Lunar Science Program Overview

Jim Adams

Objectives

Lunar Science Organization

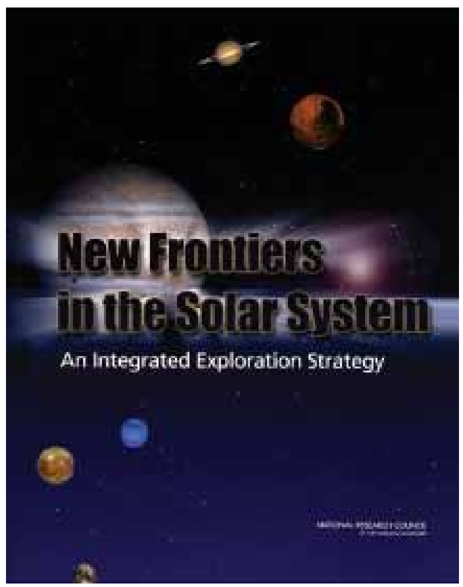
2008 Progress

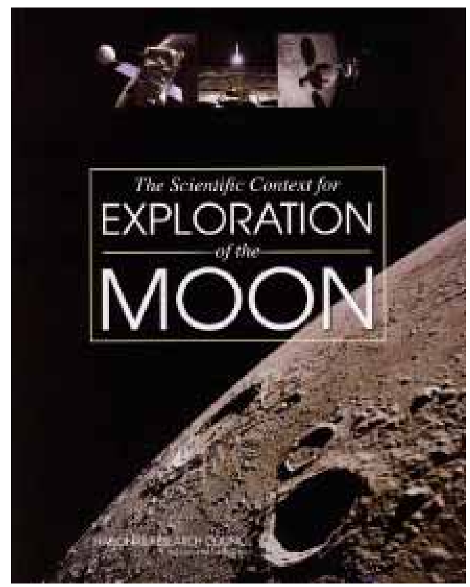
Future

Objectives

- Enhance presence of Science in the implementation of the VSE
- Build a strong Lunar Science Community
- Fly small/medium science missions
- Provide opportunities to demonstrate new technologies

Guided by Decadal Survey and the SCEM Reports





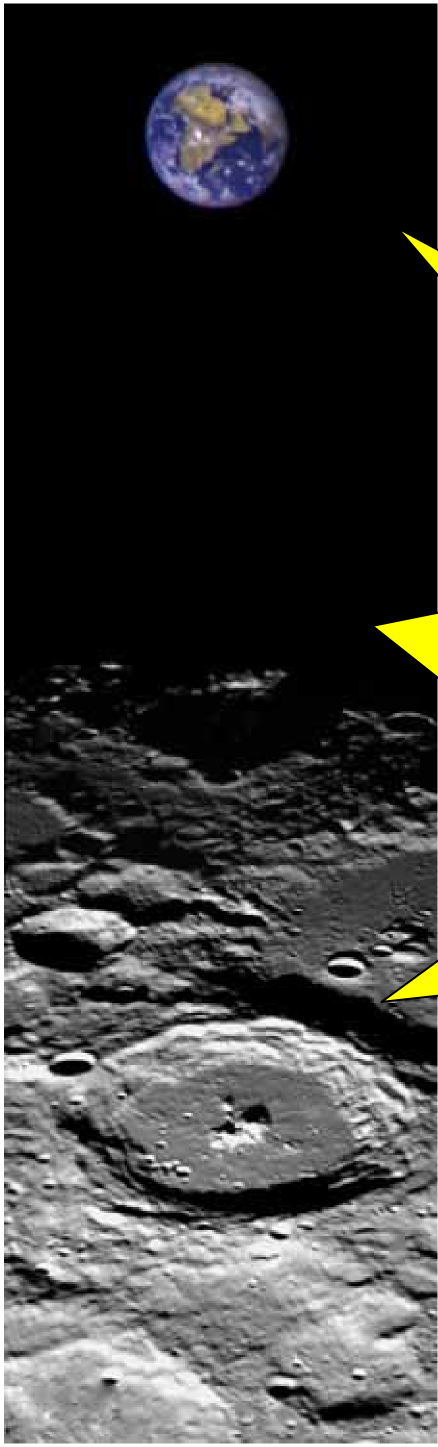
Lunar Science Program

- Perform Lunar Science missions that
  - Target SCEM Prioritized Science Goals
  - Support the National Space Policy
  - Coordinate within NASA (ESMD, SOMD)
  - Offer significant gains in Science Return through international collaboration

- Missions will be Assigned. Science and generally, Science Instruments will be Competed.

- Discovery and New Frontiers, remain open for competitive selection of additional "Category 1" Lunar Science.

- OSEWG (SMD, ESMD and SOMD) to help assure Science access and capability at Outpost, and for sorties.



Lunar Science Organization

Leadership

- Jim Adams, L nar Progra rector
- Tom Morgan ar Pro Scientist

Sup ology

K MA and

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Mission

- Joan te am ive
- Gor n John LRO ram Exec ve
- John McDou MSFC, L ar Program Mgr.
- LADEE assig d to ARC
- ILN assigned MSFC

NEWS!

The MSFC “Lunar Science Program Office” has been renamed “Lunar Quest”

2008 Progress

Science Definition

Research and Analysis

Mission Concepts

International Cooperation

Enabling Technology

LADEE Science Definition Team

SDT Charter

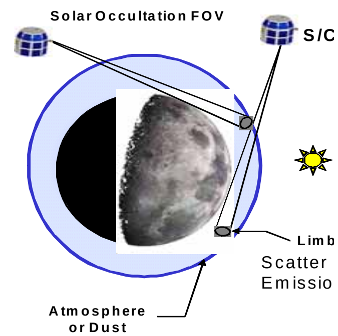
- Devise mission goals and key measurement objectives for LADEE while considering candidate payloads with existing instruments to address the key objectives of atmosphere & dust detection

  The LADEE SDT was Chaired by Laurie Leshin

Neutral Mass Spectrometer

LADEE SDT Accomplishments

- Refined the Science Objectives/Goals to the SCEM
- Optimized mission parameters; defined a mission “floor”
- Defined a “baseline” science mission; provided recommendations for spacecraft, instruments, mission design & project content



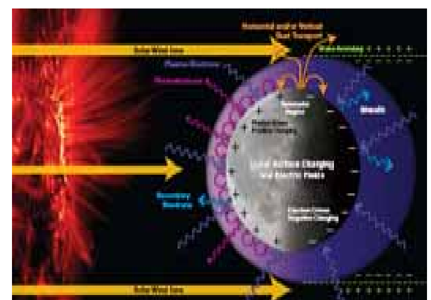
UV/Vis Spectrometer

LADEE Mission Goal

To analyze the Lunar exosphere and dust composition while the Moon is still in a “pristine” state prior to habitation

LADEE SDT Recommendations

- Obtain data from an optimized suite of 3 identified instruments within the 20kg payload constraint
- Perform science investigations in the recommended orbit maximizing passes through the greatest gas concentration
- Fly set of instruments for a minimum of 1 lunation to insure a pass through the magnetotail



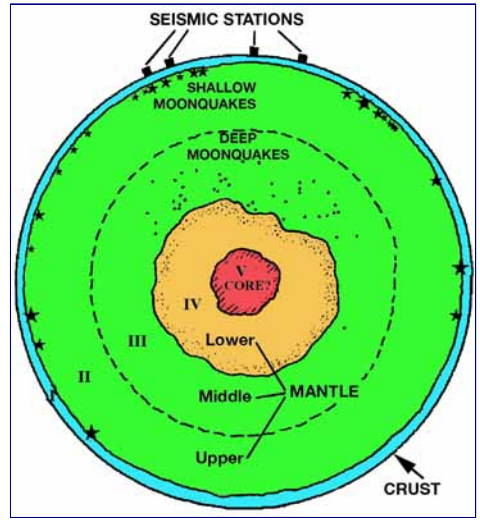
In-Situ Dust Detector

ILN Anchor Nodes

SDT Charter

Address science uniquely enabled by a lunar network by establishing the priority of science & measurement goals; defining the science “floor” and “baseline” missions

The ILD SDT was co-chaired by Joe Veverka & Barbara Cohen



ILN Mission Goal

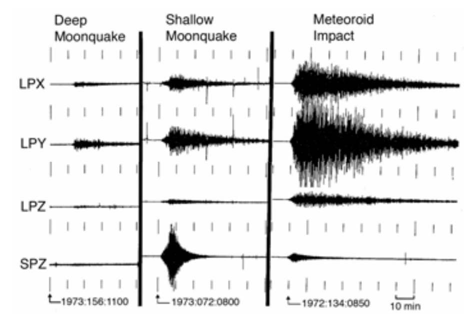
To understand the interior structure and composition of the moon; fundamental information on the evolution of a differentiated planetary body.

ILN SDT Recommendations

Perform four prioritizes science investigations: seismometry, direct heat flow measurements, electromagnetic sounding & laser ranging

Obtain complementary geophysical data from a network of at least four nodes operating simultaneously & continuously for 6 years (1 lunar tidal cycle)

Minimum science (direct investigation of the lunar core) can be accomplished with 2 nodes, carrying only seismometers, operating simultaneously & continuously for 2 years



Lunar Supporting Research & Technology

	Program	Scope	Selec-tions	# of awrds
New Lunar Initiatives	NASA Lunar Science Institute (NLSI)	Interdisciplinary teams - To, From, Of Moon	~ 2-3 yrs	5-7
	Lunar Advanced Science and Engineering Research (LASER)	Basic and applied lunar science	Yrly	~35
	Lunar Sortie Science Opportunities (LSSO)	Packages to Lunar Surface	N/A	14
	LRO Participating Scientists Program (LRO PSP)	Lunar remote sensing	~ 3 yrs	24
	Moon and Mars Analog Missions Activities (MMAMA)	Lunar Science Operations	Yrly	11
Ongoing programs with lunar components	Planetary Instrument Definition and Development Program (PIDDP)	Technology to support lunar science	Yrly	4-7
	Planetary Geology and Geophysics (PGG)	Lunar Geology and Geophysics	Yrly	4-7
	Cosmo Chemistry (Cosmo)	Lunar geochemistry	Yrly	4-7

Highlights:

LASER:

Comprehensive Analysis of Volatiles in Lunar Cold Traps

Impact basins and the evolution of the lunar crust and lithosphere

Lunar Dust Transport: Theoretical models & laboratory experiments

LSSO:

Concept Study for an Autonomous Lunar Geophysical Experiment Package (ALGEP)

Lunar Suitcase Science: A Lunar Regolith Characterization Kit (LRoCK)

MMAMA:

In Situ Mineralogical analysis with CheMin during the Scarab/RESOLVE field expedition

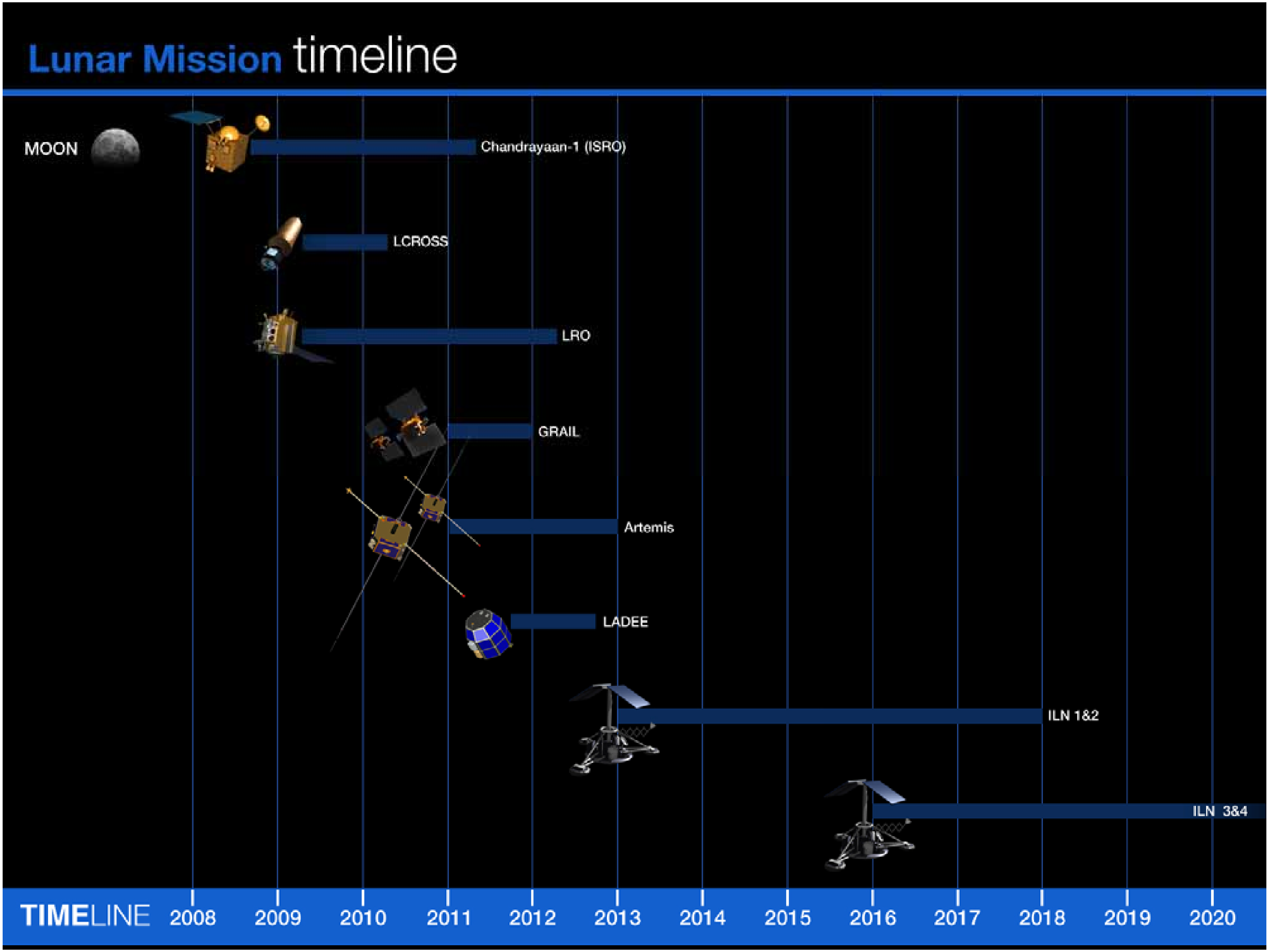
Multispectral Hand Lens and Field Microscope

PIDDP:

A Sensitive Broadband Seismometer for Lunar/Planetary Exploration

International Cooperation

- 12 March 2008:
  - ILN Informational Briefing to Potential Partner Agencies at LPSC (Houston).
  - ILN charter WG formed
- 23-24 July 2008:
  - ILN Charter Signing Ceremony by nine space agencies
  - Initial Meetings of two ILN Working Groups: Core Instrument Definition WG and Navigation and Communications WG
- On-going Work:
  - Chartering and staffing new ILN working Groups (e.g. New Technologies)
  - The Core Instruments Working Group is now developing a "Science Objectives and Measurements" spreadsheet analogous to that developed earlier by the US ILN Anchor Nodes study
- 20 December 2008:
  - ILN Core Instrument Agreement.


Lunar Mission timeline
MOON
Chandrayaan-1 (ISRO)
LCROSS
LRO
GRAIL
Artemis
LADEE
ILN 1&2
ILN 3&4
TIMELINE
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Lunar Atmosphere & Dust Environment Explorer (LADEE)

Science Objectives
- Measure Lunar Dust
- Examine the Lunar atmosphere

Key parameters
- Launch in 2011-2012
- Science Data Acquisition: 3 months

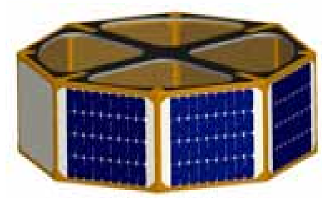
Spacecraft
- Type: Small Orbiter - Category III, Class D
- Provider: ARC and GSFC
- LCC Target: $200M
- (including LV and Technology Demo)

Instruments
- Science Instruments: NMS, UV/VIS, and Dust Detector
- Technology Payload: Lunar Laser Communication Demonstration

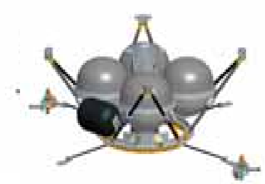
Launch Vehicle: Minotaur V or equiv.

• Bus Module

• Payload Module

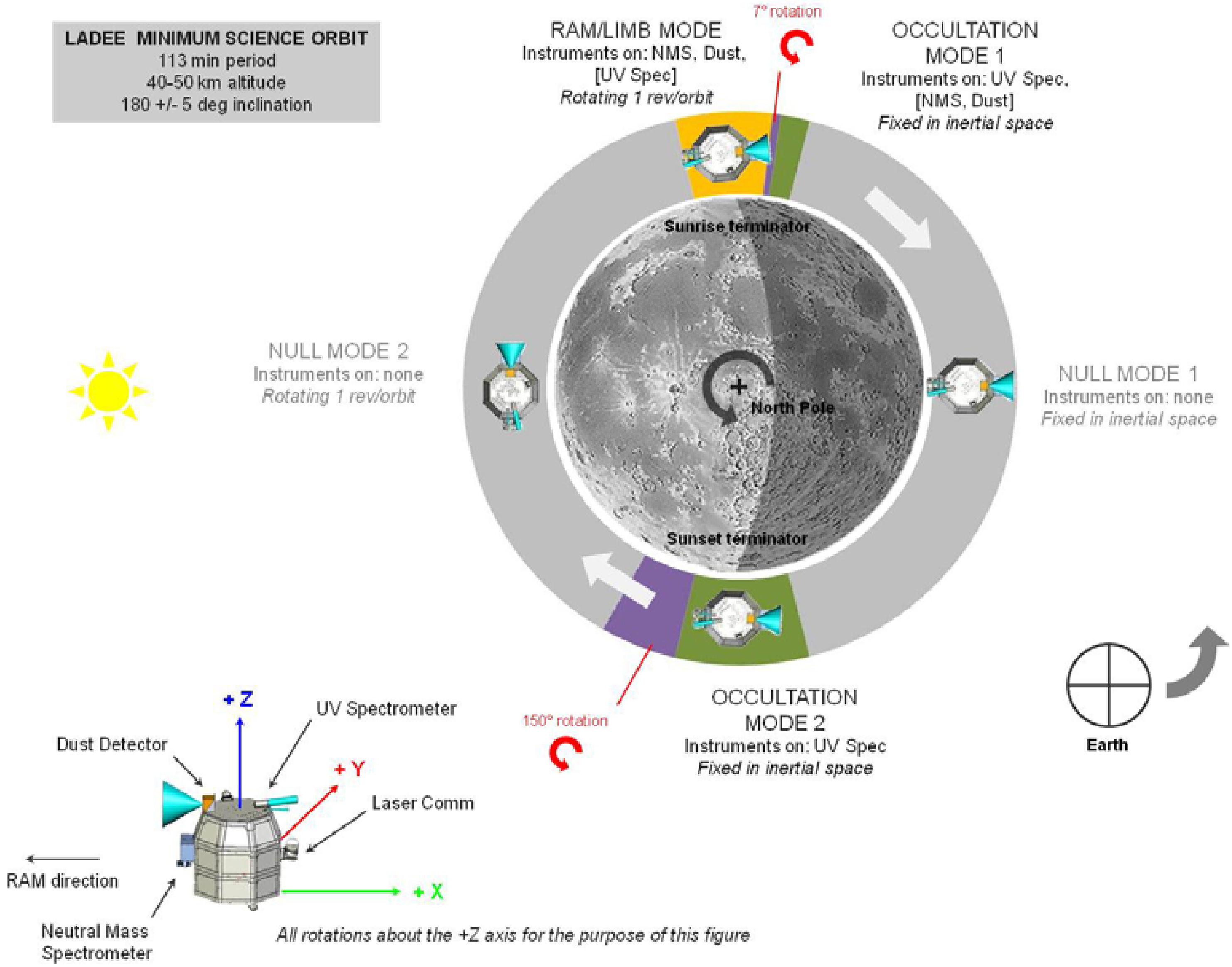


• Extension Module

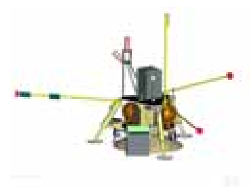
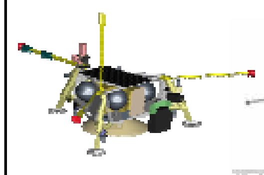
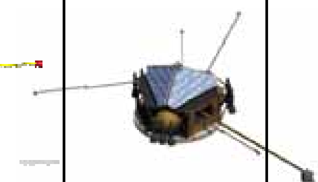


• Propulsion Module

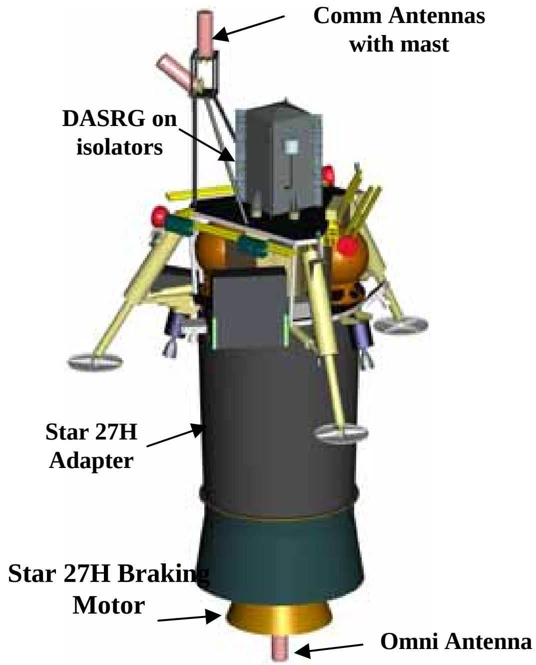
LADEE Science Mission



ILN Anchor Node Trade Studies

	Soft Landers				Hard Lander	
	Case 1	Case 2	Case 3	Case 4	Case 5	
Architecture						
Measurement Objectives	Floor / Baseline	½ Floor	Floor / Baseline	Floor / Baseline	Seis, EM, Rr	Heat Flow
Lander Dry Mass / lander (% margin)	152 kg (35%)	116 kg (21%)	255 kg (40%)	365 kg (30%)	365kg (14%)	28kg
Trajectory Approach	Direct	Direct	Direct	Direct	Direct	
Launch Vehicle Landers / launch	Taurus II:2 landers Delta II: 2 landers Falcon 9 B1: 2 landers Atlas V: 4 landers	Min V 1 lander	Falcon 9 Block 1 or 2 2 landers	Falcon 9 Block 2 2 landers	Falcon 9 Block 2 2 landers	
Power source	DASRG	DASRG	DASRG	Battery/SA	Battery/SA	Battery
Landing Propulsion	MMH/NTO	MMH/NTO	MMH/NTO	MMH/NTO	N2H4	none

Lander Summary



Case 1 Lander with Baseline Science Instrument Suite

<u>Payload(s) operate continuously</u>

Seismometer isolated from lander
EM sounder deployed on 4 booms
Mole deployed from side of lander
Passive retroreflector pointed to

Provides 21kg mass and 16W power for Payloads, Accommodations and Margin

Direct trajectory to moon with solid stage providing braking burn.

Structure includes composite decks and metal landing legs for soft landing.

Liquid bi-propellant landing using lightweight DACS thrusters and custom tanks.

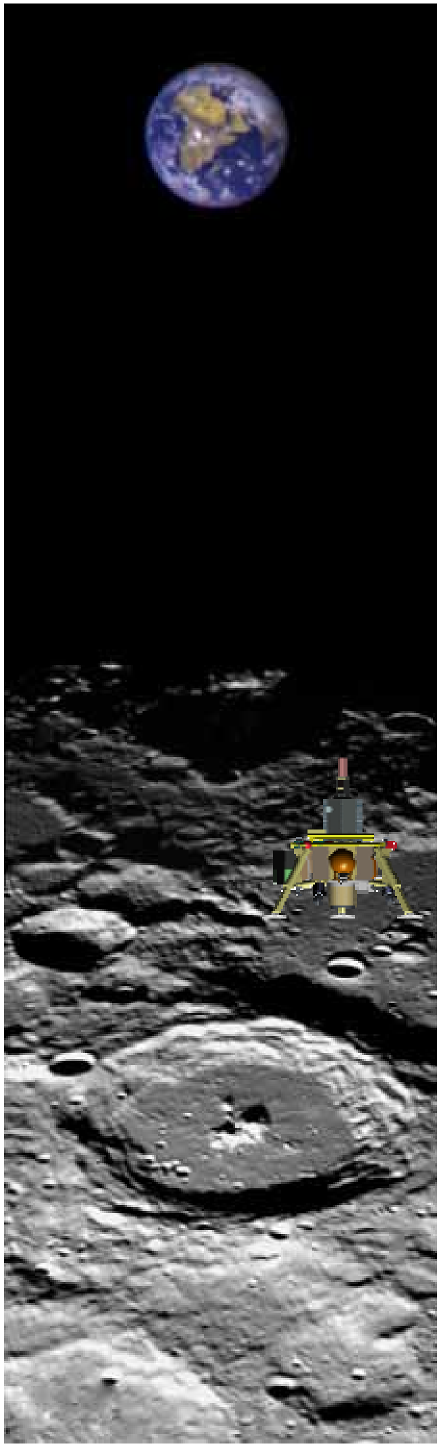
Power provided by Derivative ASRG (DASRG) nuclear power source with small batteries to handle peak power.

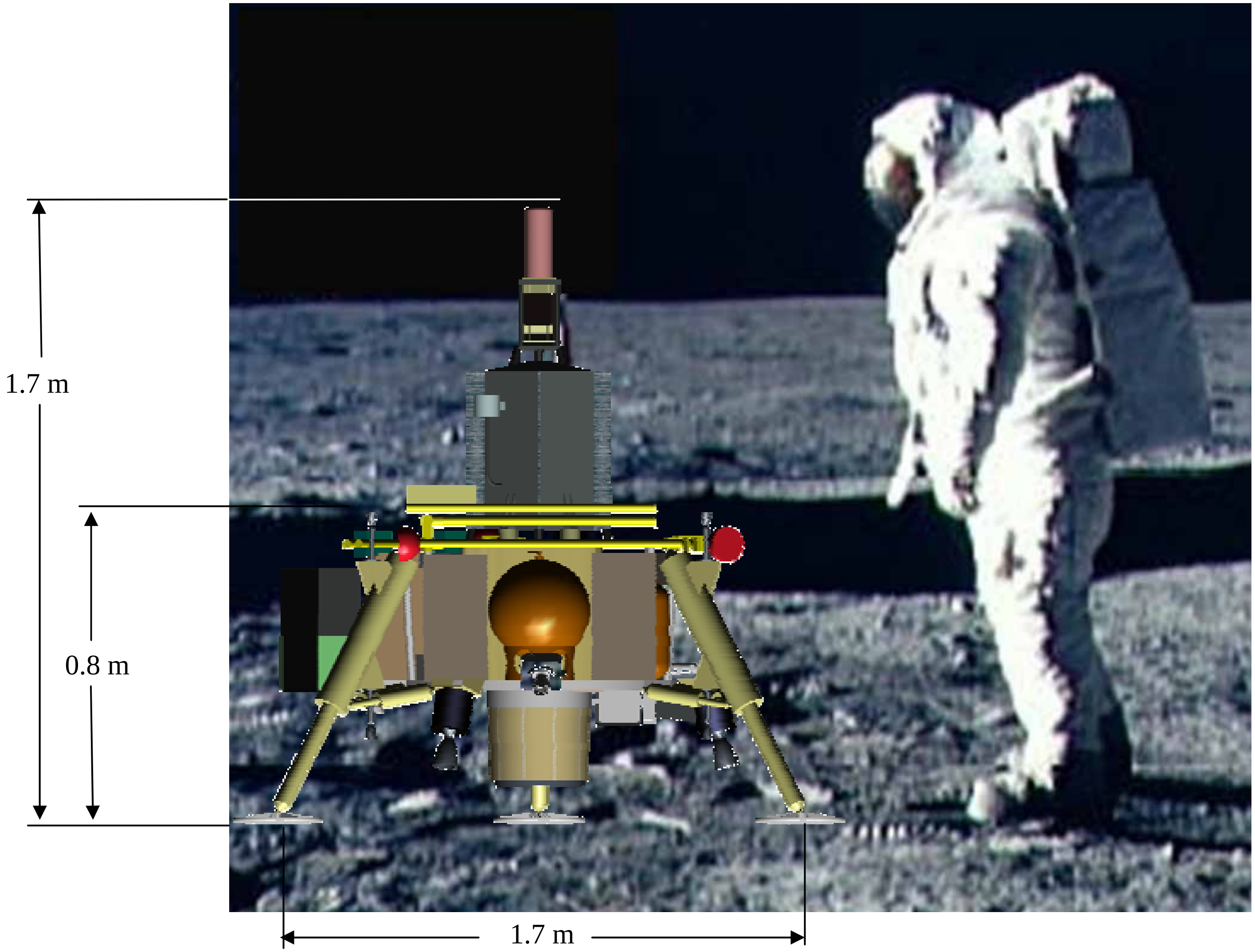
Daily data transmission to DSN

Small warm electronics enclosure with heat pipes & radiator requires no heater power on surface.

Landing cameras for horizontal velocity, drives sunlit landing (3-4 day launch window).

Case 1: Stowed Configuration

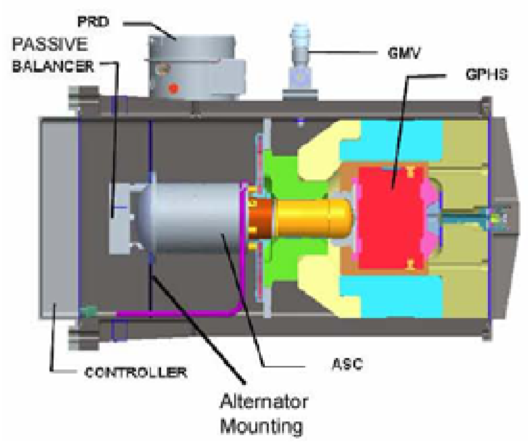




Flight Technology Investments

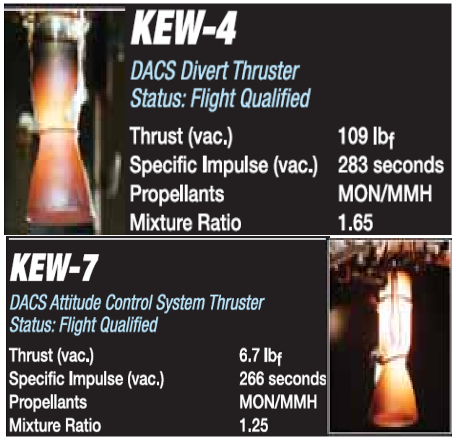
Small RPS

Based on Stirling Technology

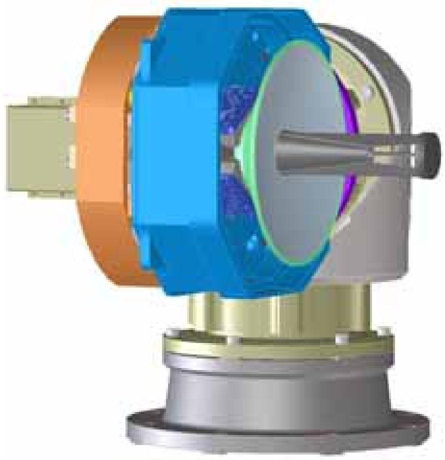


Meets 60 We power requirement
Provides reduced power system mass to enable lowest mass lander

Near-COTS DACS Thrusters



High thrust-to-weight ratio thrusters enable lowest mass lander and less thermal energy requirements.



Lunar Lasercom Demonstration (LLCD)

LLCD will demonstrate a high bandwidth space to ground link using a reliable optical terminal
51-622 Mbps xmt, 16 Mbps rcv

Future: 2009 Goals

- Chandrayaan-1/MMM to map the Moon
- NLSI In Place with 3-5 Nodes
- LRO/LCROSS to Launch
- LEAG Lunar Roadmap (feeds next Decadal Survey)
- Grail Confirmation
- LADEE PDR
- International Lunar Network; Meets 1Q 2009
  - Comm & Inst's Working Group Reports
  - Stand-up Landing Site Working Group
- ILN Anchor Node Project KDP-A
- OSEWG to Facilitate Science in Constellation
- Start Small RPS Effort


Thank You!

Setting Priorities for Lunar Science

- The Decadal Survey – “New Frontiers in the Solar System” (2003) provided a community-based weighting of Science Priorities across the Solar System and including the Earth’s Moon.
- The Decadal Survey preceded the announcement of the VSE (now NSP) and a new National Academies Effort was commissioned to examined the new possibilities for science provided by the VSE.
- “The Scientific Context for Exploration of the Moon” (2007) summarized the post-VSE adjustments.
- The SCEM report **does not invalidate the scientific weighting of the DS**, but examines the additional opportunities for achieving those scientific objectives within the National Space Policy.
- Science Concepts (8) in the DS are divided into 35 “Science Goals”, and 11 of these were prioritized **for the near term**.
- The post DS Academies study on the New Frontiers Program provides additional perspective on the role of Network missions as a tool for understanding the interiors of the inner planets.