quality Assurance

Mechanical Team

Giulio Rosanova	Mechanical System Lead Engineer	543
Pilar Joy	Material Engineer	541
Craig Stevens	Lead Structural Analysis	542
Jeff Pattison	Acoustic Analyst	542
Wayne Chen	SB, IM Structural Analyst	542
Darian Robbins	Mechanical GSE Lead Engineer	543
Gordon Casto	SB, IM Structure Lead Engineer	543
Greg Martins	HGAS Lead Engineer	543
Jason Hair	HGAS Engineering Support	543
Karl Schuler	Senior Technician	543
Larry Madison	Composite Support Engineer	543
Rene Carlos	Coupon Test Engineer	543
Steve Patton	Lead Technician	543
Katheryn Vasquez	MGSE Lead	543
Joe Schepis	Gimbals Lead Engineer	544
Kamal Thakore	GCE Lead Engineer	544
Boris Chernyakov	GCE Support Engineer	ATK
Nick Shurr	Gimbal Engineering Support	544
Charlie English	Technician	547
Chris Kolos	Technician	547
Dave Dollard	Shop Planner	547
Frank Rondeau	Technician	547
Mike Schoolman	Technician	547
Ron Walters	Technician	547
Tim Schwartz	Test Engineer	549
Nick Galassi	Senior Analyst	Aerostress
Bryan Rizzo	SAS Structural Analyst	ATK
Ed Dobins	Designer (MGSE)	ATK
George Mooney	Technician	ATK
Ginger Bronke	Designer (IM)	ATK
Greg Davis	Designer Mass Simulators	ATK
Hal Baesch	Technician (Detailed to PROP Group)	ATK
Heather Borowski	IM Structural Analyst	ATK

Jimmy Lee	QA Mechanical	ATK
Joe Green	Designer (SAS)	ATK
John Harvey	Designer HGAS MGSE	ATK
Ken Pellak	Designer (MGSE)	ATK
Mike Golob	MGSE Engineering Support	ATK
Mike Hersh	SAS Lead Engineer	ATK
Paul Baird	Loads Analyst	ATK
Pete Patterson	MGSE Analyst	ATK
Rodney Deensie	Analyst	ATK
Shelly Conkey	HGAS Structural Analyst	ATK
Steve Wasserzug	PM Lead Engineer	ATK
Suk Yoon	Senior Designer (HGAS)	ATK
Kurt Wolko	Designer (Detailed to PROP Group)	Chesapeake
Chris Ross	PM Designer	ManTech
Dan Hayward	Lead Designer (PM)	ManTech
Jim Baker	Facilitator	ManTech
Glen Byron	HGAS Support	SGT
Justin Ward	SAS Engineer	SGT
Kevin Nims	Analyst	SGT
Lisa.Mryncza	CM Drawings Administrator	SGT
Monique Fetzer	ITP/RAD Lead Engineer	SGT
Nereses Armani	Designer (SB)	SGT
Phil Kurilchik	Designer	SGT
Sandy Shuman	Designer	SGT
Cecilia Chow	Analyst/Dynamics	SGT
Rick Baird	MGSE Designer	SGT
Wasam Aboufasha	SB Analyst	SGT
Brian Kittle	Technician	OSC
Tony Sanders	AM Analyst	Vantage

Thermal System

Charles Baker	LRO Thermal Systems Lead
Christine Cottingham	LRO Thermal Hardware Lead
Sharon Peabody	LRO Thermal Analysis Lead
Matt Garrison	LRO Thermal Instrument Lead
Tony Melak	LRO Thermal High Gain and Solar Array Lead
Jeff Maynard	LRO Thermal High Gain and Solar Array Analyst
Dan Powers	LRO Thermal Analyst
Juan Rodrigues	LRO Thermal Analyst
Bill Chang	LRO Thermal Analyst
Wes Ousley	LRO Thermal Consultant
Walter Ancarrow	LRO Thermal Analyst
Diane Schuster	LRO Hardware Technician
Doug Varney	LRO Hardware Technician
Rosalyn Nelson	LRO MLI Technician
Shirley Adams	LRO MLI Technician
Brenda Estavia	LRO MLI Technician
Hume Peabody	LRO Thermal Analyst
Jesse Arminger	LRO Thermal Analyst
Markham Hacke	ITP Project Manager
Elizabeth Oey	Avionics Radiator Project Manager
Sargon Addi	Avionics Radiator Quality Assurance
Mellina Espirito	Thermal Test Manager
Chris Skocik	Thermal Test Fixture Designer
Sherrod Ware	Thermal Test Fixture Technician
Grace Miller	LRO Thermal Coating Technician
George Harris	LRO Thermal Coating Technician
John Petro	LRO Thermal Coating Technician

Mary Jane Stevenson	LRO Thermal Coating Manager
Wanda Peters	LRO Thermal Coating Manager
Jack Triolo	LRO Thermal Coating Consultant
Marcello Rodrigues	LRO Thermal Coating Engineer
Jay Chung	Kapton Film Heater Manufacturer
George Davis	Mechanical Thermostat Engineer
Doug Brown	Mechanical Thermostat Manager
Warren Chen	Heat Pipe Production Manager
Meshack Aduwu	ITP and Avionics Radiator Heat Pipe Lead
Michael Deiuliis	RWA and Battery Heat Pipe Lead
Mario Martins	Lead Test Technician

Power System

Tom Spitzer	Power System Lead
Dong Sui	Power GSE Lead

Power System--PSE

Amri Hernandez-Pellerano	PSE Lead Engineer
Brad Kercheval	PSE Design Engineer
Greg Alkire	PSE Master Controller FPGA Design Engineer
Robert Stone	PSE Slave FPGA & PMC Design Engineer
Jeff Travis	PSE PMC Design & FPGA Test Engineer
Syed Ameen	PSE Hardware Command FPGA Design Engineer
Mehul Patel	PSE Test Conductor
Federico Sanidad	PSE Test Conductor
John Washington	GSE Technician
Tom Rozanski	GSE Technician

Power System--Battery

David Jung	LRO Lead Battery Engineer
Gopal Rao	Staff Engineer
David Sullivan	LRO Battery Test Engineer
Tom Rozanski	Battery Lab Manager

ABSL Team

Raz Sawar	ABSL LRO Project Manager
Dave Curzon	ABSL LRO Project Manager (formerly)
Rod Ng	ABSL LRO Technical Lead
Andy McNamara	ABSL Mechanical/Thermal Engineer
Ralph Ball	ABSL QA Engineer

Power System--Solar Array

John Lyons	Solar Array Lead

Emcore Engineering and Management:

David Danzilio	GM/VP
Navid Fatemi	Program Director
Brad Clevenger	Director of Operations
Pat Coil	Director of Contracts
Mary Beth Chumney	Proposal mgr.
Kip Dodge	LRO Program Manager
Jeff Hillseth	Mfg. Director
Vivien Bercier	Mfg. Engineering Manager
Jody Wood	Engineering Manager
Jimmy Pappan	LRO Panel Engineer
John Crisman	QA Mgr.
Robert Young	QA
Karen Fellner	QA
Eric Lochausen	Parts and Materials
Teri King	Procurement
Kay Naranjo	Accounting Mgmt
Cheryl Anderson	Accounting
Don Wichhart	Accounting

Rick Bishop	Production
Scott Wilkinson	Cost Accounting
Eric Downard	Cell Production
Stephanie Baer	Configuration Mgmt
Drew Flores	Production Support
Jill Courtney	Shipping
Richard Coatney	Production Supervisor
Thomas Angon	Receiving
Kevin Malone	Accounting
Art Chevez	Test Panel Engineering
Robert Gallegos	Test/CIC
Andy Anders	Test Panel Engineering

Emcore Manufacturing

Alfred Gutierrez	Panel Area Manufacuring
Angelica Trujillo	Panel Area Manufacuring
Dalena Trinh	Panel Area Manufacuring
David Zier	Panel Area Manufacuring
Estuardo Marroquin	Panel Area Manufacuring
Lan Dao	Panel Area Manufacuring
Maria Luisa Verdejo	Panel Area Manufacuring
Meliane Nettles	Panel Area Manufacuring
Rene Lacad	Panel Area Manufacuring
Rick Manzanares	Panel Area Manufacuring
Samuel Watson	Panel Area Manufacuring
Mile Hicks	CIC Area Manufacturing
Gloria Kurkowski	CIC Area Manufacturing
Mai Vuong	CIC Area Manufacturing
Carmen Ceniceros	CIC Area Manufacturing
Ha Nguyen	CIC Area Manufacturing
Pamela Richardson	CIC Area Manufacturing

Fermin Rodriguez	CIC Area Manufacturing
Marianne Trinh	CIC Area Manufacturing
Ashly Donaldson	CIC Area Manufacturing
Lilibeth Manzon	CIC Area Manufacturing
Emelina Marroquin	CIC Area Manufacturing
Deanene Gonzales	CIC Area Manufacturing
Amy Saiz	CIC Area Manufacturing

National Technical Systems (NTS)—Thermal Vacuum Testing

Primary Crew

Acoustic

Jori Czajkowski	Technician
Edward Nelsen	Engineer

Thermal Vacuum

Philip Carr	Program Manager/Engineer
Eric Kogen	Technician

Secondary Crew

Mark Kawai	Technician
James King	Technician
Chris Marin	Technician
Mike Rudy	Technician

Support Personnel

Victor Alfano	Sales
Kent Burgdorfer	Instrumentation Technician
Damian Castello	Fluids Technician
Kelly Delia	Program Coordinator
Ron Foster	Shipping/Receiving Manager

Troy Haag	Maintenance Manager
Jerry Hatley	Electrician
Marie Jensen	Shipping/Receiving
Judy Jones	Quality Control
Larry Jones	Fluids Technician
Sergey Klochko	Instrumentation Engineer
Erik Knowles	Fluids Manager
Tim Kogen	Instrumentation Technician
Marco Macias	Maintenance Technician
Russell Presswood	Machine Shop Manager
Janice Saari	Quality Assurance Manager
Juan Sanchez	Fluids Technician
Randy Shaw	Environmental Manager
Mike Springer	Programs Manager
Gary Thompson	Sales

Exceptional Suppliers

Roger Green	Exclusive Welding

Applied Technology Associates (ATA)—Hot Box Design and Construction

Tony Tenorio
Steve Dolbey
Dennis Smith
Charlene Bausinger
Troy Jensen
Larry Martell
Jeff Stein
Shatona Martin

QIOPTIQ Space Technology (Cover Glass)

John Martin

Propulsion System

Chuck Zakrzwski	Propulsion Lead	
under construction		

Attitude Control System

Jim Simpson	ACS Lead Engineer	GSFC code 591

ACS Hardware Team

Ken McCaughey	ACS Hardware Lead	GSFC code 596
Laurie Easter	Technician	GSFC code 596
Steve Scruggs	Technician	GSFC code 596
Joe Roman	Technician	GSFC code 596
Tracy Price	Technician	Orbital
Rani Lavu	Technician	Orbital
Millie Ewancio	Technician	Orbital
Inpong Sivilay	Technician	Orbital
Carol Zepp	Technician	Orbital
Nat Gill	PDE and RW FPGA	GSFC code 566
Jeff Keck	FPGA Support	Northrop Grumman
Eric Bentley	Mechanical Drafting	Swales Aerospace

Reaction Wheel Team

Russ Roder	RW Lead and Mechanical Engineer	GSFC code 596
John Wilson	RW Electrical Engineer	GSFC code 596
Joe Vitale	RW Software	GSFC code 596
Mary Kerbe	RW PWB Layout	Orbital Sciences Corporation
Fred Manage	RW and PDE PWB Checking	Orbital Sciences Corporation
Tom Miccolis	RW Parts Engineer	Orbital Sciences Corporation
Bob Read	RW Support Task	Orbital Sciences Corporation

PDE Team

Jason Badgley	PDE Lead Engineer	GSFC code 596
Noble Jones	PDE Mechanical Engr	GSFC code 596
Tom Gibboney	PDE and GDS Support Task	Orbital Sciences Corporation
Allan Hoffman	PDE Module PWB Layout	Orbital Sciences Corporation
Amanda Virts	PDE Inhibit Unit PWB Layout	Orbital Sciences Corporation

Star Tracker Team

Noble Jones	Star Tracker COTR	GSFC code 596
Roberto Casini	Program Manager	Galileo Avionica
Stefano Lorenzini		Galileo Avionica
Dorico Procopio		Galileo Avionica
Massimo Materassi		Galileo Avionica
Giuseppe Borghi		Galileo Avionica
Anna Fabri		Galileo Avionica
Simone Becucci		Galileo Avionica
Andrea Landi		Galileo Avionica
Davide Fiorini		Galileo Avionica
Marco Picchi		Galileo Avionica
Moreno Stagi		Galileo Avionica

Miniature Inertial Measurement Unit Team

Ed Davis	MIMU COTR	GSFC code 596
Reginald Sherman	Technical Director	Honeywell International
Paul Brueggeman	Technical Director	Honeywell International
Jim Akins	Technical Director	Honeywell International
Marion Rowe	Program Manager	Honeywell International
Jon Lawler	Contract Management	Honeywell International
Kevin Toliver	Product Assurance	Honeywell International
Joe Protola	Systems Analysis	Honeywell International
Jeff Young	Technical Director	Honeywell International

Coarse Sun Sensor Team

Kristen Brown	CSS COTR	GSFC code 596
Dwight Barefoot	Program Director	Adcole Corporation
Mike Kagan	Electrical Engineer	Adcole Corporation
Kevin Lucciarini	Quality Assurance Engineer	Adcole Corporation
Jim Mirotta	Manager, Reliability and Quality Assurance	Adcole Corporation

ACS Design and Analysis

Joseph Garrick	Lead Analyst	GSFC code 595
Oscar Hsu	RW Sizing, Delta V and Delta H Modes	GSFC code 595
Phil Calhoun	Attitude Kalman Filter	GSFC code 595
Neerav Shah	Analyst	GSFC code 595
Roger Chen	Sun Safe Modes	R&D Research
Gerardo Ortiz-Cruz	Cooperative Education Student	GSFC code 595
Neal Patel	Cooperative Education Student	GSFC code 591
Alice Liu	Jitter Analysis	GSFC code 591
Carl Blaurock	Analysis	Nightsky Systems

GSFC Dynamic Simulator

George Heisey	GDS Project Lead	Northrop Grumman
Stephen Leake	GDS Software Lead	GSFC code 582
Juan Raymond	GDS Systems Support	
Tom Correll	GDS PMRD Card	GSFC code 596
Agbontaen Imasuen	GDS Hardware	GSFC code 596
Wattana Kem	GDS Hardware	
Namrita Owens	GDS Hardware	GSFC code 564
Brad Smith	GDS Cards	Orbital Sciences Corporation
Rob Thompson	GDS Assembly	
Laurie Easter	GDS Assembly	
Jim Rawlings	GDS Assembly	
Karin Blank	GDS Software	GSFC code 586
Kevin D Fisher	GDS Software	
Victor W. Lu	GDS Software	Emergent Aerospace
Linh Nguyen	GDS Software	GSFC code 596

PDE and RW Off-Site Teammates - Orbital Sciences Corporation

Karim Iman	Orbital
Tom Gibboney	Orbital
Bob Read	Orbital
Victor Evans	Orbital
Tom Miccolis	Orbital
Peter Koump	Orbital
Bill Seidell	Orbital

Tracy Price	Orbital
Carrol Zepp	Orbital
Milly E.	Orbital
Mary Kerbe	Orbital
Ed Naimaster	Orbital
Amanda Virts	Orbital
Allan Hoffman	Orbital
Steven Heishman	Orbital
Fred Manage	Orbital
Robert Demme	Orbital
Daryl Dillow	Orbital
Anderson Chun	Orbital
Ron Johnson	Orbital
Laura Cook	Orbital
Shirely Jones	Orbital
Glenn Luckett	Orbital
Peggy McCviker	Orbital
Vandell Roseman	Orbital

Printed Wiring Board Manufacturer

Coretec Denver, INC

Laser Ranging

Investigation

Dr. Maria T. Zuber	LOLA Deputy Principal Investigator
Dr. David E. Smith	LOLA Principal Investigator
Dr. Gregory A Neumann	LOLA Co-Investigator
Dr. Frank G. Lemoine	LOLA Co-Investigator
Mark H. Torrence	Science Analysis Support
David R. Rowlands	Science Analysis Support

Management / Systems Engineering

Ron Zellar	Laser Ranging Team Lead
Dr. Xiaoli Sun	System Scientist
Keith Cleveland	LOLA / LRO Quality Assurance Engineer

Peer Review Panel

Jay Smith	Peer Review Panel Chair
Don Cornwell	Peer Review Panel Member
Dr. Barry Coyle	Peer Review Panel Member
Dr. John Degnan	Peer Review Panel Member
Greg Ellman	Peer Review Panel Member
Dr. Tony Martino	Peer Review Panel Member
Eric Mentzell	Peer Review Panel Member
Ted Michalek	Peer Review Panel Member
Armando Morell	Peer Review Panel Member
Dr. Michael Pearlman	Peer Review Panel Member

Optics

Luis Ramos-Izquierdo	Optical Systems Lead
Joe Connelly	Optical Engineer
Scott Stan	Optical Engineer

Fiber Optics

Mark Flanegan	Fiber Optics Lead Engineer
Richard Chuska	EO Test and Manufacturing Engineer
Frank LaRocca	EO Testing Engineer
Shawn Macmurphy	Manufacturing Engineer
Melanie N. Ott	Photonics Group Lead, Lead FO Engineer LRO
Rob Switzer	EO Testing engineer
William Joe Thomes	Photonics Group Operations Manager

Mechanical

Adam Matuszeski	Mechanical Lead
Donneise Briscoe	Mechanical Fabrication Planner
Shelly Conkey	Mechanical Analyst
Caner Cooperrider	Mechanical Engineer
Ken Cory	Machinist
Dave Dollard	Mechanical Fabrication Planner
Chris Hennen	Mechanical Designer
Sid Johnson	Mechanical Technician
Mike Mulloney	Mechanical Engineer

Andrew Neal	Mechanical Technician
Dave Pfenning	Mechanical Technician
Dave Pfenning	Mechanical Technician
Steve Schmidt	LOLA Mechanical Subsystem Lead
Matt Showalter	Machinist
Craig Stevens	Mechanical Analyst
Buddy Taylor	Mechanical Designer
Bobby Taylor	Mechanical Support
Quan Tu	Machinist

Materials

Pilar Joy	Materials Engineer
Diane Kolos	Materials Engineer

Ground System

Jan McGarry	Ground System Lead
Thomas Zagwodzki	Ground System Lead
George Bertholdt	Support Engineer
Oscar Brogdon	Support Engineer
David Carter	NGSLR Manager
John Cheek	Support Engineer
Christopher Clarke	Support Engineer
Howard Donovan	Support Engineer
Mike Golob	Support Engineer
Julie Horvath	Support Engineer
Anthony Mallama	Support Engineer
Anthony Mann	Support Engineer
Carey Noll	CDDIS Lead
Donald Patterson	Support Engineer
Randall Rickelfs	SLR System Engineer at Univ. of Texas
Thomas Varghese	Support Engineer
Jerry Wiant	Support Engineer

Thermal

Christine Cottingham	Thermal Engineer
Tony Melak	Thermal Engineer

Bench Checkout Equipment

Pete Liiva	LOLA BCE Lead
Mike Rodriguez	BCE Engineer

Flight Software

Mike Blau	Flight Software Lead
Kris Naylor	FSW Requirements
Krishnan Narayanan	FSW Requirements
Ru Perrera	FSW Configuration Management
Lenard Beacraft	FSW Configuration Management
Glenn Cammarata	FSW Development Team Lead
Susie Strege	FSW Developer
Larry Shackelford	FSW Developer
Scott Walling	FSW Developer
Freemon Johnson	FSW Developer
Moses McCall	FSW Developer
Joel Chiralo	FSW Developer
Tawanda Jacobs	FSW Developer
Ladd Wheeler	FSW Developer
Tim Ray	FSW Developer
Tom Johnson	FSW Developer
George Varndell	FSW Developer
Ji-Wei Wu	FSW Development Team Lead
Dave McComas	FSW Developer
Jeff D'Agostino	FSW Developer
Michael Yang	FSW Developer
Jacob Hageman	FSW Developer
Bruce Trout	FSW Developer
Steve Mann	FSW Developer
Anne Kosloski	FSW Developer
Tom Clement	FSW Test Team Lead
Mike Paoletta	FSW Testing
Eva Stattel	FSW Testing
Scott Applebee	FSW Testing
Ray Ferrer	FSW Testing

Maureen Armbruster	FSW Testing	
Ingrid Albright	FSW Testing	
Jack Fu	FSW Testing	
Anren Hu	FSW Testing	
Bob Schwenk	FSW Testing	
Gary Welter	FSW Testing	
Bob Rapp	FSW Testing	
John Heavener	FSW Testing	
Dave Grosh	FSW Testing	
Janet McDonnell	FSW Testing	
Bill Keksz	FSW Testing	
Tom Phillips	FSW Testing	

Ground System and Operations

Rick Saylor	Ground Sys & Ops Lead	
Rick Saylor	GS&O Lead	HTSI
Jim Clapsadle	Deputy GS&O Lead	HTSI
Howard Calk	GS&O Systems	QSS
Ralph Casasanta	System Engineer	CSC
Christine Marinaccio	GS&O MOC SW Tester	QSS
Mark Neuberger	GS&O MOC SW Tester	HTSI
Dave Waters	MRT Test Lead	HTSI

Mission Operations Team

Jack Murphy	MOT Lead	HTSI
Jabari Carrington	Mission Operations	HTSI
Keith Crew	Mission Operations	HTSI
Garland Dixon	Mission Operations	Boeing
Mike Gardner	Mission Operations	HTSI
Bob Ignasiak	Mission Operations	HTSI
Tim Johnson	Mission Operations	HTSI
Tim Johnson	Mission Operations	HTSI
John Koenig	Mission Operations	Boeing
Joe Kowalski	Mission Operations	HTSI
Jeff Parker	Mission Operations	HTSI
Mehul Patel	Mission Operations	HTSI

Rich Sanidad	Mission Operations	HTSI
Maxine Saylor	Mission Operations	HTSI
Dan Sutermeister	Mission Operations	HTSI
Paul Swenson	MOC System Administrator	HTSI
Mission Operations Center Software		
Theresa Beech	Flexplan Software Eng.	GMV
Hiam Brummer	ITPS Technical Lead	HTSI
Jean-Pierre Chamoun	Flexplan Software Technical Lead	GMV
Sung Cho	ITPS Tester	HTSI
Susan Dyer	ITOS Developer	Hammers
Mike Foreman	ITOS Task Lead	GSFC code 584
Gonzalo García	Flexplan Software Eng.	GMV
Brian Goldman	ITOS Developer	HTSI
Greg Greer	ITOS Technical Lead	Hammers
Karen Keadle-Calvert	ITOS Developer	Hammers
Jay Kim	Flexplan Software Eng.	GMV
Matt Lew	ITOS Developer	Hammers
Barbara Milner	ITOS Task Lead	GSFC code 584
Jean Puckett	ITPS Sys. Admin	HTSI
Denise Reitan	ITPS Developer	HTSI
Mark Richardson	ITOS Developer	HTSI
Sheia Ritter	ITPS Task Lead	GSFC code 583
Tim Singletary	ITOS Developer	Hammers
Mike Smit	ITOS Developer	Hammers
Warren Thompson	ITOS Developer	Hammers
Lucinda Taylor	SW QA	HTSI
Flight Dynamics		
Mark Beckman	Flight Dynamics Lead	GSFC code 595
Rivers Lamb	FD Ground System Lead	GSFC code 595
Michael Mesarch	Maneuver Team Lead	GSFC code 595
Karen Richon	Maneuver Team	GSFC code 595
Dave Folta	Maneuver Team	GSFC code 595
Rick Harmon	FD Ground Attitude Lead	GSFC code 595
Ann Nicholson	FD Task Lead	AI Solutions
Steve Slojkowski	Orbit Team Lead	

Andy Dykes	Orbit Team	
Anne Long	Navigation Analysis	
Patrick Morinelli	Tracking Data Evaluation	
Richard Campion	Tracking Data Evaluation	
Mark Nicholson	Software Development	
Warren Miller	Software Development	
Attitude Ground System		
Rick Harmon	FD Ground Attitude Lead	GSFC code 591
Joe Sedlak		AI Solutions
Joe Hashmall		AI Solutions
Neil Ottenstein		AI Solutions
Rick Coon		AI Solutions
Dave Hooshmand		AI Solutions
Laurie Mann		AI Solutions
Gregory Natanson		AI Solutions
Steve Slojkowski		AI Solutions
Andy Dykes		AI Solutions
Anne Long		AI Solutions
Lauren Chung		AI Solutions
Greg Dell		AI Solutions
Mark Nicholson		AI Solutions
Ann Nicholson		AI Solutions
Patrick Morinelli		Honeywell
Richard Campion		Honeywell
Mark Scooby		Honeywell
Darla German		Honeywell
James Shaw		Honeywell
John Lorah		Honeywell
Steve Hendry		Honeywell

Flight Software Maintenance		
Kris Naylor	FSW Sustaining Engineering	CSC
Mike Oben	FSW Sustaining Engineering	GSFC code 582
Scott Snell	FSW Sustaining Engineering	CSC
Ground Network		
April Adams	NENS Documentation Support	HTSI
Bret Aguilar	USN Ops	USN
Hollys Allen	NENS System Engineer	HTSI
Scott Allen	WSC Engineer	HTSI
Leslie Ambrose	GN/SN/PSLA	GSFC code 582
Mike Anderson	NENS WS1 Project Management	HTSI
Velma Anderson	NENS System Engineer	HTSI
Robert Ash	NENS Facilities	SGT
Cathy Barclay	NENS WS1/USN Project Management	HTSI
Joe Baros	NENS RF SOC/Compat	HTSI
Merri Benjamin	NENS O&M/WSC	HTSI
Matthew Bieneman	NENS Engineering	HTSI
Elaine Bowers	NENS Docs	SGT
Matt Boyd	USN Ops	USN
Ronna Brockdorff	GN Architecture	
Bill Brown	NENS Sys Eng	HTSI
David Carter	GN SLR Lead	GSFC code 582
Bill Chaney	NENS Engineering	HTSI
Chris Christopolous	NENS Engineering	HTSI
Dale Cole	NENS I&T	HTSI
Abbas Contractor	NENS Facilities	HTSI
Chris Cook	NENS Security	HTSI
Art Corella	NENS Facilities	SGT
Steve Currier	GN DPM	GSFC code 453
Mark Czumak	NENS Engineering	HTSI
Dumas Donna	NENS Admin	HTSI
Debbie Dukes	NENS O&M/GN	HTSI
Alice Eskins	NENS Docs	HTSI
Richard Feinstein	NENS Facilities	SGT
John Fleming	NENS Engineering	HTSI
Linda Fuller	NENS Docs	HTSI

Fred Gams	NENS RF SOC/Compat	CRC
William Gardner	NENS Security	HTSI
Don Gittle	USN Lead Engineer	USN
Bob Gonzales	SN TO&A	GD
Jane Gracie	NENS Docs	SGT
Joanne Greet-Swank	USN PM Support	USN
Jay Heberle	USN Project Manager	USN
Daniel Hobel	USN Engineering	USN
Bob Hudgins	GN Scheduling	GD
Doug Hughes	USN Engineering	USN
Connie Jefferies	NENS Admin	HTSI
Brad Johnson	PSLA Support	HTSI
Evans Jones	TO Management Support	HTSI
Deepak Kaul	NENS Enigneering	HTSI
John Kim	NENS RF SOC/Compat	HTSI
Mike Kohout	NENS Network Commitment	HTSI
Tom Kovac	NENS Scheduler	HTSI
David Lassiter	GN WS1 Systems	GSFC code 569
Ken Lavery	NENS RF SOC/Compat	
Barry Lusby	NENS O&M/WSC	HTSI
Scott Lynch	USN Engineer	USN
Dale Massey	USN Engineer	USN
Dennis Mateik	NENS O&M/WSC	HTSI
Ken McIntyre	NENS Docs	HTSI
Marco Midon	WS1 Technical Lead	GSFC code 567
Peter Militch	NENS Chief Eng	HTSI
Steve Montgomery	USN Engineer	USN
Yonwoo Nam	NENS I&T	HTSI
Valeria Nitz	NENS Docs	HTSI
Onyeali Onyeberechi	NENS Docs	HTSI
Paul Pardoe	NENS Docs	HTSI
Brent Parker	NENS RF SOC/Compat	HTSI
Pati Peskett	NENS GN Eng	HTSI
Lesley Rahman	NENS O&M	HTSI
Peggy Reno	NENS QA	HTSI

Laurel Rossow	NENS Safety	HTSI
Gregory Sanders	NENS Sys Eng	HTSI
Jul Scarborough	NENS Security	HTSI
Bruce Schupler	NENS Sys Eng	HTSI
Thomas Shult	NENS Ops	USN
Don Small	WS1 Sys Eng	HTSI
Donna Smith	NENS Admin	HTSI
Jeanette Smolinski	NENS GN Eng	HTSI
Bob Stancel	GN Software Engineering	GSFC code 589
Frank Stocklin	GN Architecture Support	GSFC code 450
Rod Summerford	NENS I&T	HTSI
John Taylor	USN Engineer	USN
Steve Testoff	NENS Docs	SGT
Mike Uffer	NENS Eng	HTSI
Scott Underwood	GN Chief Eng	LJT
Bourgondien Van	NENS Facilities	HTSI
Steve Vogelwede	USN SW Engineer	USN
Jim Wiedman	WS1 Security	HTSI
Stephania Young	NENS Scheduler	HTSI
Deep Space Network		
Ida Baker	LRO NOPE Lead	ITT
Ed Luers	DSN POC	NASA/JPL
Steve Walderr	DSN MCM	NASA/JPL
NISN		
Jim Cameron	NISN Network Engineer	GSFC code 721
Mike Eder	NISN Network Engineer	SAIC
Chris Jermann	NISN IPNOC	SAIC
Chi Le	NISN Network Engineer	GSFC code 721
Chris Spinolo	NISN Network Engineer	GSFC code 721

Command and Data Handling

William Yuknis	C&DH System Lead (2007-2008) / Technical Lead	GSFC
Quang Nguyen	C&DH System Lead (2004-2007)	GSFC
Dennis Albaijes	Housekeeping I/O Card Engineer / Signal Integrity Engineer	GSFC
Omar Haddad	Jack of All Trades Engineer	GSFC
Noosha Haghani Leviste	Communications Card Engineer	GSFC
Damaris Guevara	Communications Card Engineer	GSFC
James Fraction	Low Voltage Power Converter Engineer	GSFC
John Siedlecki	SpaceWire Engineer / Multifunction Analog Card Digital Engineer	GSFC
George Moore	Multifunction Analog Card Test and Verification Engineer	GSFC
Michael Lin	Multifunction Analog Card Analog Engineer	GSFC
Renee Reynolds	Multifunction Analog Card Digital Engineer	GSFC
Glenn Rakow	SpaceWire Consultant	GSFC
Loc Luu	Test and Diagnostic Software Engineer	GSFC
Tawanda Jacobs	Test and Diagnostic Software Engineer	GSFC
Warren Thompson	Communications Ground Support Equipment Engineer	GSFC
Timothy Johnson	Test Conductor	GSFC
Robert Ignasiak	Test Conductor	GSFC
Scott Pursley	Data Storage Board Engineer	GSFC
Dudley Yuknis	Mascot Engineer	GSFC
Cynthia Lewis	Integration and Test Manager	GSFC
Darryl Younger	Test Facilities Manager	GSFC
Locksley Haynes	Data Storage Board Digital Engineer	GSFC
Cin Swangwatanaratn	Technican Support	GSFC
Brenda Wallace	Technican Support	GSFC
Brenda Feldman	Technican Support	GSFC
Thomas Winkert	Communications Encoder FPGA Engineer	GSFC
Al Grasley	PWB Designer	Northrop Grumman
Al Lookingland	Mechanical Engineer	Northrop Grumman
Tony Granados	PWB/Mechanical Designer	Northrop Grumman
Barbara Neff	Task Manager	Northrop Grumman

Betty Pearsall	Assemby Technician	Northrop Grumman
Charlie Mcclunin	Packaging Engineer/Checker	Northrop Grumman
Dave Meyers	Planning Inventory Control (PIC)	Northrop Grumman
Doug Lumsden	Program Manager	Northrop Grumman
Eva Rice	Procurement/Buyer	Northrop Grumman
Frank Vreeland	PWB Designer	Northrop Grumman
Mike Merryman	PWB Designer/Manager	Northrop Grumman
Harry Yackman	Packaging Engineer/Checker	Northrop Grumman
Jim Krivensky	PWB Designer	Northrop Grumman
Jeff Keck	Electrical Engineer	Northrop Grumman
Jeff Diehl	Operations/Lab Manager	Northrop Grumman
John Cook	Mechanical Designer	Northrop Grumman
Karen Nearhoff	Assemby Technician	Northrop Grumman
Karen Chaney	Assemby Technician	Northrop Grumman
Keith Ellis	Assemby Technician	Northrop Grumman
Lang Diep	Assemby Technician	Northrop Grumman
Lori Protheroe	QA Inspector	Northrop Grumman
Lorinda Burrows	Assemby Technician	Northrop Grumman
Mike Johnson	QE/QA Manager	Northrop Grumman
Nancy Baily	Configuration Management (CM)	Northrop Grumman
Nicole Hackley	Quality Engineer	Northrop Grumman
Paul Kemlage	Mechanical Designer	Northrop Grumman
Rick Butler	QA Inspector	Northrop Grumman
Richard Burrows	Components Engineer	Northrop Grumman
Roy Kohn	Packaging Engineer/Checker	Northrop Grumman
Ryan Pranschke	Mechanical Engineer	Northrop Grumman
Sean Bowen	Planning Inventory Control (PIC)	Northrop Grumman
Thomas Anderjaska	Test Engineer	Northrop Grumman
Jerry Belote	Planning Inventory Control (PIC)	Northrop Grumman
Tracey Clay	Mechanical Engineering Manager	Northrop Grumman
Tuan Duong	Electrical Engineer	Northrop Grumman
Viguen Ter-Minassian	Mechanical Engineer	Northrop Grumman

Alan Dennis	Lead Electrical Engineer	BAE
Suzanne Miller	EPM and Software Engr	BAE
Cathy Lue Chee Lip	SUROM Software engineer	BAE
Dean Saridakis	Lead Software Engineer	BAE
Marc Vancampen	Lead Mechanical Engineer	BAE
Michael E Smith	Mechanical Enginer STE	BAE
Les Crawley	Quality Assurance	BAE
Steve Johnson	STE Software	BAE
Joseph Hilger	Operations Program Manager	BAE
David Eckhardt	Program Manager	BAE
Mason Fisher	Material Planning	BAE
Everett Drew	Engineering Manager	BAE
Richard Kim	Manufacturing Engineer	BAE
Robert Davidson	Electrical Engineer	BAE
Tim Whalen	Mechancal Analysis	BAE
Rema Smoot	Contracts	BAE
John Carr	Finance	BAE
James Ramsden	Reliability	BAE
Phuong "Tee" Osborne	Assembly Operator	BAE
Tri Nguyen	Assembly Operator	BAE
Pauline Gordon	Assembly Operator	BAE
Hang Tran	Assembly Operator	BAE
Conrad Walker	Assembly Operator	BAE
Margaret High	Assembly Operator	BAE
Judy Bui	Assembly Operator	BAE
Teresa Blaylock	Stock room	BAE
Ben Reardon	9639B Electronics Design Engineer	Symmetricom
Luis Vargas	9639B Electronics Design Engineer	Symmetricom
Sanjiv Patel	9639B Test Engineer	Symmetricom
Johan Welgemoed	9512A Development Engineer	Symmetricom
Doug Harvey	9512A Engineering Technician	Symmetricom
Liz Lasher	9512A Prototype/Senior Assembler	Symmetricom

Communications

LRO Communications System

Adan Rodriguez-Arroyo	Communications System Lead	GSFC code 567
Vince Briani	RF Networks (S-/Ka-Band)	ATK, Inc
Daniel Feldman	MEI Task29 Leader (Coupler, Hybrids, coax, waveguides, omni procurements)	MEI Technologies
Rick Jacobs	Senior Buyer (Coupler, Hybrids, coax, waveguides, omni procurements)	MEI Technologies
Bill Klimczak	HGAS RF Support	MEI Technologies
James Lee	QA	ATK, Inc
Anatoly Lyubomirsky	RF support	MEI Technologies
John Pocius	Ground Support Equipment	GSFC code 567
Lamont Poole	Ground Support Equipment	GSFC code 567
Victor Sank	Senior RF Support	MEI Technologies
Steve Seufert	RF Test Support	GSFC code 567
Dale Shama	RF Networks Support	MEI Technologies
Steve Smith	RF Test Support	ATK, Inc
Barbara Selby	Contract Specialist (Coupler, Hybrids, coax, waveguides, omni procurements)	MEI Technologies
John Staren	Modeling / Analysis	MEI Technologies
Jerry Visalsawat	Ka-Band Subsystem	GSFC code 567

LRO Ka-band Modulator

Jeff Jaso	LRO Ka-band Modulator Lead Designer	GSFC code 567
Carl W. Kellenbenz	LRO Modulator Power Supply Lead	GSFC code 563
Robert Lussier	Modulator Power Supply Technical Support	GSFC code 563
Hanson Nguyen	Modulator Power Supply Test Engineer	GSFC code 563
Laura Cook	Power Supply Re-work	Orbital
Jeff Keck	Initial Northrop Project Manager	Northrop - Lanham
Doug Lumsden	Second Northrop Project Manager	Northrop - Lanham
Terry Miller	Third Northrop Project Manager	Northrop - Lanham
Kim Allgood	Materials Technician - Assembly & coat and stake	Ball
Richard Burrows	Northrop Parts Manager	Northrop - Lanham
Jeff Diehl	Northrop Manufacturing Lead	Northrop - Lanham
Kyle Huth	Wirebonding specialist	Independent consultant
Al Lookingland	Northrop Assembly Documentation	Northrop - Lanham

Shawn McMurphy	Communications Engineer	MEI Technologies
Xuan Nguyen	Communications Engineer	MEI Technologies
Traci Pluchak-Rosnack	Micro Electronic Technician	Orbital
Art Ruitberg	Design Consultant	Space Power Electronics, Inc.

LRO S-/Ka-band High Gain Antenna

Ali Mahnad	High Gain Antenna Lead	MEI Technologies
John Boger	LRO HGA Sr. Manufacturing Engineer	AASC
Nelis DuToit	Antenna Design / Analysis	Perot Systems, Inc.
David Green	HGA electro-mechanical Support	MEI Technologies
Mike Guthmiller	LRO HGA Sr. Program Manager	AASC
Ken Hersey	Senior High Gain Antenna Support	Perot Systems, Inc.
Doug Keehr	LRO Purchasing Manager	AASC
Todd Krafchak	HGA mechanical analysis	Orbital Science Corporation
Scott Miskovish	LRO HGA Thermal Analysis Lead	ATA-E
Eric Nelson	LRO Sr. Assembly Technician	AASC
Mike Noyes	LRO HGA Mechanical Design Lead	AASC
Troy Nunes	LRO HGA Manufacturing Engineer	AASC
Bob Phillips	LRO HGA Quality Engineer	AASC
Anna Shifflet	LRO Production Control	AASC
Dawn Valero	LRO HGA Strutural Analysis Lead	AASC

Telemetry Tracking and Command Unit

Ken Moloney	Project Leader	General Dynamics Advanced Information
Cheryl Ross	Program Manager	General Dynamics Advanced Information
Fichelle Fields	Configuration & Data Manager	General Dynamics Advanced Information
Tricia Lord-Brumm	Contracts	General Dynamics Advanced Information
Christina Muckenhoupt	Document Control	General Dynamics Advanced Information
Jeffery Gaines	Finance	General Dynamics Advanced Information
Jerry Thorson	Finance	General Dynamics Advanced Information
Gary Placke	Integrated Cost & Schedule	General Dynamics Advanced Information
Jim Crawford	Sr Lead Engineer - Systems	General Dynamics Advanced Information
Paul Schneider, Jr.	Sr Lead Engineer - Systems	General Dynamics Advanced Information
John Stephen	Principal Engineer - Electrical	General Dynamics Advanced Information
Mark Bockmann	Sr Lead Engineer - Electrical	General Dynamics Advanced Information

Clarence Huntley	Sr Lead Engineer - Electrical	General Dynamics Advanced Information
Robert Prentice, Jr.	Sr Lead Engineer - Electrical	General Dynamics Advanced Information
Carl Robello	Sr Lead Engineer - Electrical	General Dynamics Advanced Information
Rick Scott	Lead Engineer - Electrical	General Dynamics Advanced Information
Wade Understiller	Lead Engineer - Mechanical	General Dynamics Advanced Information
Dave Anderson	Lead Engineer - Software	General Dynamics Advanced Information
Marty Siemon	Distinguish Member Technical Staff	General Dynamics Advanced Information
Mike Henggeler	Designer	General Dynamics Advanced Information
James Praught	Designer	General Dynamics Advanced Information
Paul Scott	Designer	General Dynamics Advanced Information
Dan Glenn	Manufacturing Manager	General Dynamics Advanced Information
Todd Zuercher	Manufacturing Engineer	General Dynamics Advanced Information
Betty Marsh	Material Planner	General Dynamics Advanced Information
Fred Dunikoski	Material Specialist	General Dynamics Advanced Information
Rosemarie Nelson	Manufacturing Technician	General Dynamics Advanced Information
Lois Washington	Manufacturing Technician	General Dynamics Advanced Information
David Baker	Engineering Technician	General Dynamics Advanced Information
Jack Brust	Engineering Technician	General Dynamics Advanced Information
Lawrence Clint	Engineering Technician	General Dynamics Advanced Information
Robert Cordray	Engineering Technician	General Dynamics Advanced Information
Les Eakins	Engineering Technician	General Dynamics Advanced Information
Virgina Grajiola	Engineering Technician	General Dynamics Advanced Information
Steven Hair	Engineering Technician	General Dynamics Advanced Information
Joan Harnish	Engineering Technician	General Dynamics Advanced Information
Edward Harrison	Engineering Technician	General Dynamics Advanced Information
James Henry	Engineering Technician	General Dynamics Advanced Information
Marilyn Law	Engineering Technician	General Dynamics Advanced Information
Chip Leivas	Engineering Technician	General Dynamics Advanced Information
Bach Nguyen	Engineering Technician	General Dynamics Advanced Information
Mike Nichols	Engineering Technician	General Dynamics Advanced Information
Michael Pellerin	Engineering Technician	General Dynamics Advanced Information
Carlos Fraijo	Engineering Technician	General Dynamics Advanced Information

Ruth Freeze	Engineering Technician	General Dynamics Advanced Information
Terry Mendoza	Engineering Technician	General Dynamics Advanced Information
Fern Ross	Engineering Technician	General Dynamics Advanced Information
John Shaw	Engineering Technician	General Dynamics Advanced Information
Myron Stineman	Engineering Technician	General Dynamics Advanced Information
Steven VanHolton	Engineering Technician	General Dynamics Advanced Information
Bennie Warren	Engineering Technician	General Dynamics Advanced Information
Dolores Anaya	Operator	General Dynamics Advanced Information
Rannie Arnold	Operator	General Dynamics Advanced Information
Ruth Boivin	Operator	General Dynamics Advanced Information
Theresa Duffy	Operator	General Dynamics Advanced Information
Leeann Guest	Operator	General Dynamics Advanced Information
Donna Longacre	Operator	General Dynamics Advanced Information
Rachel Slater	Operator	General Dynamics Advanced Information
David Soto	Operator	General Dynamics Advanced Information
Pauline Williams	Operator	General Dynamics Advanced Information
Pam Embree	Principal Quality Engineer	General Dynamics Advanced Information
Don Davenport	Sr Lead Quality Engineer	General Dynamics Advanced Information
Greg Hayes	Quaility Specialist	General Dynamics Advanced Information
Joseph Levine	Quaility Specialist	General Dynamics Advanced Information
Charles Beckham	Quality Specialist	General Dynamics Advanced Information
Keyana Willcox	Inspector 1 - Quality	General Dynamics Advanced Information
Russ Graves	Radiation Engineer	General Dynamics Advanced Information
Lamonte Einspahr	Reliability Engineer	General Dynamics Advanced Information
Mike Newman	Reliability Engineer	General Dynamics Advanced Information
Mitch Witkowski	Reliability Engineer	General Dynamics Advanced Information
Lynda Dorsett	Sr Technology Specialist	General Dynamics Advanced Information

Traveling Wave Tube Amplifier

Todd T. Peterson	TWTA Project Manager	NASA/GRC
Dale A. Force	TWTA COTR	NASA/GRC
Rainee N. Simons	TWTA Principal Engineer	NASA/GRC
Jane M. Cochran	TWTA Contracting Officer	NASA/GRC
Ben Bauman	TWTA Budget Analyst	NASA/GRC

Corinna Vilkatis	Contract Manager	L-3 Electron Technologies, Inc
Lou Ann Flaherty	Program Office Director	L-3 Electron Technologies, Inc
Paul Spitsen	Program Manager	L-3 Electron Technologies, Inc
Dan Scaboo	TWT Manufacturing Engineeing	L-3 Electron Technologies, Inc
Daniel Dibb	TWT Responsible Engineering Authority	L-3 Electron Technologies, Inc
Dave Newell	TWT Engineeing	L-3 Electron Technologies, Inc
David Eze	TWT Mechanical Engineeing	L-3 Electron Technologies, Inc
Eric Young	TWT Test Engineeing	L-3 Electron Technologies, Inc
Helen Cohen	TWT Manuracturing Engineeing	L-3 Electron Technologies, Inc
Mary Connors	TWT Test Engineeing	L-3 Electron Technologies, Inc
Matt Patterson	TWT Engineeing Manager	L-3 Electron Technologies, Inc
Randy Gibson	TWT Test Engineeing	L-3 Electron Technologies, Inc
Tony Romero	TWT Manufacturing Engineeing	L-3 Electron Technologies, Inc
Tony Ronco	TWT Manufacturing Engineeing	L-3 Electron Technologies, Inc
Dr. William Menninger	TWT Design Engineeing	L-3 Electron Technologies, Inc
Zev Liang	TWT Test Engineeing	L-3 Electron Technologies, Inc
Dr. Roger Hollister	TWT Mechanical Engineeing	L-3 Electron Technologies, Inc
Neal Robbins	Ka Band TWT Development	L-3 Electron Technologies, Inc
Adileen Saucedo	TWT Assembly Technician	L-3 Electron Technologies, Inc
Anh Nguyen	TWT Assembly Technician	L-3 Electron Technologies, Inc
Barbara Lemons	TWT Assembly Technician	L-3 Electron Technologies, Inc
Tina Nguyen	TWT Assembly Technician	L-3 Electron Technologies, Inc
Dennis Lynch	TWT Assembly Technician	L-3 Electron Technologies, Inc
Dorothy Kratzer	TWT Assembly Technician	L-3 Electron Technologies, Inc
Edna Beleno	TWT Assembly Technician	L-3 Electron Technologies, Inc
Emy Estocado	TWT Assembly Technician	L-3 Electron Technologies, Inc
Fernando Lizaraga	TWT Assembly Technician	L-3 Electron Technologies, Inc
Florence Militar	TWT Assembly Technician	L-3 Electron Technologies, Inc
Janet Ekenstam	TWT Assembly Technician	L-3 Electron Technologies, Inc
Jose Peralta	TWT Assembly Technician	L-3 Electron Technologies, Inc
Kyong Su	TWT Assembly Technician	L-3 Electron Technologies, Inc
Lani Faalafua	TWT Assembly Technician	L-3 Electron Technologies, Inc
Linda Clark	TWT Assembly Technician	L-3 Electron Technologies, Inc
Margaratia Hydro	TWT Assembly Technician	L-3 Electron Technologies, Inc
Mary La Riccia	TWT Assembly Supervisor	L-3 Electron Technologies, Inc

Peral Dupuy	TWT Assembly Technician	L-3 Electron Technologies, Inc
Rebecca Huizar	TWT Assembly Technician	L-3 Electron Technologies, Inc
Rhonda Gersh	TWT Assembly Technician	L-3 Electron Technologies, Inc
Stephanie Collins	TWT Assembly Technician	L-3 Electron Technologies, Inc
Sueng Lim	TWT Test Technician	L-3 Electron Technologies, Inc
Bruce Sharp	TWT Manufacturing Planning	L-3 Electron Technologies, Inc
Pamela Donnelly	TWT Manufacturing Planning	L-3 Electron Technologies, Inc
Andrew Peak	TWTA Design Engineering	L-3 Electron Technologies, Inc
Dave Lewis	TWTA Electrical Engineering	L-3 Electron Technologies, Inc
Douglas Strother	TWTA Test Engineering	L-3 Electron Technologies, Inc
Farrell Deibel	TWTA Mechanical Engineering	L-3 Electron Technologies, Inc
Jack McDowell	TWTA Mechanical Engineering	L-3 Electron Technologies, Inc
Janusz Pyter	TWTA Engineering Manager	L-3 Electron Technologies, Inc
Jatin Vaghela	TWTA Test Engineering	L-3 Electron Technologies, Inc
Joe Araki	TWTA Test Engineering	L-3 Electron Technologies, Inc
Keith Loi	TWTA Test Engineering	L-3 Electron Technologies, Inc
Keith Phelps	TWTA Electrical Engineering	L-3 Electron Technologies, Inc
Manuel Peralta	TWTA Electrical Engineering	L-3 Electron Technologies, Inc
Mark Tafoya	TWTA Electrical Engineering	L-3 Electron Technologies, Inc
Mike Choe	TWTA Mechanical Engineering	L-3 Electron Technologies, Inc
Oliver Graham	TWTA Test Engineering	L-3 Electron Technologies, Inc
Phil Todd	TWTA Electrical Engineering	L-3 Electron Technologies, Inc
Richard Atienza	TWTA Mechanical Engineering	L-3 Electron Technologies, Inc
Roger Williams	TWTA Design Engineering	L-3 Electron Technologies, Inc
Roy Perry	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
William Takahashi	TWTA Design Engineering	L-3 Electron Technologies, Inc
Cullen Chapman	TWTA Lead Manufacturing Engineering	L-3 Electron Technologies, Inc
Greg Maxwell	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
Brian Nguyen	TWTA Test Engineering	L-3 Electron Technologies, Inc
Tan Nguyen	TWTA Test Engineering	L-3 Electron Technologies, Inc
William Council	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
Wesley Clanin	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
Mirna Lima	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
Deanne Widmark	TWTA Manufacturing Planning	L-3 Electron Technologies, Inc
Buzz Carter	TWTA Manufacturing Planning	L-3 Electron Technologies, Inc

Donna Mahony	TWTA Manufacturing Planning	L-3 Electron Technologies, Inc
Andy Dailo	TWTA Manufacturing Engineering	L-3 Electron Technologies, Inc
Chris Trudeau	Assembly and Test Supervisor	L-3 Electron Technologies, Inc
Al Martinez	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Albert Solis	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Andrew Calderon	TWTA Test Technician	L-3 Electron Technologies, Inc
Anthony Bui	TWTA Test Technician	L-3 Electron Technologies, Inc
Bharti Shah	TWTA Test Technician	L-3 Electron Technologies, Inc
Brian Yamanoha	TWTA Test Technician	L-3 Electron Technologies, Inc
Cynthia Gomez	TWTA Assembly Technician	L-3 Electron Technologies, Inc
David Hernandez	TWTA Test Technician	L-3 Electron Technologies, Inc
Dung Le	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Georginia Resurrection	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Grace Rameriz	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Guadalupe Amezcua	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Jim Parsons	TWTA Test Technician	L-3 Electron Technologies, Inc
John Vu	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Juan Reyes	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Ken Hodge	TWTA Test Technician	L-3 Electron Technologies, Inc
Kyong Kim	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Lettie Morales	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Michelle Staton	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Mike Martin	TWTA Test Technician	L-3 Electron Technologies, Inc
Patricia Williams	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Ramona Diaz	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Tanya Pham	TWTA Test Technician	L-3 Electron Technologies, Inc
Teresita Espanola	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Tien Nguyen	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Trung Nguyen	TWTA Assembly Technician	L-3 Electron Technologies, Inc
Tuan Bui	TWTA Assembly Technician	L-3 Electron Technologies, Inc

Harness Team

Doug Duvall	Harness lead (2007-2008)
Rick Kinder	Harness lead (2004-2007)
Curtis Dunsmore	Technician
Deneen Ferro	Technician
Greg Griffith	Technician
Shirley Jones	Technician
Brian Kittle	Technician
Lester Putnam	Technician
Ram Ramrattan	Technician
Daryl Riley	Technician
Steve Smith	Technician
Charley Stone	Technician
Brad Swearingen	Technician
Rob Thompson	Technician
Steven Tomaszewski	Technician
Carroll "Trick" Trickey	Technician
Brenda Wallace	Technician

CRaTER Team

Harlan Spence	CRaTER Principal Investigator	Boston University
Michael Golightly	Deputy Project Scientist	Boston University
Kristin Sacca	Project Coordinator	Boston University
Nicholas Gross	E/PO Lead	Boston University
Tony Case	Calibration Scientist	Boston University
Erik Wilson	SOC Programmer	Boston University
Jennifer Brown	Data Technician	Boston University
David Bradford	IT Management	Boston University
Jeffrey Sanborn	Technical Support	Boston University
Eric O'Dea	Thermal Modeling	Boston University
Huade Tan	Thermal Modeling	Boston University
Justin Kasper	Project Scientist	Harvard-Smithsonian
Demetrios Athens	GSE Programmer	MIT
Bill Forbes	Machinist	MIT
Peter Ford	SOC Developer	MIT
Rick Foster	Program Manager	MIT

Robert Goeke	Project Engineer	MIT
Dorothy Gordon	Electrical Engineer	MIT
Brian Klatt	SMA Manager	MIT
Fred Miller	Technician	MIT
Jimmy O'Connor	Project Technician	MIT
Matt Smith	Mechanical Engineer	MIT
Joan Quigley	SOC Analyst	MIT
J. Bernard Blake	Co-Investigator	The Aerospace Corporation
Joesph Mazur	Co-Investigator	The Aerospace Corporation
William Crain	Electrical Engineer	The Aerospace Corporation
Albert Lin	Mechanical Engineer	The Aerospace Corporation
Deborah Salvaggio	Program Manager	The Aerospace Corporation
Paul Carranza	Quality Assurance	The Aerospace Corporation
Francisca Fuentes	Senior Research Assistant	The Aerospace Corporation
Rachael Galvan	Senior Research Assistant	The Aerospace Corporation
Mark Lalic	Research Associate	The Aerospace Corporation
Larry Townsend	Co-Investigator	University of Tennessee, Knoxville
Terry Onsager	Co-Investigator	NOAA Space Weather Prediction Center

Diviner Team

David Paige	Diviner PI
Wayne Hartford	Instrument Project Manager
Bradley Drake	Electronics Fabrication
Orland Harrison	Software
Scott Nolte	Integration
Mark Duran	Thermal Eng
Charles Avis	SOC Lead
Peter Barry	Mission Assur Mgmt
Jim Aragon	Quality Assurance
John Bousman	Integration
Nick Taylor	Reliability
Dennis Cate	Integration
Scott Loring	Software Eng
Michael O'connell	Dynamics Test

Tom Pierce	EMC Test
Kim Plourde	Project Mgmt Staff
Daniel Preston	Calibration Eng
Laurie Guay	Business Mgmt Staff
Henry Awaya	Test
Nickolas Emis	Thermal Eng
Gary Kinsella	Thermal Eng
Tarek Baayoun	Business Mgmt Staff
Marc Foote	Integration
Bruno Jau	Mechanical Eng.
Susan Lee	Software Assurance
Cami Vongsouthy	Safety Eng
Michael Blakely	Environmental Eng
Bryan Bell	Reliability
Don Lewis	Material End
Glenn Aveni	Contamination Control Eng
Lee Wigglesworth	Test Support
Robert Stephenson	Structural Analysis
Dave Randall	Test Support
Sam Galaske	Mechanical Design
Robert Hughes	Thermal Analysis

LEND Team

Igor Mitrofanov	LEND PI
under construction	

LOLA Team

David Smith	LOLA PI
under construction	

LROC Team

Mark Robinson	LROC PI
Eric Eliason	
Harald Hiesinger	
Brad Jolliff	
Michael Malin	
Alfred McEwen	
Peter Thomas	
Elizabeth Turtle	
Scott Brylow	Instrument Manager
Mike Ravine	Senior Project Manager
Mike Caplinger	Systems Engineer
Jacob Schaffner	Lead Electrical Engineer
Paul Otjens	Electrical Engineer
Tony Ghaemi	Lead Optical Engineer
David Humm	
Chris Martin	Flight Assembler
Hakeem Olawale	Lab Technician
Jose Navarro	Junior Mechanical Engineer
Will Cowell	Junior Mechanical Engineer
Steven Mi	Junior Mechanical Engineer
Ann Pasquini	Procurement Lead
Jeff Zerr	I&T Maser

LROC Science Operations Center

Ernest Bowman-Cisneros	SOC Manager
Ian Bennett	SOC Senior System Administrator
Ken Bowley	SOC System Administrator
Joe Digilio	SOC System Administrator
Tim Donnelly	SOC Operations
Sean Merritt	SOC Operations
David Nelson	SOC Operations
Julie Stopar	SOC Operations
Shane Thompson	SOC Operations
Jim Stewart	SOC Lead Software Developer
Nick Avlontis	SOC Software Developer

Jacob Danton	SOC Software Developer
Erick Malaret	ACT President, supporting LROC SOC Operations
Doug Fuller	HPCI Manager, supporting LROC SOC Operations
Kirt Karl	HPCI Storage, supporting LROC SOC Operations
Gil Speyer	HPCI Software Developer, supporting LROC SOC Operations
Dan Stanzione	HPCI Director, supporting LROC SOC Operations
Carmen Salas	Business Manager & LROC EPO
Doug Roberts	EPO Lead
Wendy Taylor	EPO
Brett Denevi	Post-Doc
Sam Lawrence	Post-Doc
Martin Tschimmel	Post-Doc

LAMP Team

Randy Gladstone	LAMP PI (2007-2008)
Alan Stern	LAMP PI (2004-2007)
Ron Black	
Dave Slater	
Maarten Versteeg	
Michael Davis	
Kristian Persson	
Greg Dirks	
Ken Johnson	
Henry Sykes	
Armando De Los Santos	
Jessica Stack	
John Scherrer	
Brian Gupta	
John Stone	
Kurt Retherford	
Larry McCullough	
Joerg Gerhardus	
Tommy Greathouse	
David Kaufman	

Joel Parker
Anthony Egan
Traci Case
Rebecca Thibodeaux
Roy Graham
Michael Young
Dana Crider
Paul Feldman
Wayne Pryor
Polly Andrews
Gianna Sullivan
Sensor Sciences
NuTek
Jobin-Yvon
SwRI Division 15 Power Systems Group
SwRI Division 15 Quality Assurance
SwRI Division 15 Drafting Department
SwRI Division 15 Model Shop
SwRI Division 15 Parts Control Group
SwRI Division 15 Fabrication Group

Program Office at MSFC

Tony Lavoie	Program Manager	
Larry Hill	LRO Mission Manager	MSFC
Todd Holloway	Launch Service Provider Interface	MSFC
Danielle Moran	Education and Public Outreach	MSFC
Donna Patterson	Business Office	MSFC

Independent Review Team

Linda Pacini	Review Chair/Systems Review Manager	NASA Goddard Space Flight Center (GSFC)
Chris Jones	Review Co-chair/ Director for Solar System Explorati	Jet Propulsion Laboratory (JPL)
John Niehoff	IPAO Review Chair	SAIC
Dave Kusnierkiewicz	Space Division Chief Engineer	Applied Physics Laboratory
Brian Keegan	Chief Engineer	NASA HQ (Retired)
Steven Scott	GSFC Chief Engineer	GSFC code 500
Ed Powers	Thermal and Systems	Swales, ATK, SGT
Ed Ashford	Mission Design	Science International Applications Corporati
Mike Bay	Instrument Systems	J&T
Tom Kenney	GN&C	GSFC code 591
Ivar Tillotson	Mission Operations	HTSI
Minh Phan	Mechanical	GSFC code 540
Stephen Thompkins	Mission Operations	GSFC
Robert Kichak	Electrical, C&DH	NESC
Daniel Nguyen	Thermal	GSFC code 545
SRR only		
Pete Theisinger	Deputy Director for Mars Exploration	JPL
Liz Citrin	Project Management	GSFC code 464
Riley Duren	Systems Engineering	JPL
James C. Smith	Systems Engineering	GSFC code 550
Steve Wasserzug	Systems, I&T	Swales
PDR only		
Randy Hedgeland	Contamination	GSFC code 546
Don Cornwell	Instrument Systems	Swales
Tom Luchik	Mgr. Instruments and Science Data Systems	Jet Propulsion Laboratory (JPL)
Paul Geithner	SMD Program Executive	NASA HQ
CDR additions		
Eileen Dukes	Spacecraft Systems	Aerospace
Fred Huegel	Electrical, C&DH	GSFC code 560
Scott Gordon	Mechanical Systems	GSFC code 542
Alphonso Stewart	Mechanical Systems	GSFC code 543
Dave Ward	Spacecraft Systems	GSFC code 599
Carolyn Dent	Mission Operations	GSFC code 301

Launch Support Team

A.I. Solutions		
Clinton E. Plaisted	Flight Controls	a.i. solutions
Analex		
Bill Boggs	AE Comm and Telemetry	Analex
Tom Casale	Power Systems/Batteries	Analex
Marsha Causey	Launch Site Support	Analex
Tim Clinger	AE Comm & Telemetry Engr	Analex
Lamar Davis	Launch Site Support Engineer	Analex
Milt Draves	Mission Integration Coordinator	Analex
Roy A. Fisher	Launch Site Support Engineer	Analex
Richard A. Flage	Flight Software	Analex
Eugene J. Fourney	LV Mechanical - Denver	Analex
John Glass	Ordnance	Analex
Penni Herbst	Contamination Control	Analex
Chuck Holmes	Booster Prop	Analex
Kathleen Kerr	Badging/Security	Analex
Angela M. Lawhead	OCE Support	Analex
Dave Loiselle	Avionics	Analex
John Magisano	Denver Res Office - Avionics	Analex
Linda Lee Matthias	Contamination Control	Analex
Janice E. McMillen	Mission Integration Coordinator	Analex
Ruby Montoya	Denver Resident Office	Analex
Chip Moore	Ordnance	Analex
Jim Myers	Propulsion	Analex
Skip Owens	Flight Design	Analex
John Pavone	Environmental Control Systems	Analex
Suzie Raines	Technical Integration	Analex
Randy Reid	Booster Prop	Analex
Ted Schmoll	Pneumatics	Analex
Carl Schultz	Denver Res Office - LV Structures	Analex
Estil G. Smith	Launch Support	Analex
Gregg Stoll	AE Comm	Analex
Charlie Thompson	AE Comm & Telemetry Engr	Analex
Domenick Tutera	Flight Design	Analex

Tom Vogel	Propulsion	Analex
Tom Woodard	Electrical	Analex
Paul Wubbena	EGSE	Analex
James W. Zimmerman	Loads	Analex
Astrotech		
Bruce Campbell	ASO Safety Lead/Mission Manager	Astrotech
Beau Suzanne Du	ASO Badging/Security	Astrotech
Rob Ferrraro	ASO Mission Manager - LCROSS	Astrotech
Gerard Gleeson	ASO Mission Manager - LRO	Astrotech
Dwayne Light	ASO Facility Manger	Astrotech
Don Moore	ASO Mission Manager - LCROSS	Astrotech
Don White	ASO Manager	Astrotech
Boeing KSC		
Jeffery Boykin	Design Visualization Modeling	Boeing KSC
David Muldowney	S/C Security	Boeing KSC
Sharon Sieber	S/C Securtiy	Boeing KSC
Charlie Smith	CAPPS Fueling Lead	Boeing KSC
NASA KSC		
Carlos Alvarado	Flight Controls	NASA KSC
Omar Baez	Assistant Launch Director (ALD)	NASA KSC
Dan Baker	LSIM	NASA KSC
Serkan Bastug	Strength	NASA KSC
John Bauschlicher	Flight Dynamics	NASA KSC
Gary Beatovich	ASO Contract Officer	NASA KSC
Brian Beaver	Flight Design	NASA KSC
Norman M. Beck	LCROSS Integration Engineer	NASA KSC
Bill Benson	Flight Dynamics	NASA KSC
Frank M. Billingham	Propulsion	NASA KSC
Jamie Bjornbak	Instrumentation	NASA KSC
Robert J. Bosnyak	Integration Engineer	NASA KSC
Donald E. Brandl	Thermal	NASA KSC
Jacqueline A Brooks	Contracting Officer	NASA KSC
Diana M. Calero	LRO Integration Engineer	NASA KSC
Danial M. Campbell	Thermal Analysis	NASA KSC
Michael C. Carbone	Mechanical and GSE	NASA KSC

Keith Castilow	Denver Resident Office Mngr	NASA KSC
Robert L Choy	Launch Director	NASA KSC
Kevin J. Clinton	EMC/RF	NASA KSC
Harold Coleman	COTR/PIM	NASA KSC
Daniel M. Coon	LV Software	NASA KSC
Emilio Cruz	LSP Budget Office	NASA KSC
Chuck Davis	KSC Fueling Lead	NASA KSC
George Diller	Public Affairs	NASA KSC
Charles P. Dovale	Launch Director	NASA KSC
Ronald B Driggers	Safety & Mission Assurance	NASA KSC
Lennie Duncil	Thermal	NASA KSC
Kristie Durham	Education and Public Outreach	NASA KSC
Mary Faller	LRO Integration Engineer	NASA KSC
Eb Farris	Launch Vehicle Testing	NASA KSC
Daniel K. Foss	Launch Operations Manager	NASA KSC
Aaron Fournier	Ordnance	NASA KSC
Kevin Grelck	LV Software	NASA KSC
Eric Haddox	Orbital Debris Analysis	NASA KSC
Stephen A. Jeffress	Comm & Telemetry	NASA KSC
Mark Jensen	Instrumentation	NASA KSC
Daniel J. Johnson	Atlas Vehicle Systems Engr	NASA KSC
James C. Kinney	LV Loads Analysis	NASA KSC
Susan Lambert	S/C Processing Support Manager	NASA KSC
Cynthia D. Lessne	PIM	NASA KSC
Martin J. Lougheed	Comm & Telemetry	NASA KSC
Jeffrey R. Lyons	Denver Resident Office - Electrical	NASA KSC
Shermane Martino	Budget Analyst	NASA KSC
Sam Michel	S/C Processing Support Manager	NASA KSC
Randall K Mizelle	PIM/COTR	NASA KSC
Tiffany V. Nail	Public Affairs/Outreach	NASA KSC
Gary J. ONeil	Thermal	NASA KSC
Christine A. Pacariem	Electrical	NASA KSC
Michael D. Patton	Comm & Telemetry	NASA KSC
Christopher B. Rawlins	Contamination Control	NASA KSC

Thomas R. Reinarts	LRO-LCROSS Mission Chief Engineer	NASA KSC
Craig Schreiber	Mission Assurance	NASA KSC
Keith M Schuh	Electrical	NASA KSC
Mark D. Shugg	Launch site integration Manager	NASA KSC
George Simone	Centaur Propulsion	NASA KSC
David R. Sollberger	OCE	NASA KSC
Ben Studenski	Budget Office/Fairing Decals	NASA KSC
Charles A Tatro	Mission Manager	NASA KSC
Karl J. Thal	Stress	NASA KSC
Akash V. Vangani	Vehicle Systems Engineer - Lead	NASA KSC
Michele L. Veneri	MGSE and LV Mech Operations	NASA KSC
Martha Vreeland	Education and Public Outreach	NASA KSC
Mic Woltman	Vehicle System Engineer	NASA KSC
James S. Wood	NASA LSP Chief Engineer	NASA KSC
Nate Wood	AE Telemetry	NASA KSC
Tracy Young	Public Affairs	NASA KSC
Redi-Critique		
Tom Rucci	Launch Site Support Engineer	Redi-Critique
ULA		
Pamela K Alstott	Atlas Control Dynamics	ULA
Mitchel C Arnold	Atlas Tiger Team Engineer	ULA
Douglas E Baker	Atlas Range Requirements Lead	ULA
David Ballou	Atlas Cape Ops Contamination Control	ULA
James J Becia	Atlas EMI/EMC Analysis	ULA
Eric Best	Atlas System Software	ULA
Fred Boudreau	Atlas Structural Analysis	ULA
Jason Buchholz	Atlas Contamination Control	ULA
Kathryn Buchholz	Atlas Systems Engineer	ULA
Grant E Colley	Atlas Systems Integration	ULA
Jeffrey S Dekruif	Atlas Thermodynamics	ULA
Gordon England	Atlas Chief Vehicle Engineer	ULA
Donald E Foley	Atlas Systems Integration	ULA
Thomas E George	Atlas Mass Properties	ULA
Richard D Gerberding	Atlas Thermal Control	ULA
Marc A Ginsburg	Atlas Flight Design	ULA

Jeffery R Gonzales	Atlas Aerophysics	ULA
Paul R Gross	Atlas Systems Engineer	ULA
Michael L Grubbs	Atlas Video System Design	ULA
Kevin Harris	Atlas Range Requirements	ULA
Al J. Hegemann	Atlas System Software	ULA
Jeff Holdridge	Atlas Separation System CPE	ULA
Steven W Kuethe	Atlas Contamination Control Lead	ULA
Matthew J Lacy	Atlas RF Systems	ULA
Brian Lathrop	Atlas Mission Design Lead	ULA
David R Lollini	Alas Deputy Integration Mgr	ULA
Marty R Malinowski	Atlas Chief Engineer's Staff	ULA
Dedra M Martinez	Atlas Avionics & Electrical Design Lead	ULA
Brian McGraw	Atlas System Software Mgr	ULA
Kelly McTeer	Atlas P/L Stuctural I/F Design	ULA
Patrick J Murphy	Atlas Payload Ops Engineer	ULA
Ken L Nauta	Atlas Control Dynamics Mgr	ULA
Lars J Onsager	Atlas Mission Design	ULA
Scott Person	Atlas Guidance & Accuracy Lead	ULA
Darrell J Ray	Atlas System Safety	ULA
John G Reed	Atlas Guidance & Accuracy	ULA
Paul A Rizzo	Atlas Ground Mechcanical Design	ULA
James E Rotole	Atlas P/L Stuctural I/F Design Mgr	ULA
Lee E Salem	Atlas Accoustics & Shock Analysis	ULA
Steven P Sakla	Atlas Propulsion Systems	ULA
Dirk U Schreier	Atlas Mission Mgr	ULA
Randal W Smith	Atlas Chief Engineer's Staff	ULA
Antonio M Soto	Atlas Cape Ops Payload Integrator	ULA
Carl D Sterling	Atlas Vehicle Thermal Control Mgr	ULA
Michael C Stitt	Atlas Mission Thermal Control Mgr	ULA
Lee H Terwilliger	Atlas Systems Engineer	ULA
Walter E Thompson	Atlas Mission Design Mgr	ULA
Darin Toronjo	Atlas P/L Stuctural I/F Design	ULA
Phillip D Vanlaw	Atlas Dyamic Loads & Environments	ULA
Randall S Walker	Altlas Integration Mgr	ULA
Reza Zarei	Atlas Ground Mechanical Design	ULA
David H Zimmermann	Atlas Contamination Control	ULA