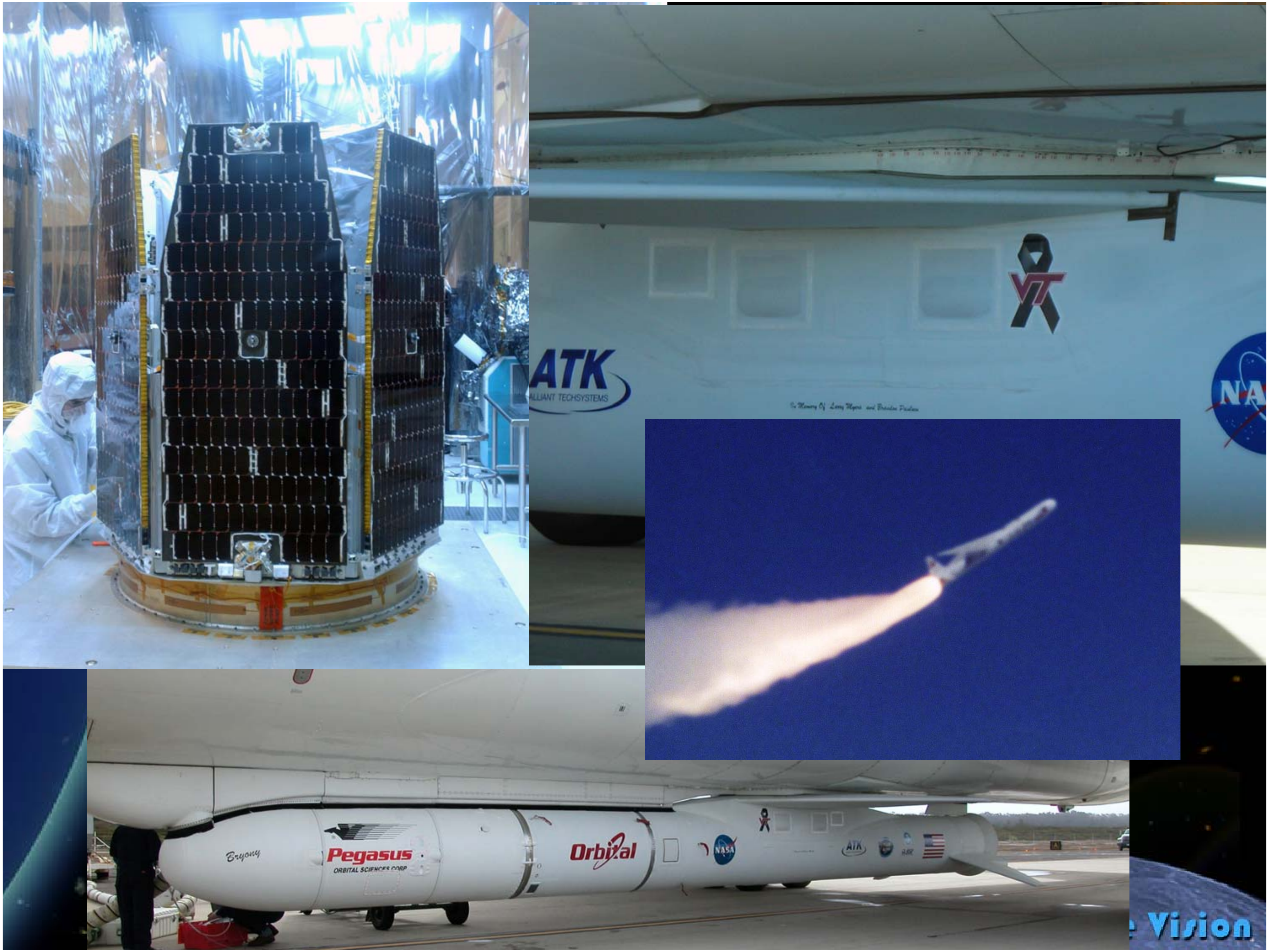

ATK
ALLIANT TECHSYSTEMS
Bryony
Pegasus
ORBITAL SCIENCES CORP
Orbital
NASA
Vision

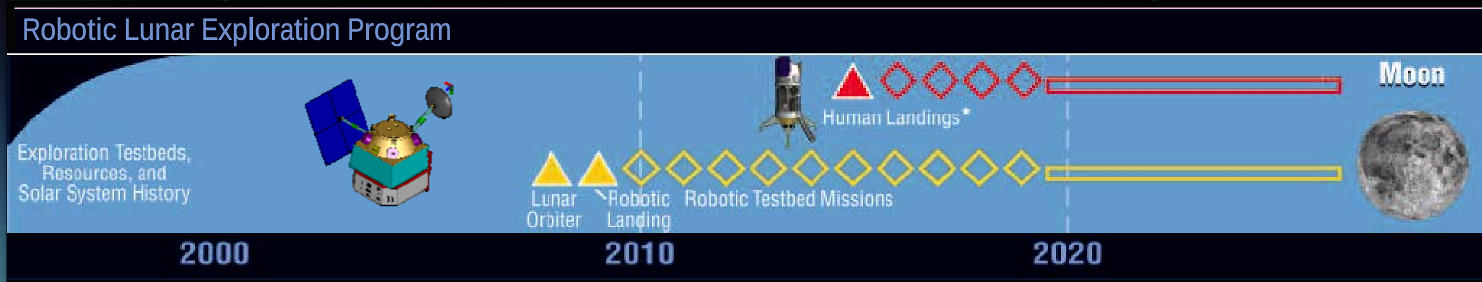
Lunar Reconnaissance Orbiter

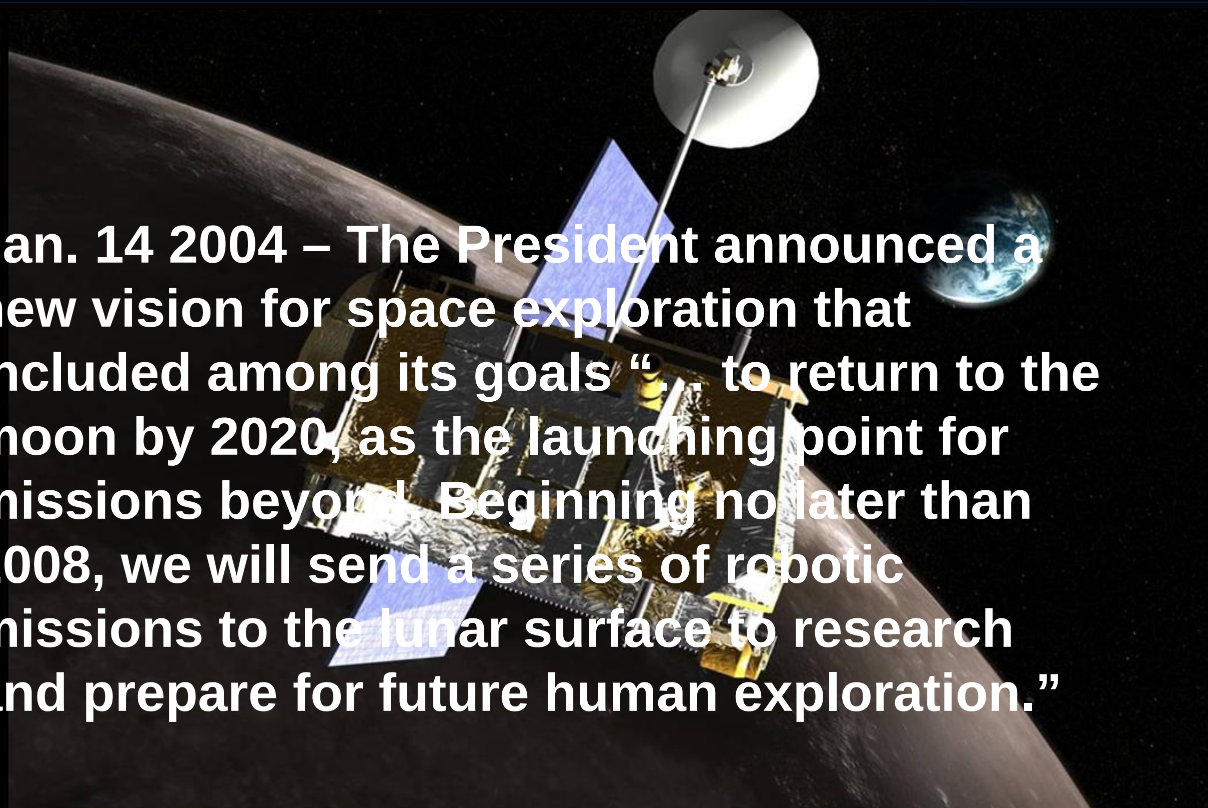
Project Overview & Status

NASA Goddard Space Flight Center
craig.r.tooley@nasa.gov
http://lunar.gsfc.nasa.gov/

Implementing the Vision

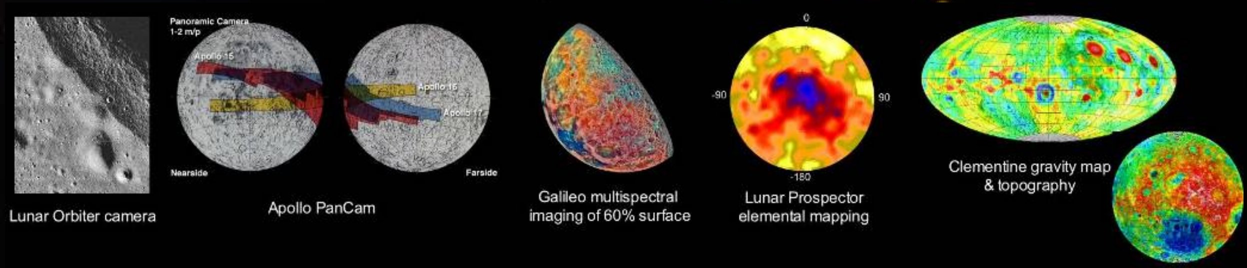
NASA's Vision For Space Exploration
LRO's Role





Jan. 14 2004 – The President announced a new vision for space exploration that included among its goals "… to return to the moon by 2020, as the launching point for missions beyond. Beginning no later than 2008, we will send a series of robotic missions to the lunar surface to research and prepare for future human exploration."

Lunar Reconnaissance Orbiter
Mission Objectives



Objective: The Lunar Reconnaissance Orbiter (LRO) mission objective is to conduct investigations that will be specifically targeted to prepare for and support future human exploration of the Moon.

Locate Potential Resources

Hydrogen/water at the lunar poles
Continuous solar energy
Mineralogy

Safe Landing Sites

High resolution imagery
Global geodetic grid
Topography
Rock abundances

Space Environment

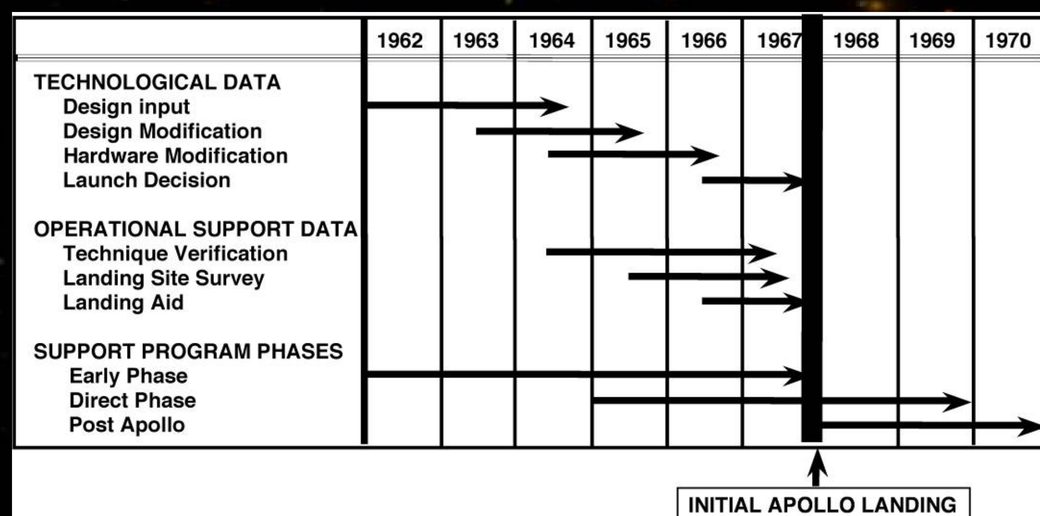
Energetic particles
Neutrons

Implementing the Vision

LRO Follows in the Footsteps of the Apollo Robotic Precursors

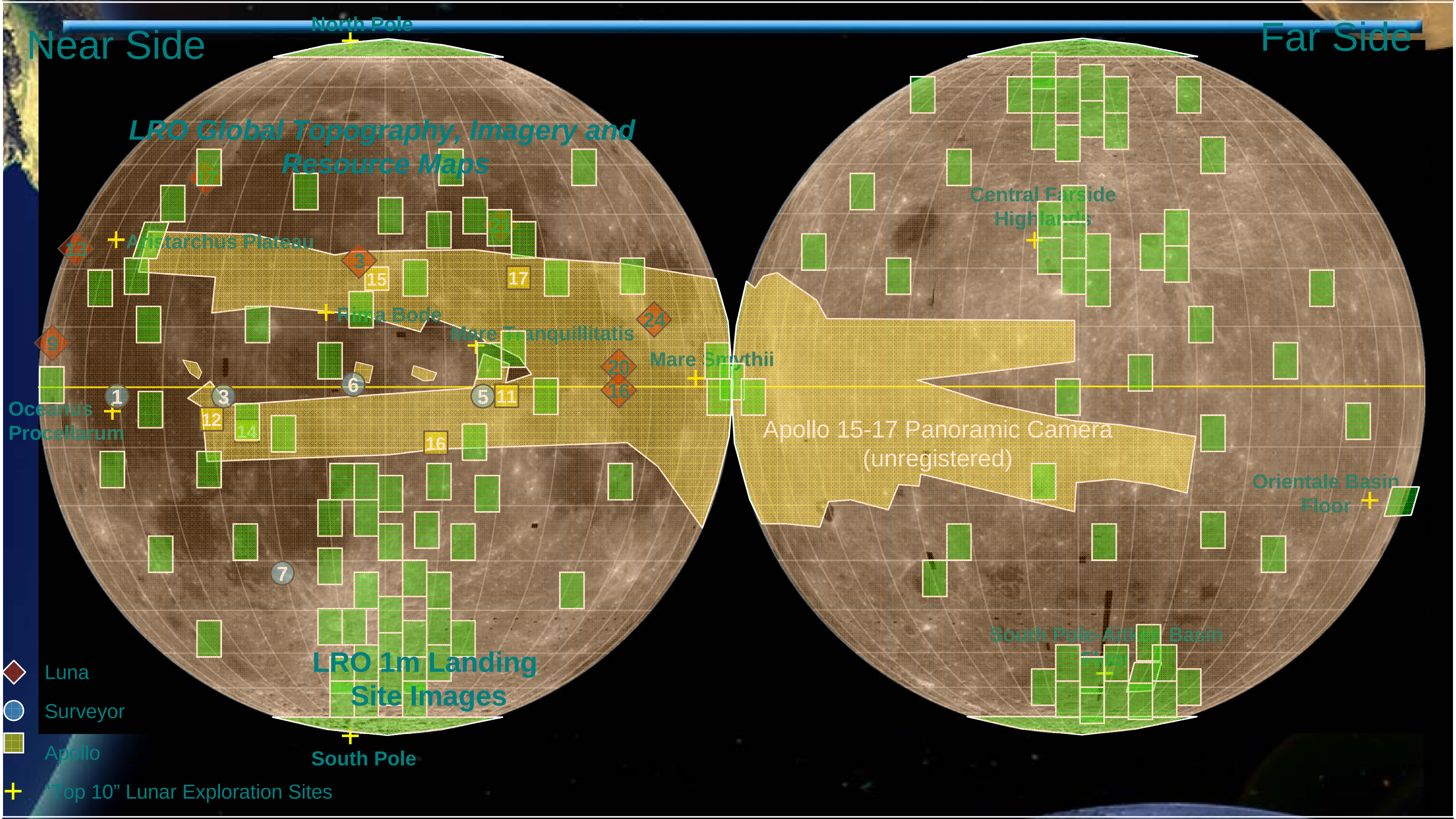
- **Apollo had three (Ranger, Lunar Orbiter and Surveyor) robotic exploration programs with 21 precursor missions from 1961-68**
  1. **Lunar Orbiters provided medium & high resolution imagery (1-2m resolution) which was acquired to support selection of Apollo and Surveyor landing sites.**
  2. **Surveyor Landers made environmental measurements including surface physical characteristics.**
  3. **Ranger hard landers took the first close-up photos of the lunar surface**
- **Exploration needs the above information to go to new sites *and* resource data to enable sustainable exploration.**

Lunar Orbiter ETU in Smithsonian Air & Space Museum, Washington DC



Implementing the Vision

LRO Enables Global Lunar Surface Access



Current Apollo heritage image set only Covers 4 of 10 ESAS sites.

LRO extends coverage to entire Moon

Most other high priority sites identified lie outside Apollo heritage area

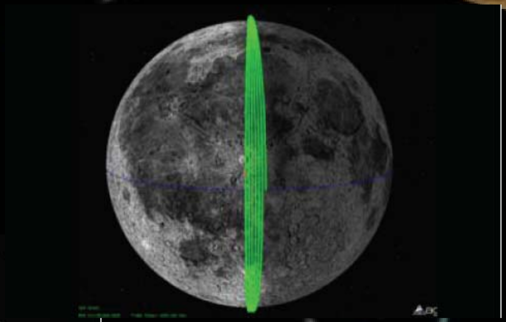
Implementing the Vision

LRO Mission Overview

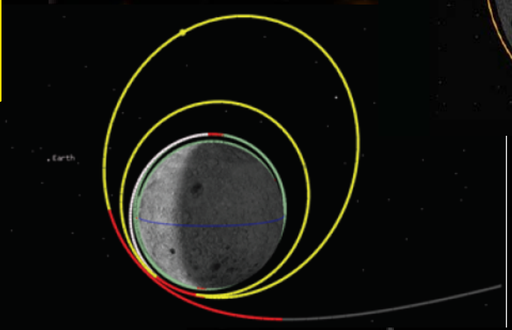
- **Launch in late 2008 on a EELV into a direct insertion trajectory to the moon. Co-manifested with LCROSS spacecraft.**
- **On-board propulsion system used to capture at the moon, insert into and maintain 50 km mean altitude circular polar reconnaissance orbit.**
- **1 year mission with extended mission options.**
- **Orbiter is a 3-axis stabilized, nadir pointed spacecraft designed to operate continuously during the primary mission.**
- **Investigation data products delivered to Planetary Data Systems (PDS) within 6 months of primary mission completion.**

LRO Mission Overview

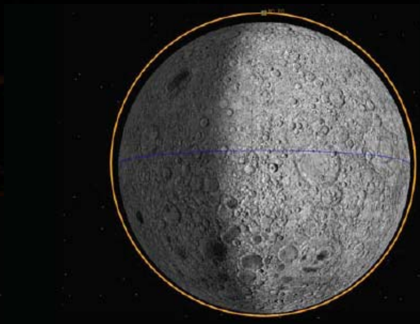
Launch: October 28, 2008



Polar Mapping Phase,
50 km Altitude Circular Orbit,
At least 1 Year

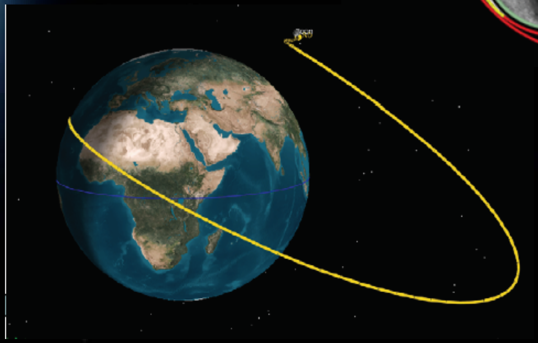


Lunar Orbit Insertion Sequence, 4-6 Days



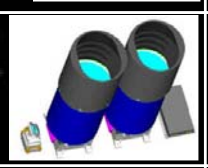
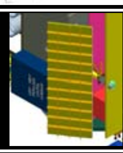
Commissioning Phase,
30 x 216 km Altitude
Quasi-Frozen Orbit,
Up to 60 Days

Minimum Energy
Lunar Transfer ~ 4 Days



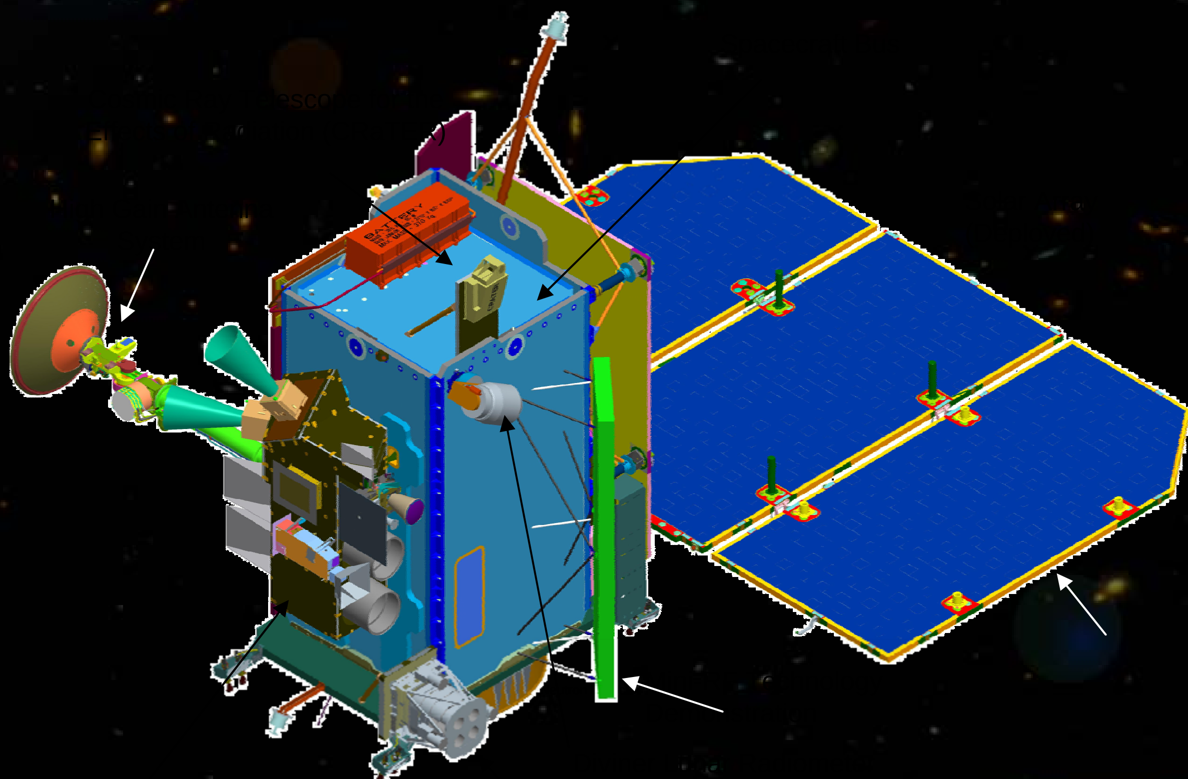
Nominal End of Mission: February 2010

LRO Instrument Summary

INSTRUMENT	SPONSORSHIP	MEASUREMENT	LVL 1 RQMTS TRACEABILITY
CRaTER Cosmic Ray Telescope for the Effects of Radiation 	PI:Harlan Spence, BU IM: Rick Foster, MIT ISE: Bob Goeke, MIT	*Tissue equivalent response to radiation* *LET energetic particle spectra 200 keV – 1 GeV /nuc*	*M10 - Radiation Environment* *M20 - Radiation on Human-equivalent tissue*
DLRE Diviner Lunar Radiometer Experiment 	PI: David Paige, UCLA IM: Wayne Hartford, JPL ISE: Marc Foote, JPL	*Better than 500m scale maps of temperature, rock abundances, mineralogy*	*M50 - Surface Temperatures* *M80 - Surface Features and Hazards* *M90 - Polar Illumination* *M100 - Regolith Resources*
LAMP Lyman-Alpha Mapping Project 	PI: Alan Stern, SwRI IM: Ron Black, SwRI ISE: Dave Slater, SwRI	*UV Albedo maps of the permanently shadowed areas* *Maps of frosts in permanently shadowed areas, 3km resolution*	*M60 – Images of PSRs* *M70 – Subsurface Ice*
LEND Lunar Exploration Neutron Detector 	PI: Igor Mitrofanov, IKI Deputy PI: Roald Sagdeev, UMD IM: Anton Sanin, IKI ISE: Maxim Litvak, IKI	*Maps of hydrogen in upper 2m of Moon at 10km scales* *Global distribution of neutrons around the Moon*	*M10 – Radiation Environment* *M70 – Subsurface Ice* *M110 – Hydrogen Mapping*
LOLA Lunar Orbiter Laser Altimeter 	PI: David Smith, GSFC Co-PI: Maria Zuber, MIT IM: Glenn Jackson,GSFC ISE: John Cavanaugh, GSFC	*~50m scale polar topography at <10cm vertical, and roughness and slope data*	*M30 - Topography Grid* *M40 - Topography Resolution* *M60 – Images of PSRs* *M80 - Surface Features and Hazards* *M90 – Polar Illumination*
LROC Lunar Reconnaissance Orbiter Camera 	PI: Mark Robinson, ASU IM: Scott Brylow, MSSS ISE: Mike Caplinger, MSSS	*1000s^2 of 50cm/pixel images (125km), and entire Moon at 100m visible, 400m UV*	*M40 – Topography Resolution* *M80 – Surface Features and Hazards* *M90 – Polar Illumination* *M100 – Regolith Sources*
Mini-RF *Technology Demonstration* 	POC: Keith Raney, JHU/APL PM: Bill Marinelli, NAWC DPM: Dean Huebert, NAWC	*X&S-band Radar imaging and radiometry*	*P160 - Demonstrate new lightweight SAR Technologies*

LRO Spacecraft

LRO Orbiter Characteristics		
Mass (CBE)	**1823 kg**	Dry: 924 kg, Fuel: 898 kg (1263 m/sec)
Orbit Average Bus Power	**681 W**	
Data Volume, Max Downlink rate	**459 Gb/day, 100Mb/sec**	
Pointing Accuracy, Knowledge	**60, 30 arc-sec**	



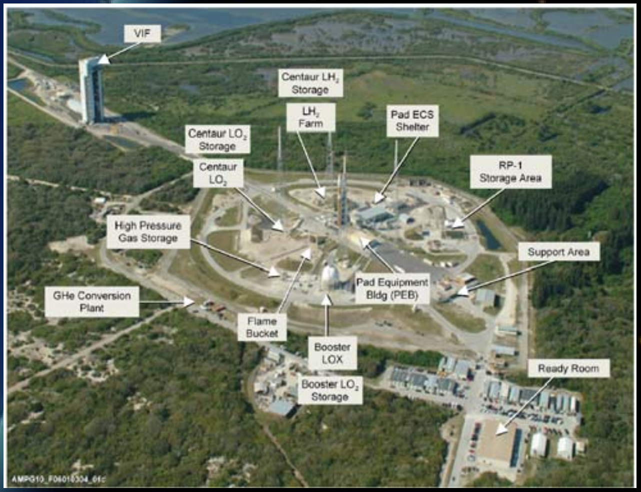
Implementing the Vision

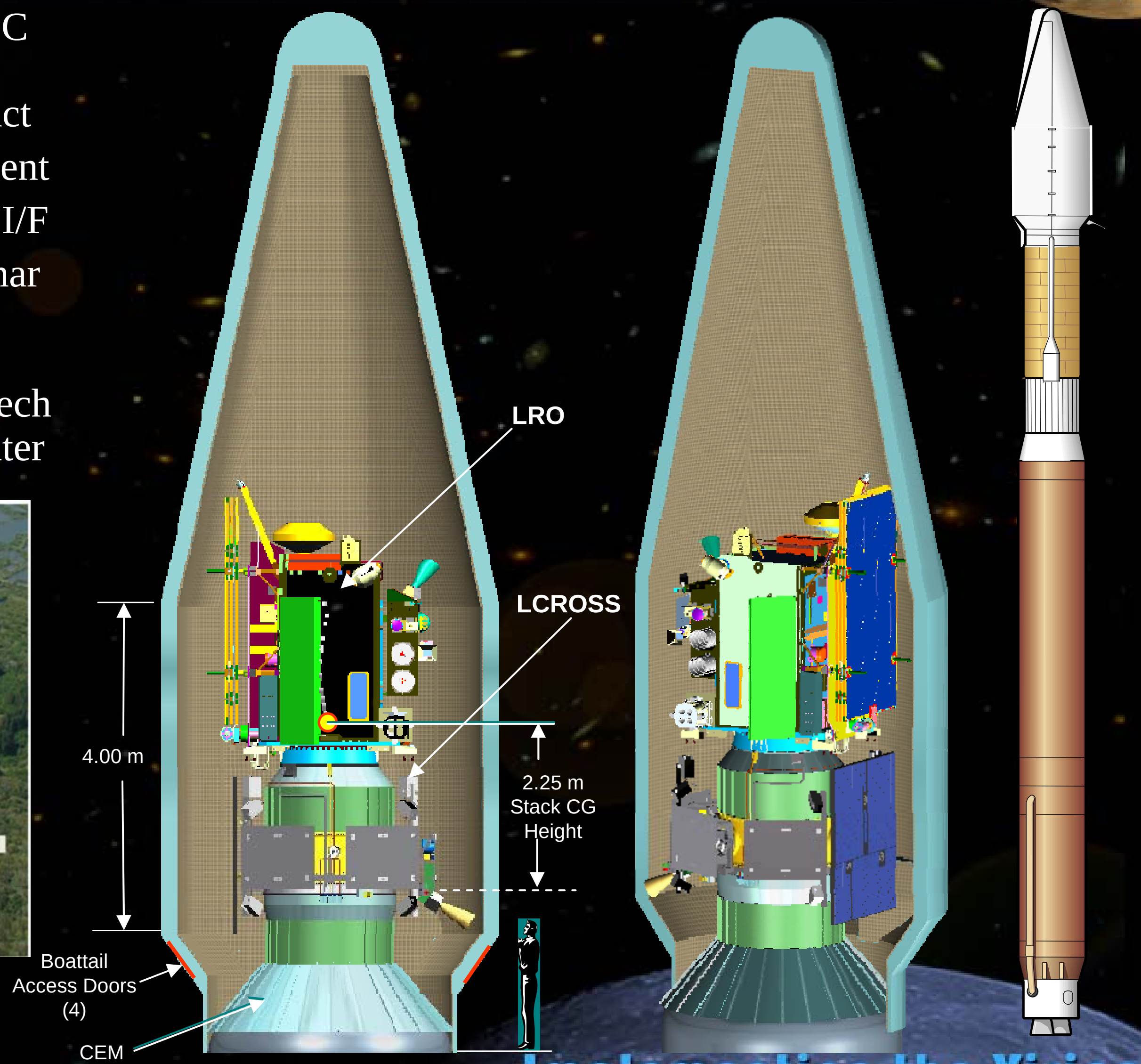
LRO-LCROSS Launch Segment

- Launch Services Provided by KSC

- Atlas V 401 through NLS Contract
- 2000 kg; Sun Exclusion thru Ascent
- 4m fairing; H/K data thru EELV I/F
- Co-manifested with LCROSS lunar mission

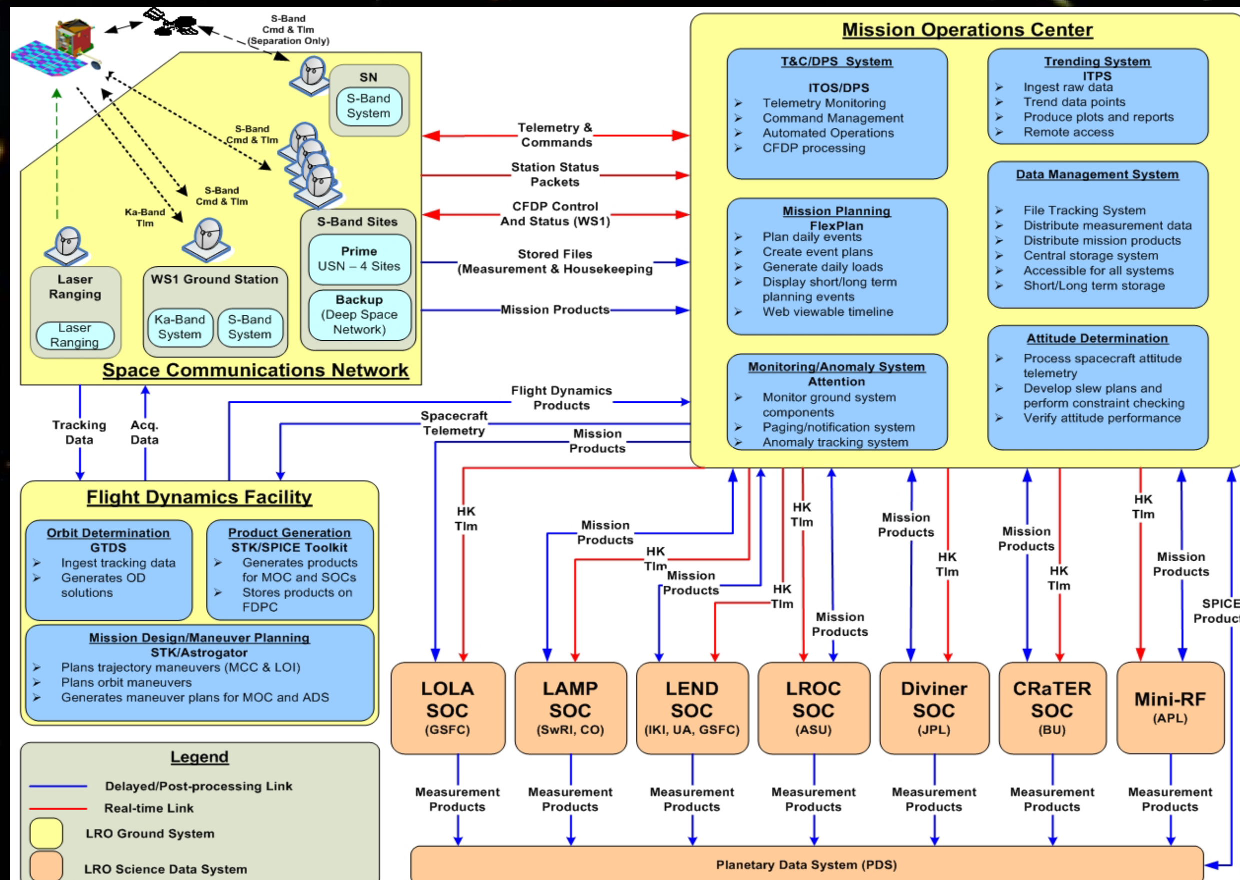
- Launch Site Processing at Astrotech including Fueling & Control Center





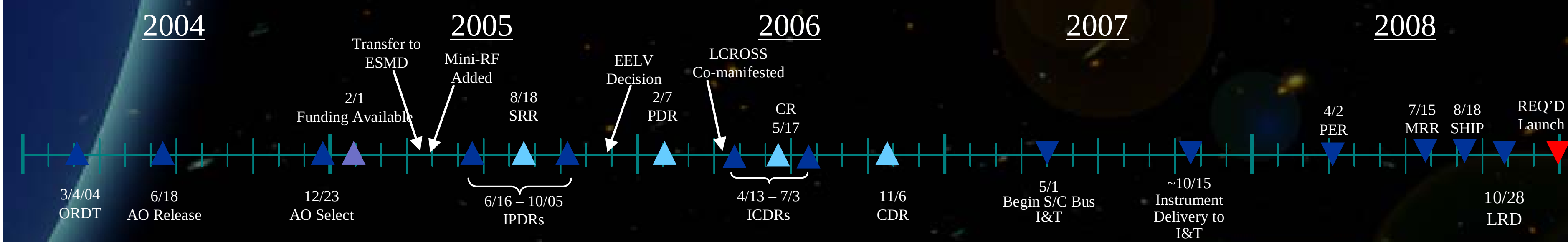
LRO Ground Segment Overview

- Mission Operations Center & Flight Dynamics Facility at GSFC
- Primary Ground Station at White Sands (Ka & S-Band)
- Global S-Band TT&C provided by NASA GN & SN.
- Science Operations Centers (SOC) at PI institutions
- S-band tracking augmented by laser ranging system to improve accuracy.



LRO Mission – Current Status

- The LRO Mission was confirmed in May 2006 and successfully completed its mission CDR in November 2006
- Instruments completed CDRs during Spring and Summer 2006 and are proceeding with fabrication and testing.
- All spacecraft bus avionics are in ETU testing and proceeding toward flight fabrication
- All major procurements (ACS sensors, battery, gimbal actuators, RF systems) are awarded and on schedule for required delivery dates.
- Mission Operations Center being outfitted at GSFC
- White Sands 1 (WS1) Ka-S Band primary ground station under construction
- Project Reserves (Budget, Schedule, Mass, Power) are stable and at acceptable levels.



Implementing the Vision