MSFC-564_Abstract

**The University of Cincinnati**

# Department of Aerospace Engineering and Engineering Mechanics

## Graduate Seminar

## "Is There Water on the Moon? NASA's LCROSS Mission"

*Mr. Steven Noneman*
*NASA's Marshall Space Flight Center*

***Dates:*** November 9, 2007
***Time***: 3:00 - 4:00 p.m.
***Place***: 755 Baldwin

**ABSTRACT**

NASA is preparing for its return to the moon with the Lunar CRater Observation and Sensing Satellite (LCROSS) mission. This secondary payload spacecraft will travel with the Lunar Reconnaissance Orbiter (LRO) satellite to the Moon on the same Atlas-V 401 Centaur rocket launched from Cape Canaveral Air Force Station, Florida.

The LCROSS mission will robotically seek to determine the presence of water ice at the Moon's South Pole. This mission provides a 2300kg (5070 lb) Kinetic Impactor that creates nearly a 1000 metric ton plume of lunar ejecta (more than 200 times the energy of Lunar Prospector (LP)) which will be visible from a number of Lunar-orbital and Earth-based assets. The impact will excavate a much larger area, and the resultant 70km plume will provide a much longer window of observation than would be possible if limited to a 1000kg Secondary Payload impact. The 1000kg Secondary Payload budget is efficiently used to provide a highly modular and reconfigurable LCROSS Spacecraft with extensive heritage to accurately guide the expended Centaur into the crater. Upon separation, LCROSS flies through the impact plume, telemetering real-time images and characterizing water ice in the plume with infrared cameras and spectrometers. LCROSS then becomes a 700kg impactor itself, to provide a second opportunity to study the nature of the Lunar Regolith. LCROSS provides a critical ground-truth for Lunar Prospector and LRO neutron and radar maps, making it possible to assess the total lunar water inventory.

**BIOGRAPHICAL SKETCH**

Steven R. Noneman is the Mission Manager for the Lunar Crater Observation and Sensing Satellite (LCROSS) in Lunar Precursor Robotic Program Office at NASA's Marshall Space Flight Center (MSFC). The LCROSS spacecraft is scheduled to launch in 2008, fly to the moon, and impact a permanently shadowed crater at its south pole in search of water.

He has worked for NASA since 1974. He is a 2006 graduate of NASA's Leadership Development Program that included assignments at NASA Headquarters in the Exploration Systems Mission Directorate and with the RAND Corporation.

He has chaired a Source Evaluation Board responsible for evaluating proposals to select a contractor for the Huntsville Operations Support Center (HOSC) services contract. He was the Lead Engineer for Operations Analysis for the Space Launch Initiative (SLI) in the Systems Engineering and Integration Office. He was the Assistant Group Lead for the Training and Crew Operations Group in the Flight Projects Directorate, and Chief of the Training Branch.

He is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA), and is a member of AIAA's Board of Directors representing the southeastern region of the United States. His education includes a Master of Science degree in Systems Engineering from University of Alabama in Huntsville (1984) and a Bachelor of Science in Aerospace Engineering from the University of Cincinnati (1978).

***Please Post***

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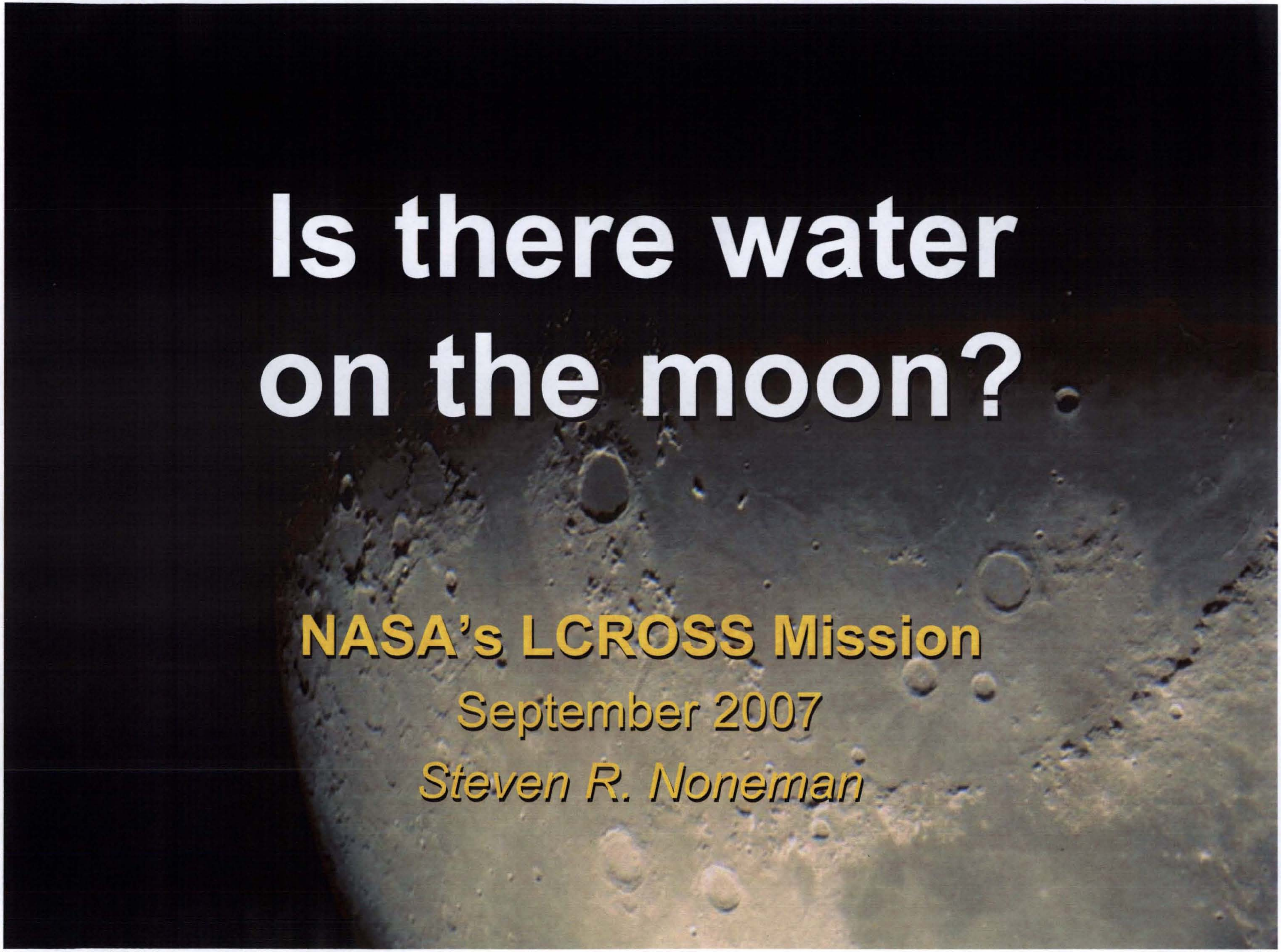


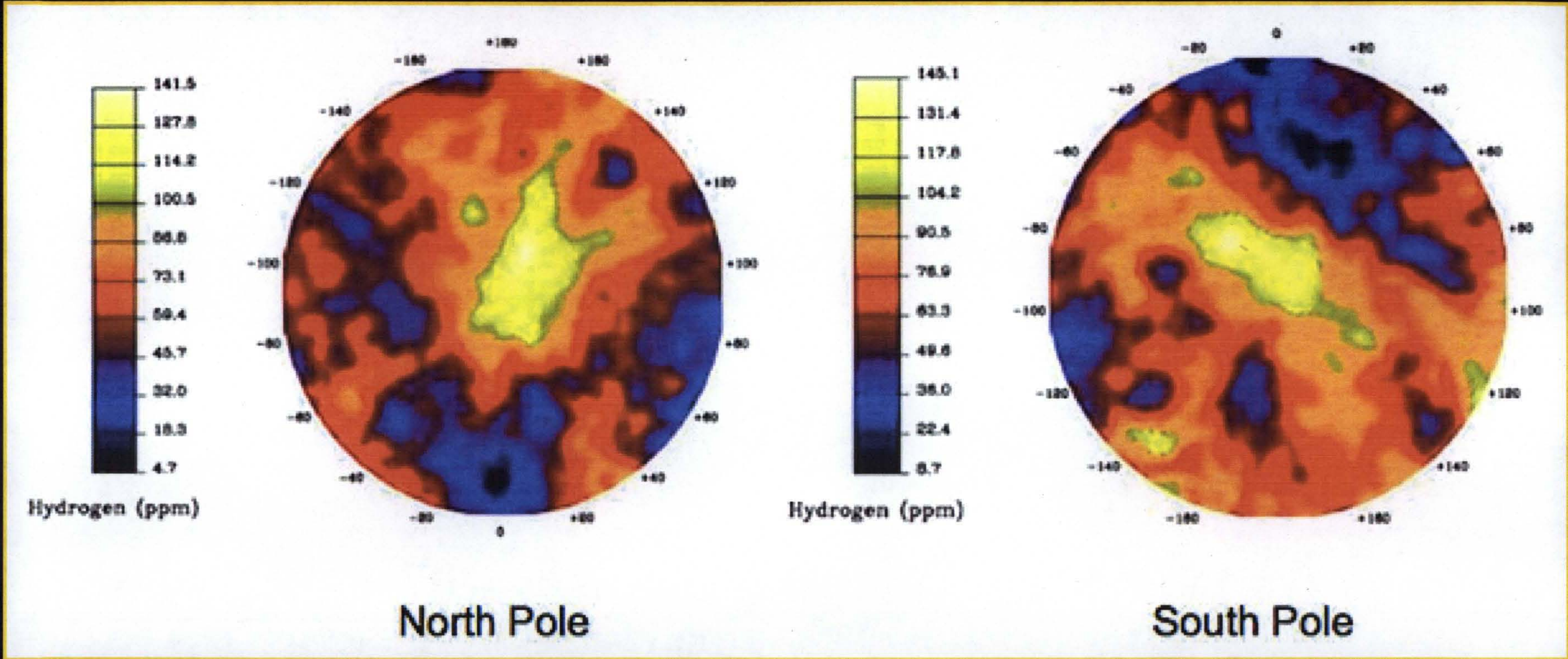
# *We return to the Moon!*

- **The Vision for Space Exploration includes objectives for robotic and human spaceflight:**
  - Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
  - Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- **A lunar outpost is envisioned… but how will it work???**

# *Why look for water?*

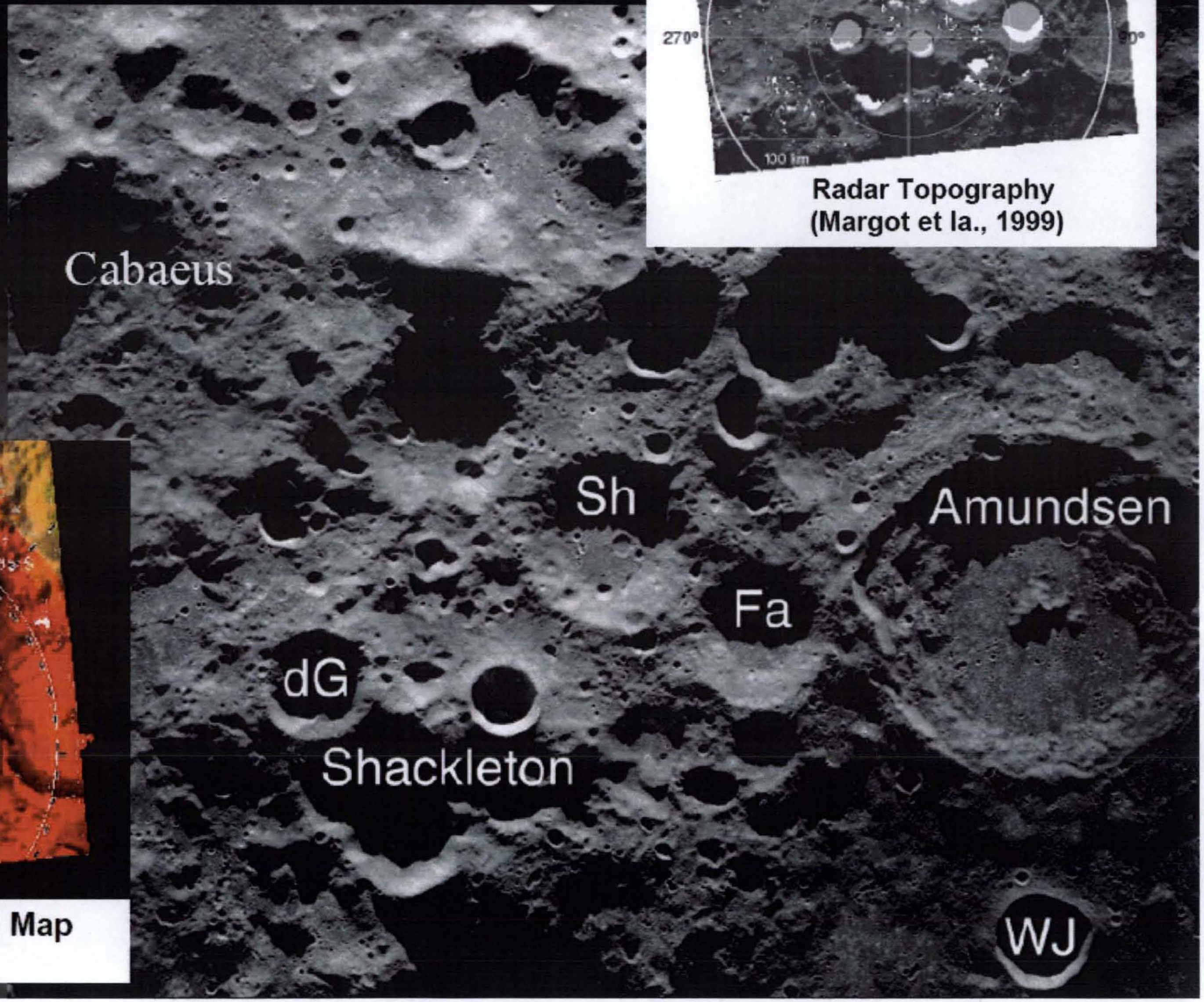
- **Humans at a lunar outpost will need water:**
  - Option 1: Carry it there.
  - Option 2: Use water that may be there already!
- **Carrying water to the moon will be expensive!**
- **Learning to "Live off the land" could make sustainability of a lunar outpost easier and cheaper.**

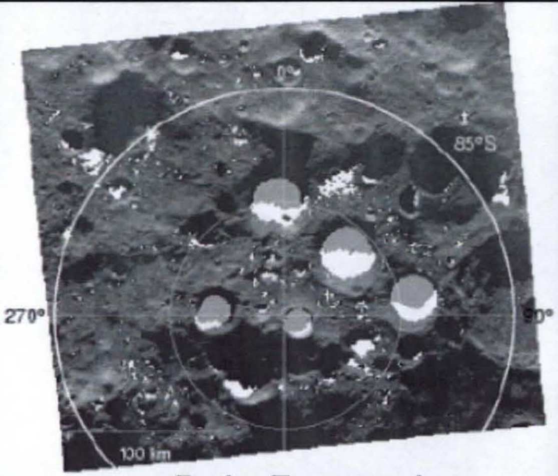
## *Hydrogen has been detected at the poles...*
## *Is it water ice???*



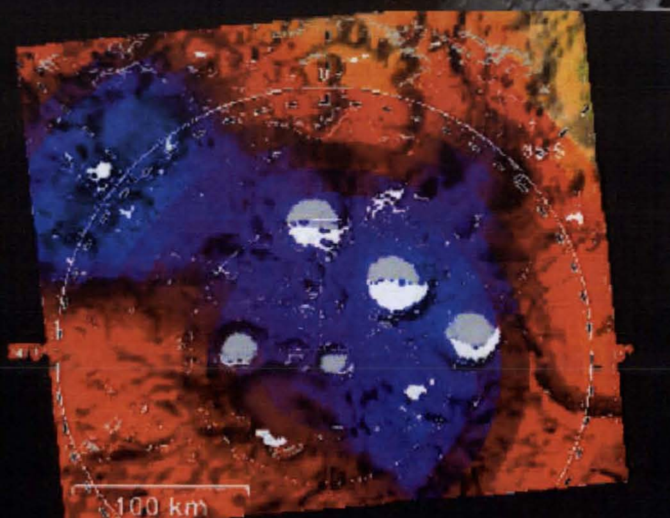

**Lunar Prospector neutron spectrometer maps of the lunar poles. These low resolution data indicate elevated concentrations of hydrogen at both poles; it does not tell us the form of the hydrogen. Map courtesy of D. Lawrence, Los Alamos National Laboratory.**

# *Where will we look?*



**Radar Topography**
**(Margot et la., 1999)**

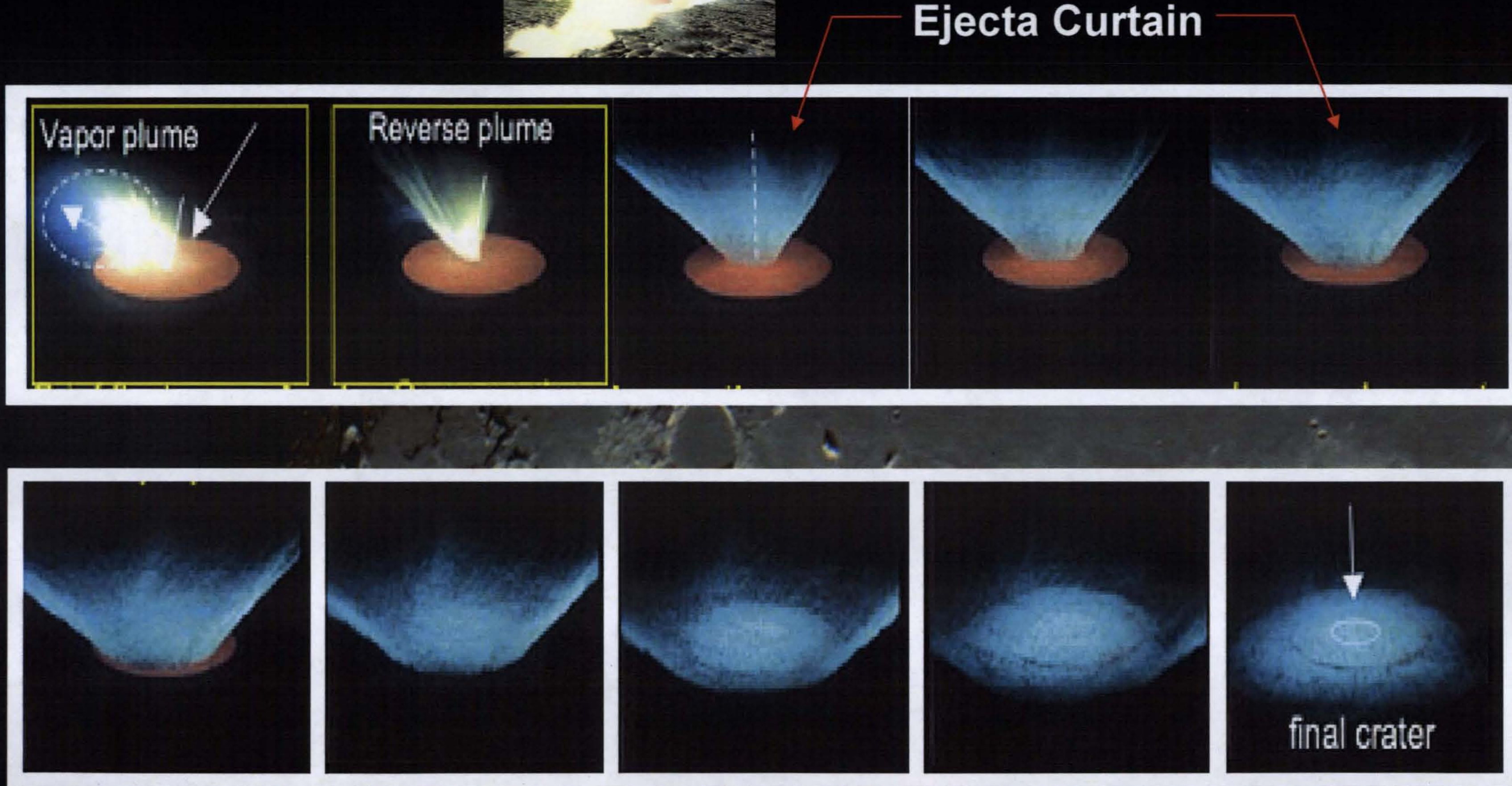


**Lunar Prospector Hydrogen Map**
**(Maurice et la., 2003)**

# How can we look for water?

- **With a robotic spacecraft:**
  - The Lunar Crater Observation and Sensing Satellite (LCROSS)

# Concept




Peter Schultz

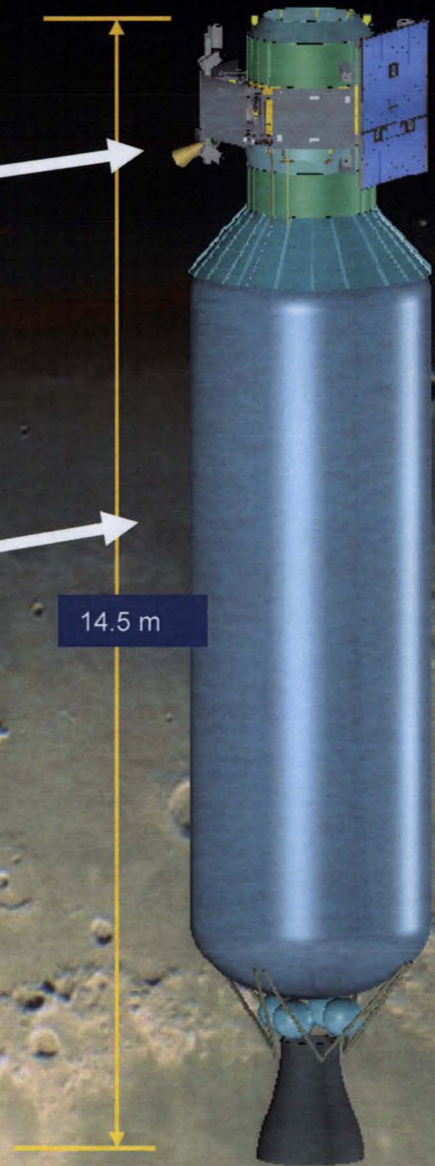
- Impact the moon at 2.5 km/sec with a Centaur upper stage and create an ejecta cloud that may reach 30 km about the surface
- Observe the impact and ejecta with instruments that can detect water

# Instruments

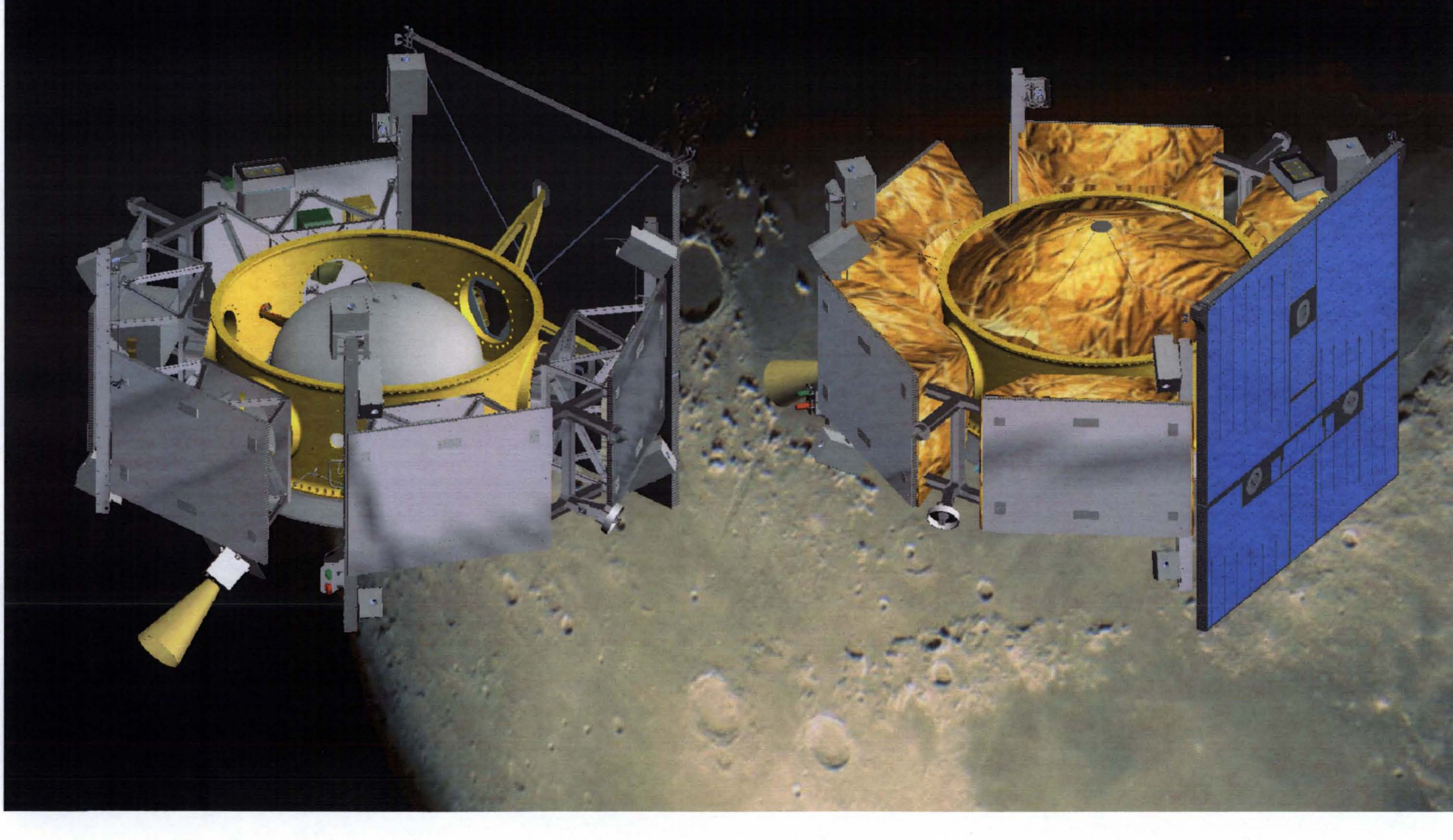
| LCROSS Payload Science Instrument | | Sponsorship | Measurement |
|---|---|---|---|
|  | Visible Camera | Ecliptic Enterprises RocketCam | Visible context imagery; Monitor exacta cloud morphology; Determine visible grain properties |
|  | Near Infrared Cameras | Goodrich Sensors Unlimited SU320-KTX | NIR (1.1-1.7 um) context imagery; Monitor exacta cloud morphology; Determine NIR grain properties; Water concentration maps |
|  | Mid-Infrared Cameras | Thermoteknix MIRIC TB2-30 | MIR (6.5-15 um) thermal image; Monitor the exacta cloud morphology; Determine MIR grain properties; Measure thermal evolution ejecta cloud; Remnant crater imagery |
|  | Visible Spectrometer | Ocean Optics | Visible (260-660 nm) emission and reflectance spectroscopy of vapor plume, ejecta cloud; Measure grain properties; Measure emission H2O vapor disso iation, OH- (308nm ) and H2O+ (609nm ) fluorescence |
|  | Near Infrared Spectrometers | Polychromix | NIR (1.4-2.4 um) emission and reflectance spectroscopy of vapor plume, ejecta cloud; Measure grain properties; Measure broad H2O ice features; Occultation viewer to measure water vapor absorption by cloud particles |
|  | Total Luminance Photometer (TLP) | Ames | Measure total impact flash luminance (400-1000 nm), magnitude and decay of luminance curve |
|  | Data Handling Unit (DHU) | Ecliptic Enterprises | Instrument control and data acquisition |

# *Mission System*

- **LCROSS Shepherding Spacecraft**
- **Centaur Upper Stage**



# Shepherding Spacecraft



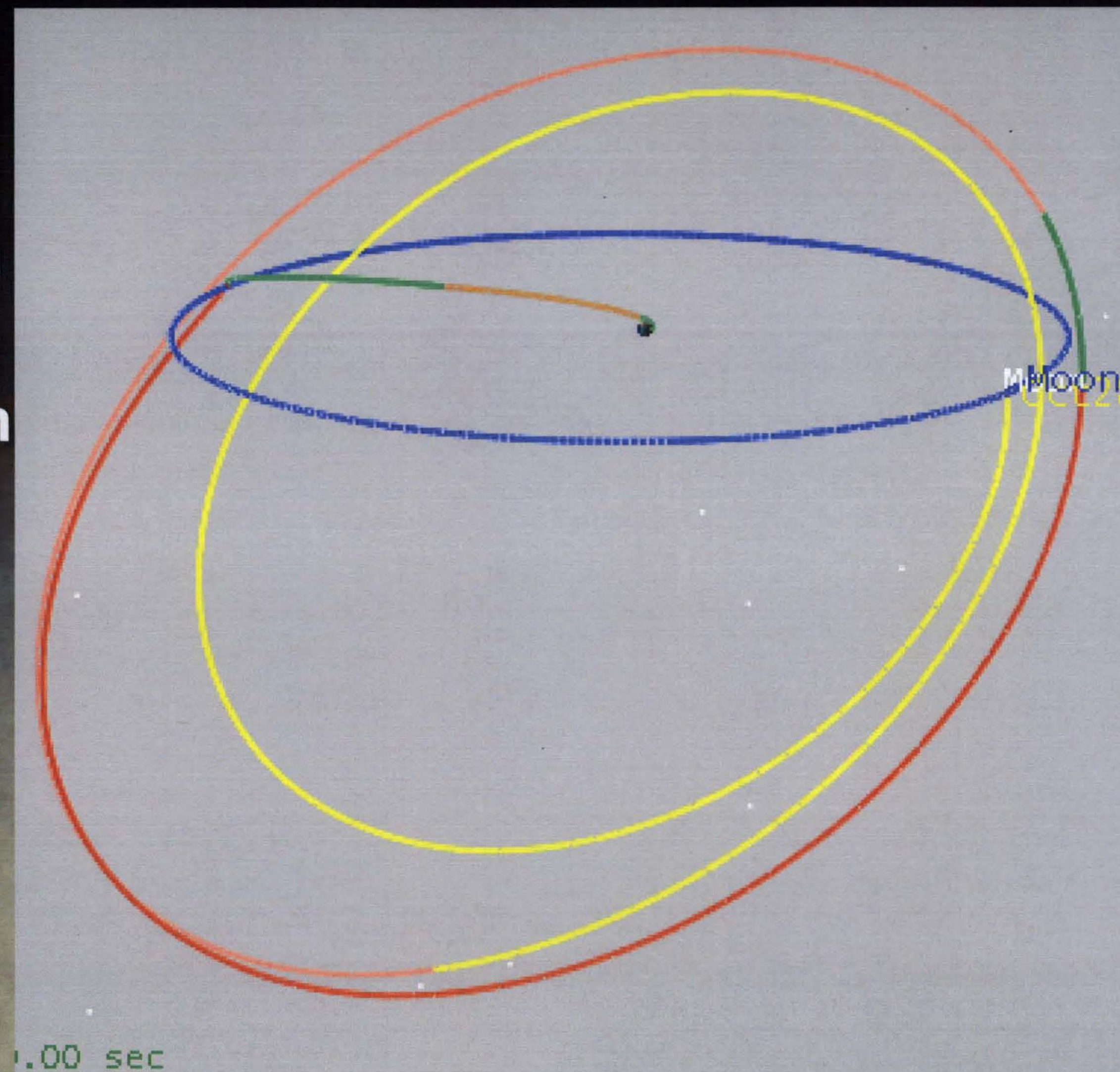
# *Subsystems*

- Command and Data Handling
- Electrical Power
- Thermal Control
- Payload
- Communications
- Propulsion
- Structures
- Attitude Control

| | SV State | | | | | |
|---|---|---|---|---|---|---|
| | Launch | Activation | Cruise | Maneuver | Science | Survival |
| **C&DH** | | | | | | |
| CADH | | | | | | |
| PDE | | | | | | |
| **EPS** | | | | | | |
| PSE | | | | | | |
| Solar Array | | | | | | |
| Batteries | | | | | | |
| **TCS** | | | | | | |
| Operational Htrs | | | | | | |
| Survival Htrs | | | | | | |
| **Payload** | | | | | | |
| DHU | | | | | | |
| Sensors | | | | | | |
| **Comm** | | | | | | |
| Transponder | | | | | | |
| Omni | | | | | | |
| MGA | | | | | | |
| **ACS** | | | | | | |
| IRU | | | | | | |
| Sun Sensors | | | | | | |
| Star Tracker | | | | | | |
| **Propulsion** | | | | | | |
| 5N Thrusters | | | | | | |
| 22N Thrusters | | | | | | |
| 5N Cat Bed Htr | | | | | | |
| 22N Cat Bed Htr | | | | | | |

# *Trajectory*

- 3.5 Month Cruise
- 400,000x700,000km earth orbit
- Flyby of lunar north pole for lunar gravity assisted plane change
- Impacts south pole of Moon.



# Mission Animation

got water?

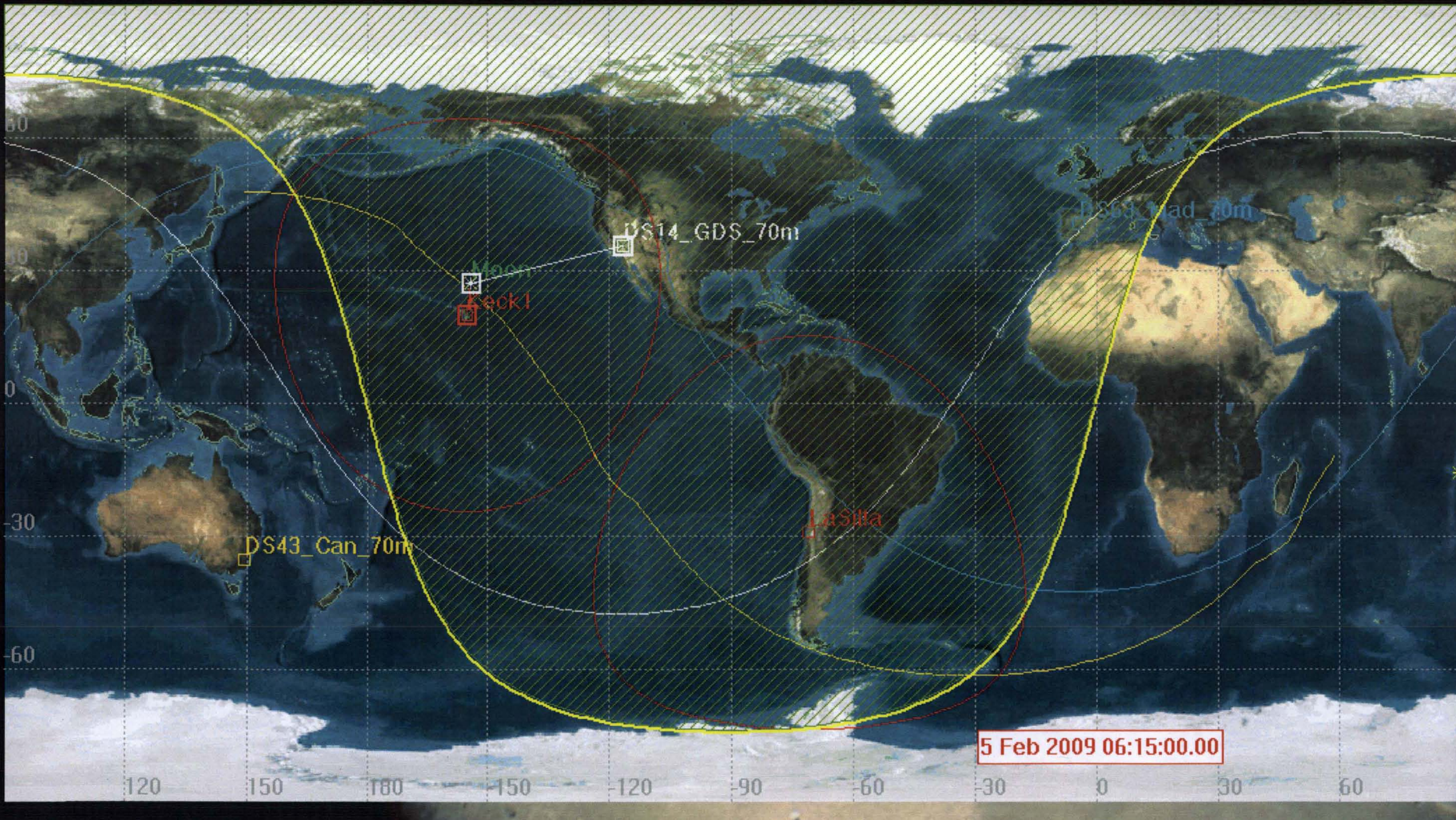
LCROSS

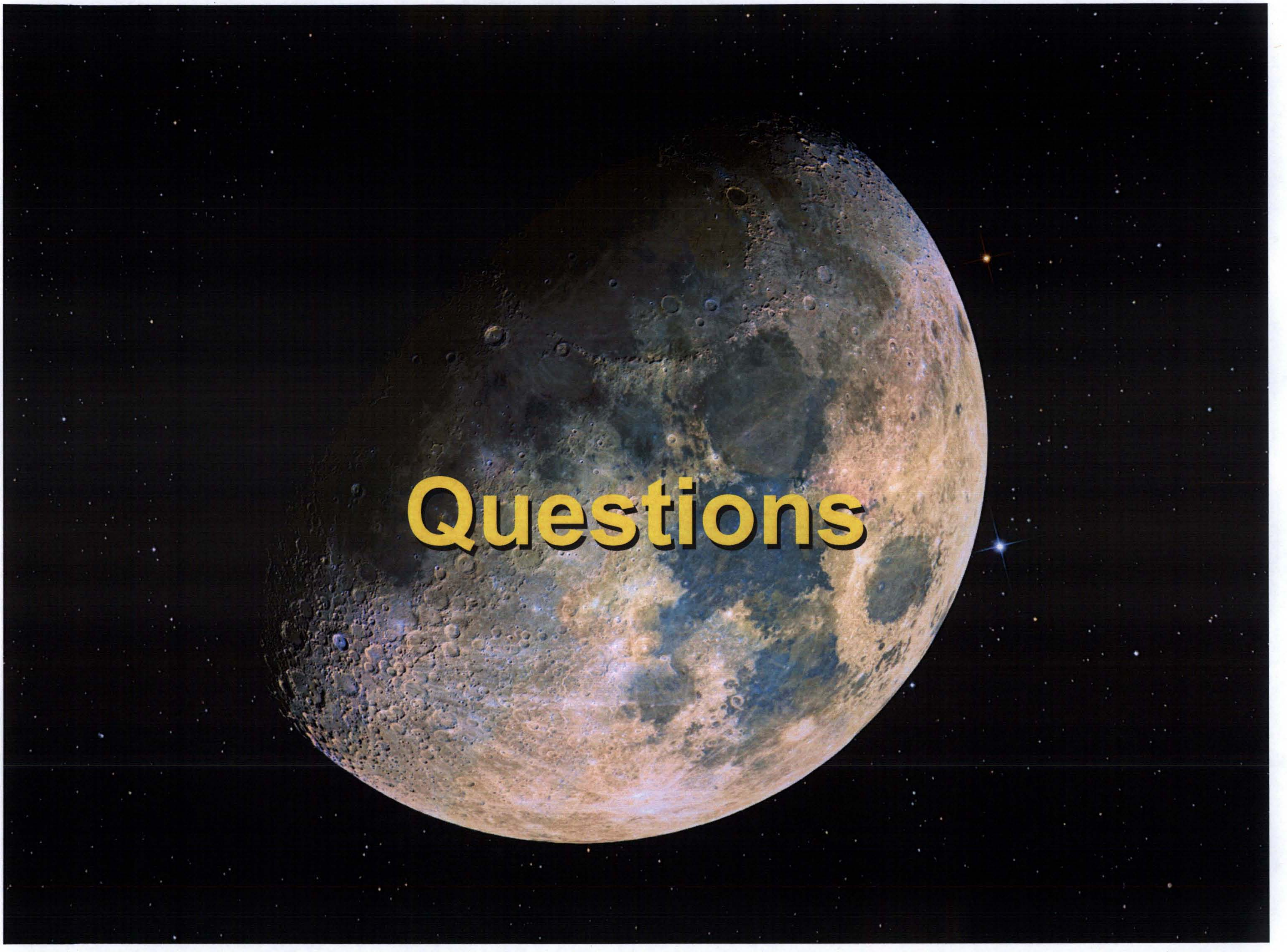
# *Schedule*

- **Launch: October 28, 2008**

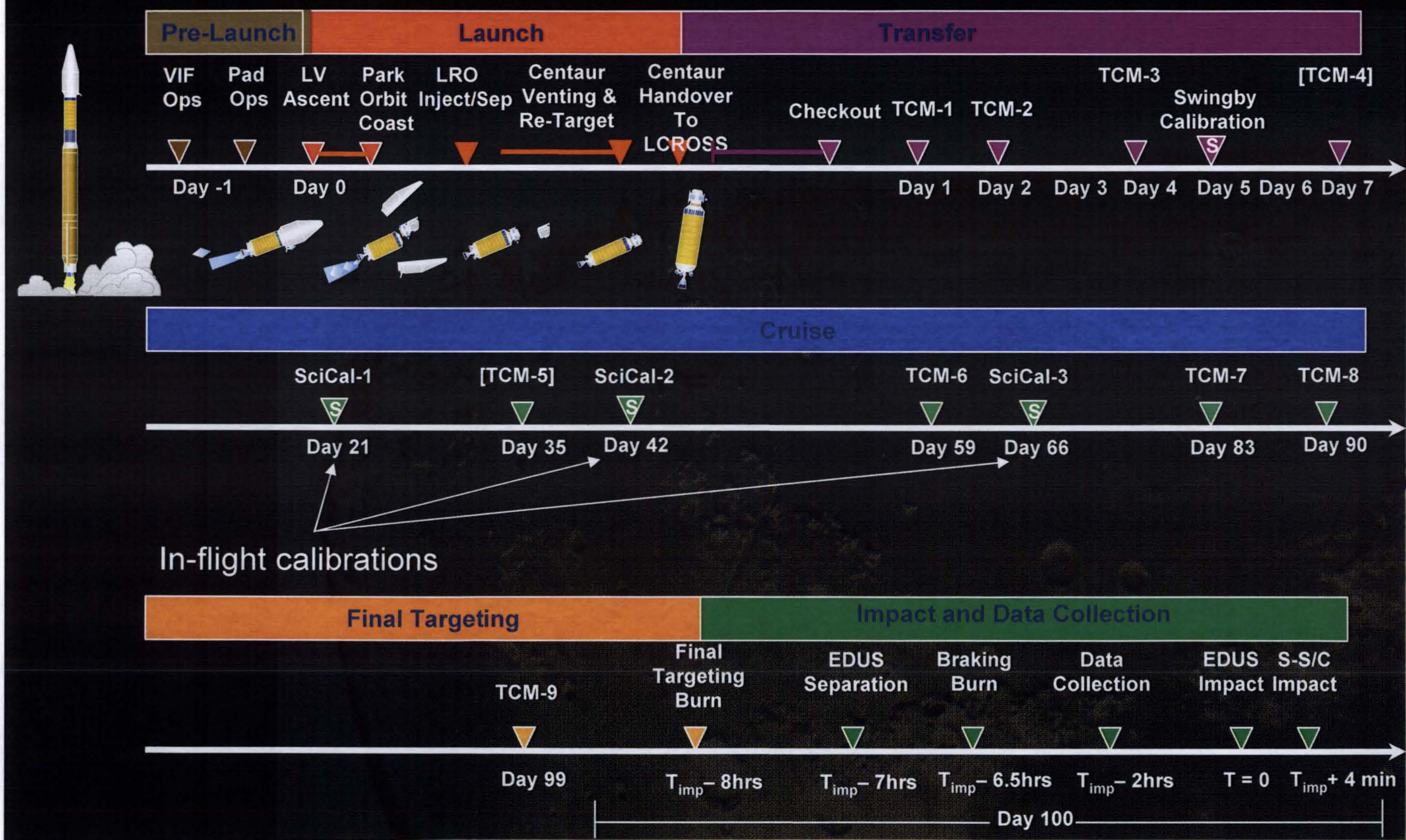
- **Impact: February 5, 2009; 0615Z**
  - Mission duration: 3.5 months
  - Impact angle: ~65 degrees from local horizontal
  - Crater: Faustini

# Oct. 28 Baseline Description: Impact Observation from Earth




Questions

# Baseline Mission Timeline [Oct. 28, 2008 Launch]



# Space to Ground Data Flow Diagram