Science Mission Directorate

Plans for an International Lunar Network

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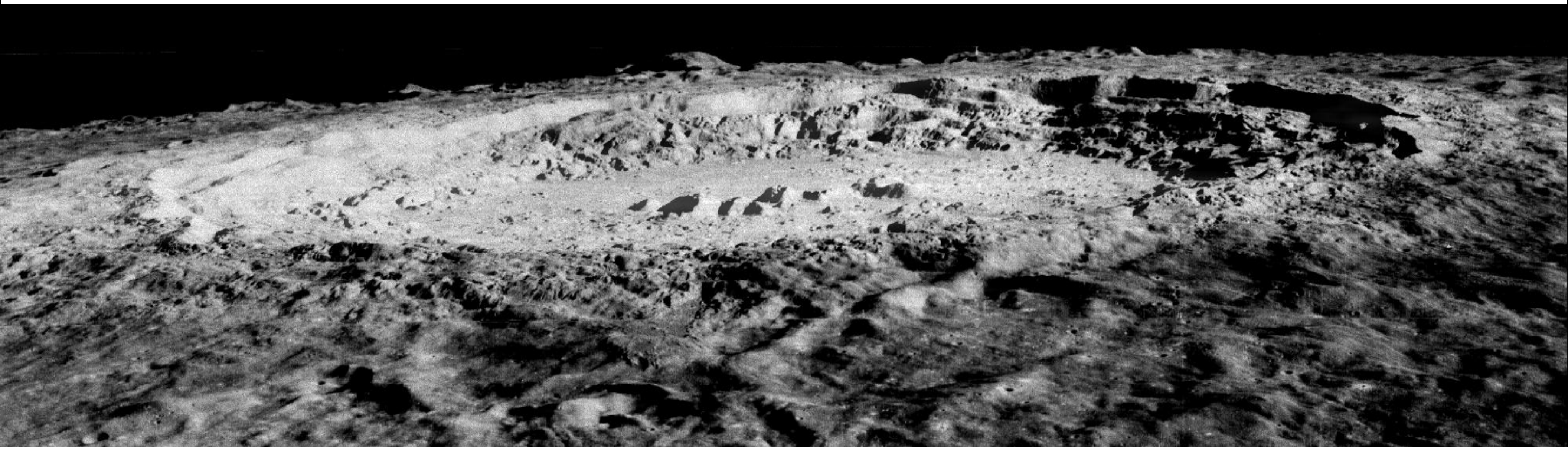
ROBOTIC LUNAR EXPLORATION

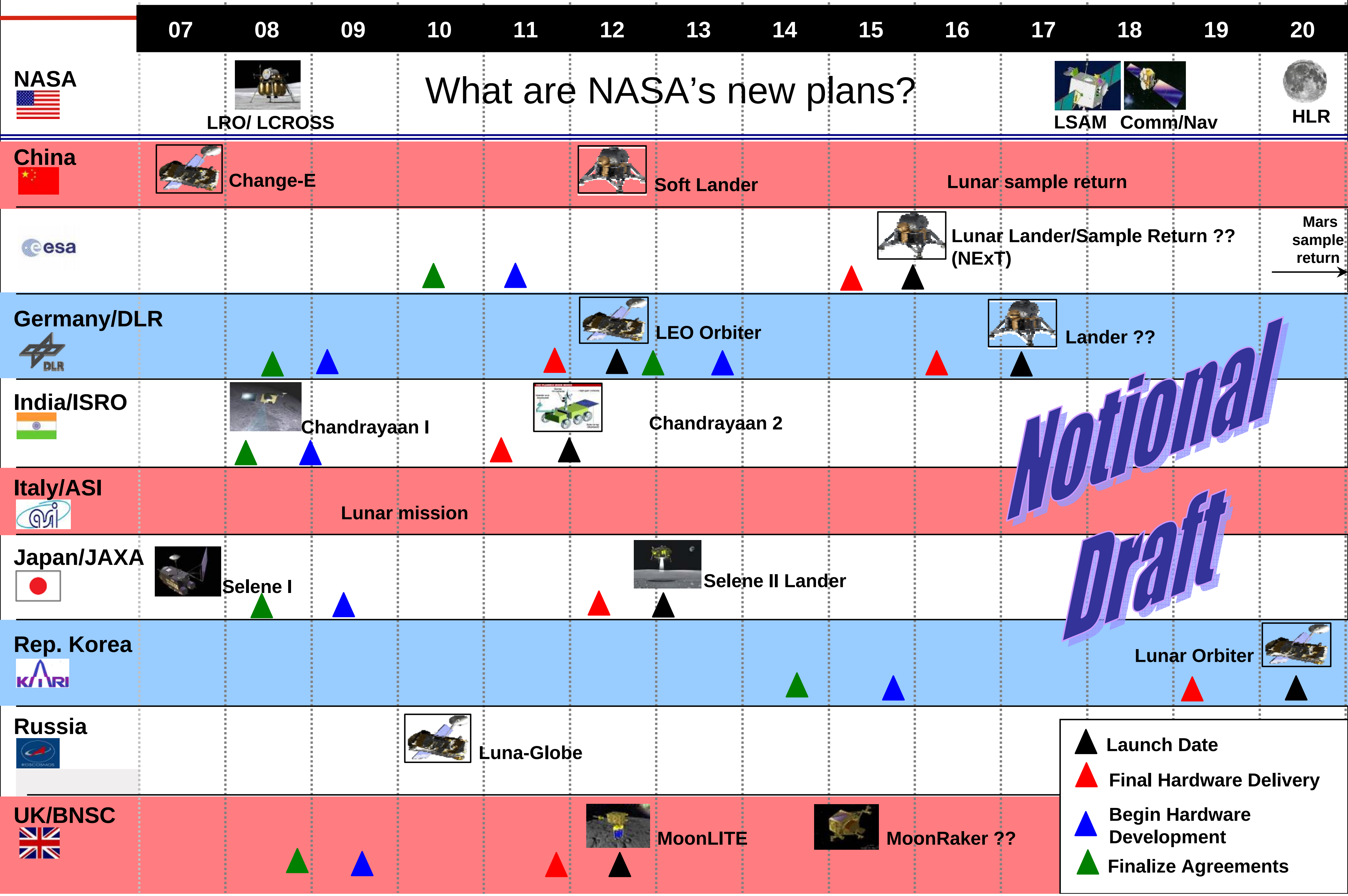
"Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities"*--Space Exploration Policy Directive (NPSD31), Jan 2004*

NASA Objectives:

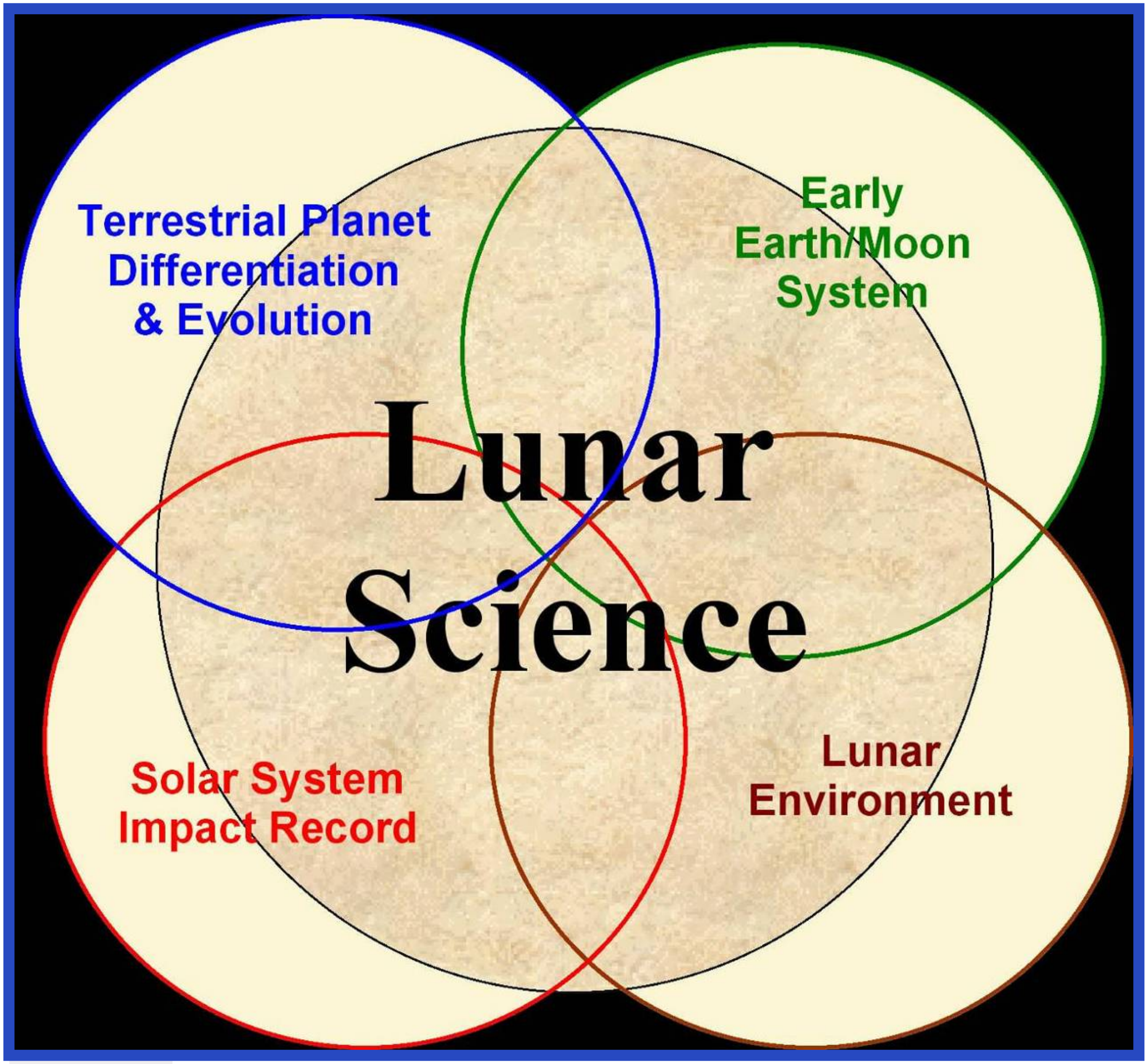
- Science of and from the Moon.
- Global topography and targeted mapping for site selection and safety; environmental characterization for safe access.
- Resource prospecting and assessment of In-Situ Resource Utilization (ISRU) possibilities.
- Technology proving ground.



INTERNATIONAL LUNAR ROBOTIC MISSION PLANS



SMD LUNAR SCIENCE ROBOTIC MISSION INITIATIVE

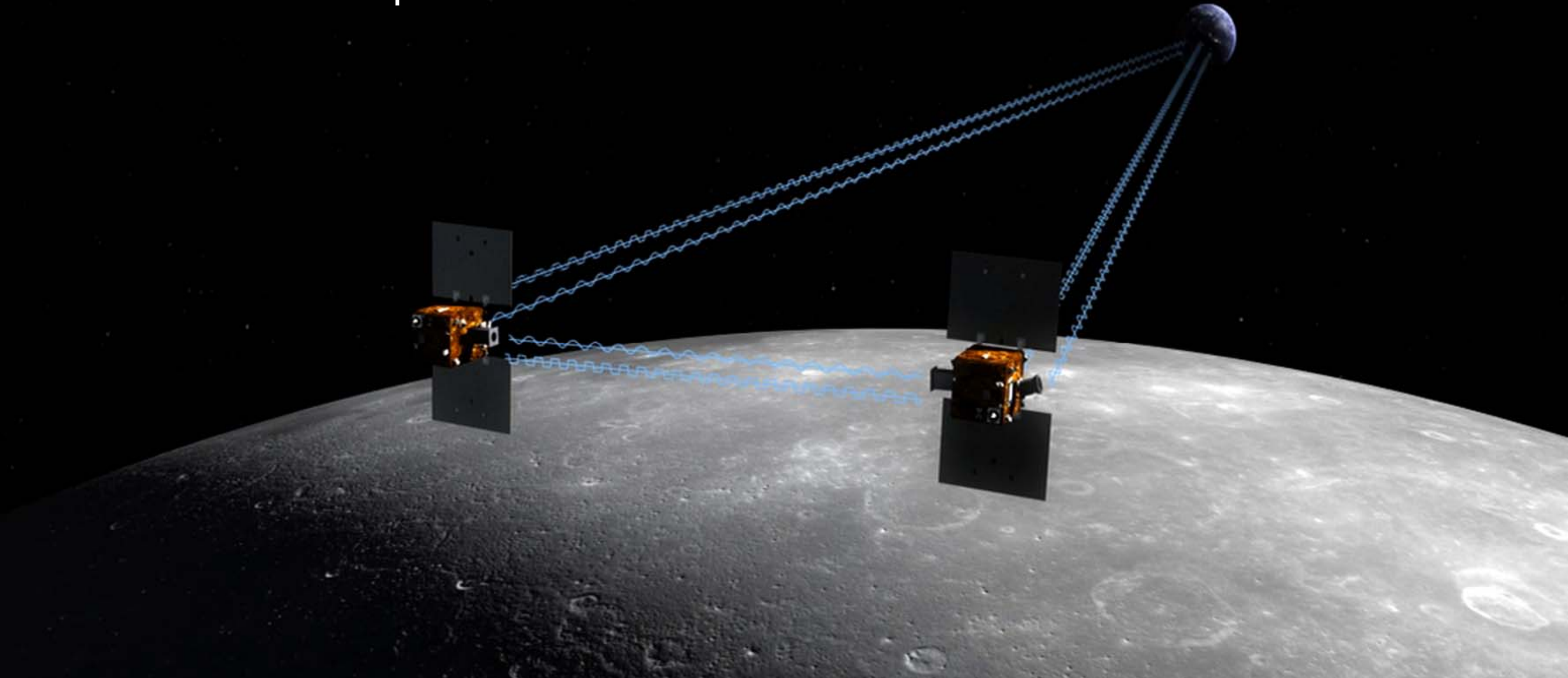


"*It is the unanimous consensus of the (NRC) committee that the Moon offers profound scientific value.*….A vigorous near term robotic exploration program providing global access is central to the next phase of scientific exploration of the Moon and is necessary both to prepare for the efficient utilization of human presence and to maintain scientific momentum as this major national program moves forward."

-*The Scientific Context for Exploration of the Moon*, National Research Council, Space Studies Board, 2007.

GRAIL DISCOVERY MISSION:
2011 (Maria Zuber, PI)

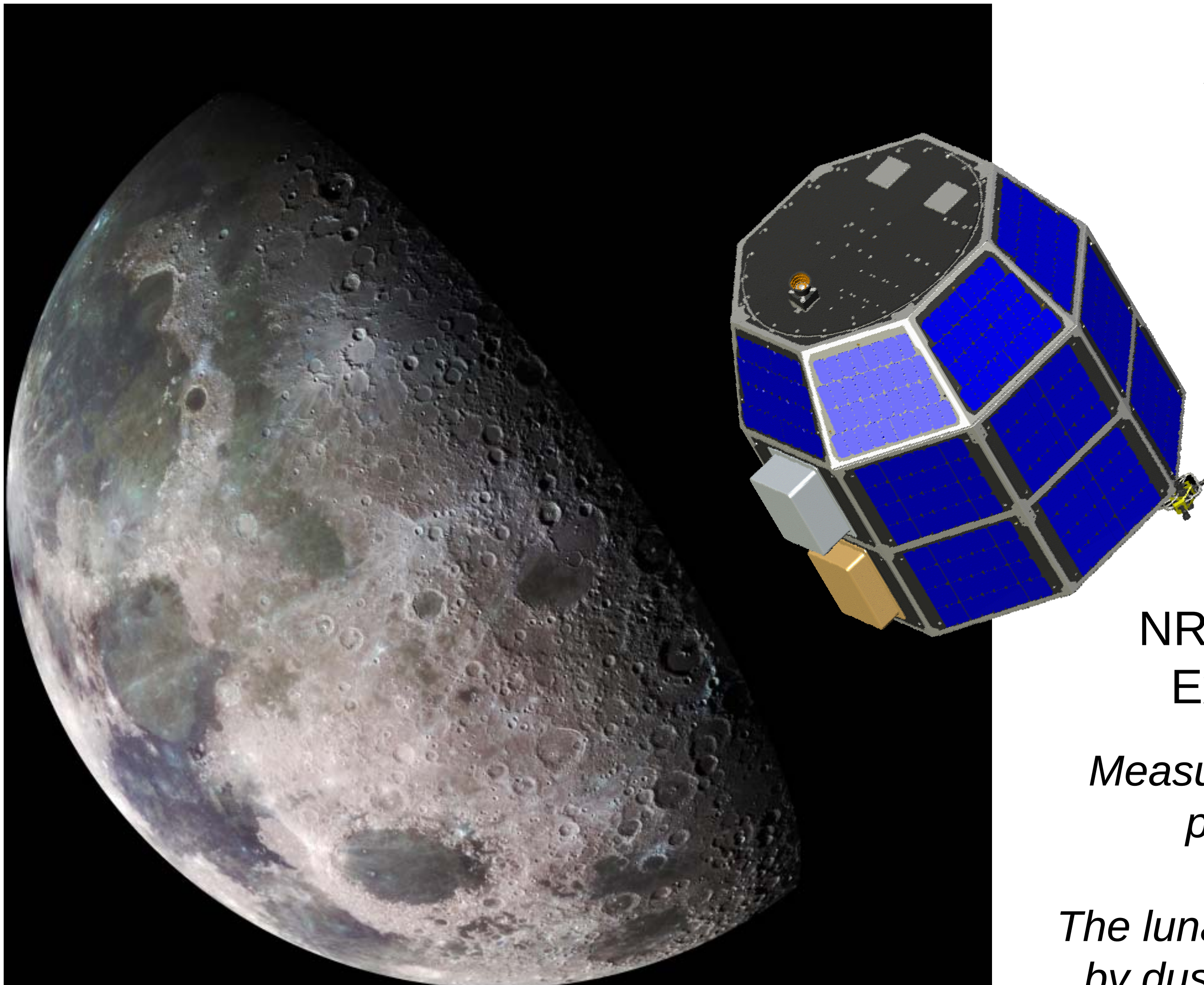
Goals: Determine the structure of the lunar interior from crust to core; advance understanding of the thermal evolution of the Moon; extend the knowledge to the other terrestrial planets.



Mission: Provide a global, high-accuracy (<10mGal),high-resolution (30km) lunar gravity map; build upon successful GRACE mission; adapt flight-proven LM XSS-11 bus.

Lunar Atmosphere & Dust Environment Explorer

LADEE: Examining the Lunar atmosphere/exosphere



SmallSat Orbiter
Provider: ARC / GSFC

Core Instruments:
Dust Counter
Neutral Mass Spectrometer

NRC: Scientific Context for Exploration of the Moon

Measuring the atmosphere before it is perturbed by human activity

The lunar atmosphere may be dominated by dust although its properties are not well known.

Launch in 2010 as secondary payload with Grail

SMD's LUNAR SCIENCE MISSION INITIATIVE

- Strategic SMD missions with science teams and instruments selected competitively.

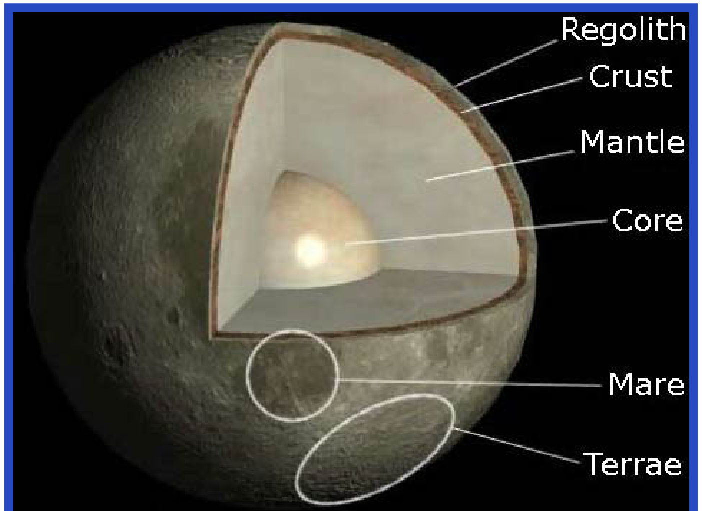
- First mission: small atmospheric/dust science orbiter, to be launched with GRAIL by 2011: LADEE (Lunar Atmosphere and Dust Environment Explorer).

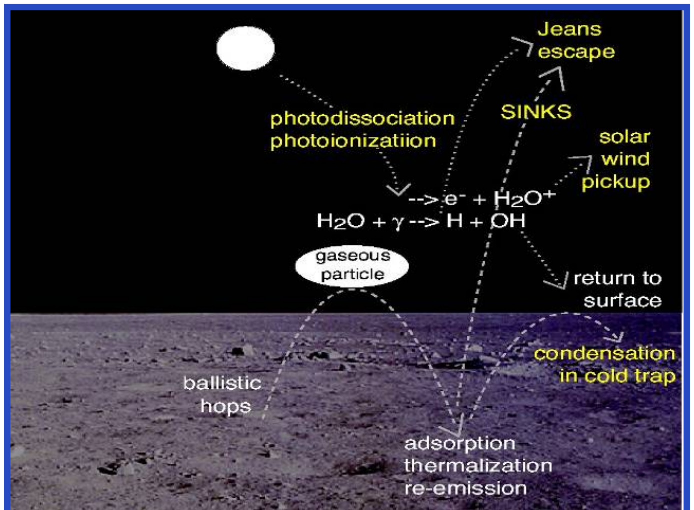
- Second mission: Surface geophysical network mini-lander nodes launched in pairs; first pair (ILN 1 and 2) to be launched by 2014. Follow-on ILN nodes 3 and 4 in 2016/2017.

ALSEP'S FIRST GENERATION LUNAR NETWORK

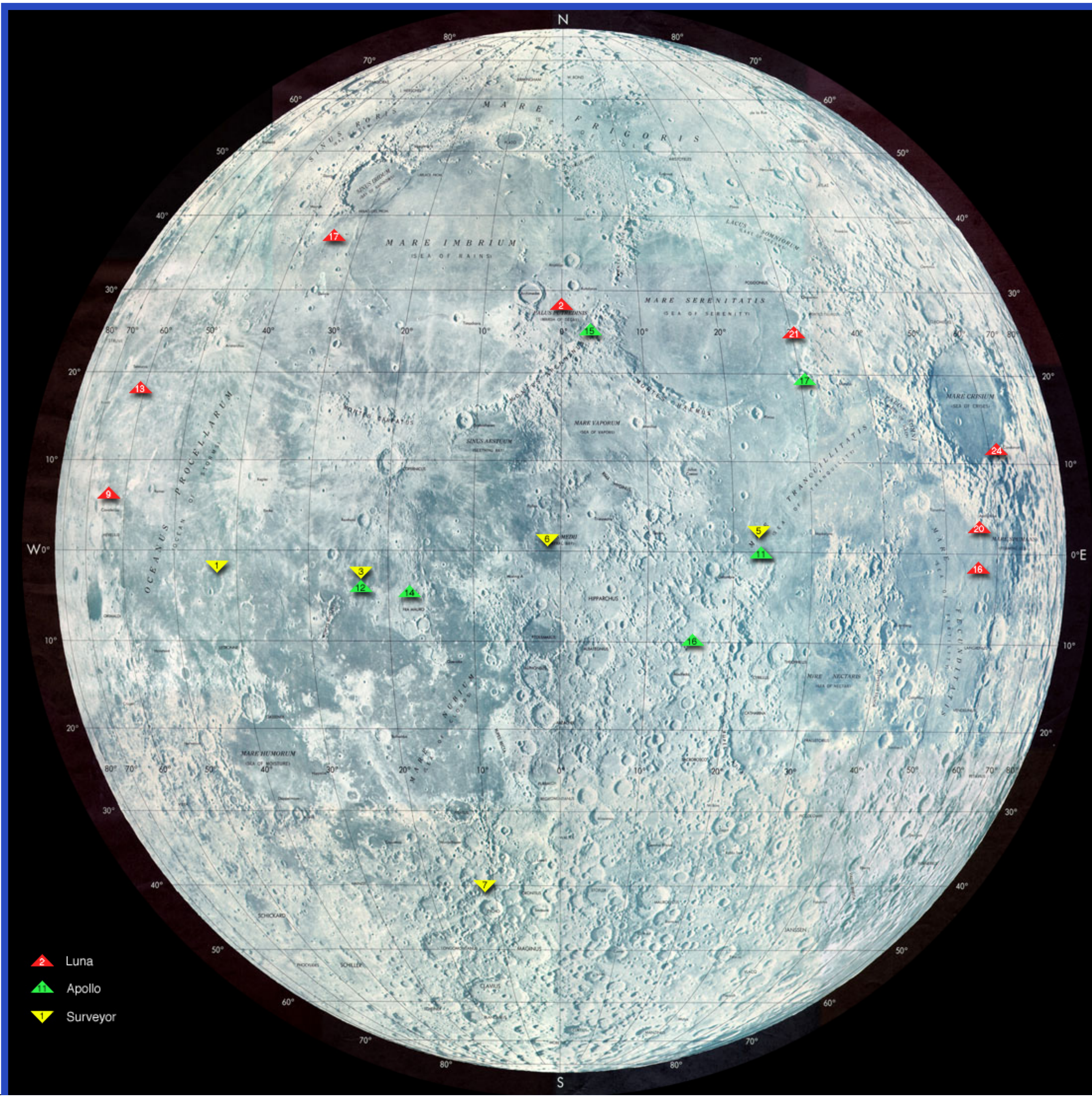
Lunar Landing Sites

Red=Russian Luna
Yellow=Surveyor
Green=Apollo





Background photo from N.S.S.D.C., Apollo 11 landing site



THE PROPOSED INTERNATIONAL LUNAR NETWORK (ILN)

- NASA's Science Mission Directorate is initiating an effort to coordinate future lunar landed missions into an International Lunar Network (ILN).

- The ILN is designed to emplace 6-8 stations on the lunar surface, forming a second-generation geophysical network.

- Individual stations could be fixed or mobile.

- Each ILN station would fly a core set of instrument types (e.g., seismic, laser retro-reflector, heat flow) requiring broad geographical distribution on the Moon.

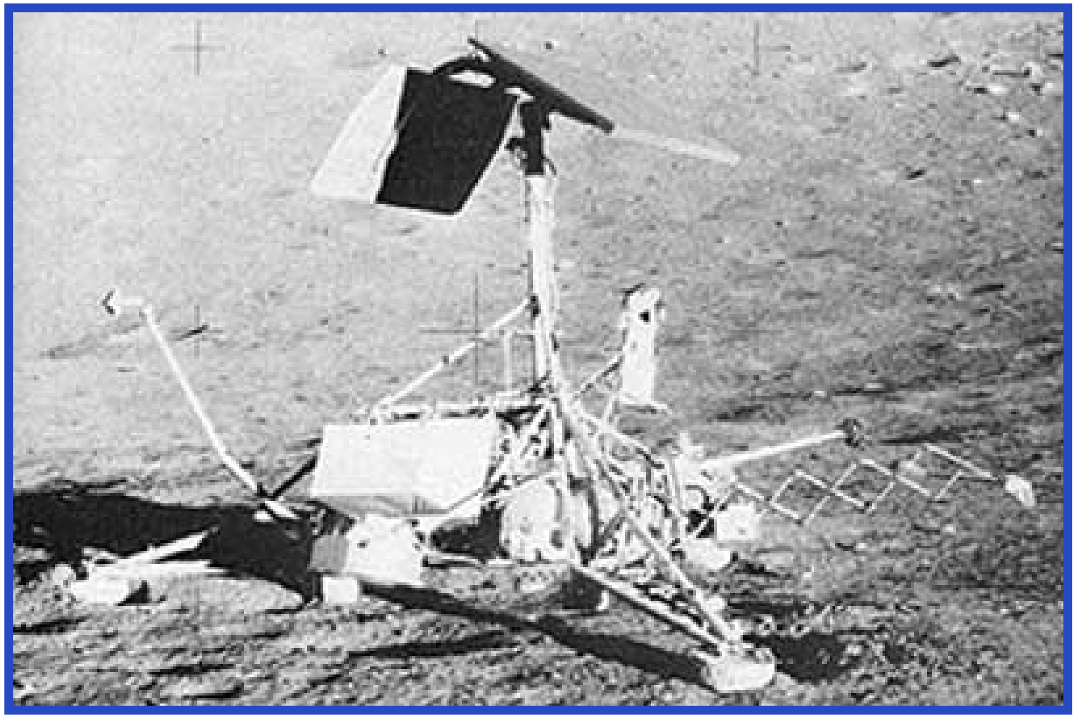
- Each ILN station could also include additional passive, active, ISRU, or engineering experiments, as desired by each sponsoring space agency.

US ILN CONTRIBUTIONS

- The US is committing now to two ILN nodes, launched to the lunar poles, in 2013/2014.

- The US is studying the option for a lunar comm relay orbiter enabling lunar far-side access for ILN nodes.

- The US is planning a second pair of ILN nodes in 2016/2017.

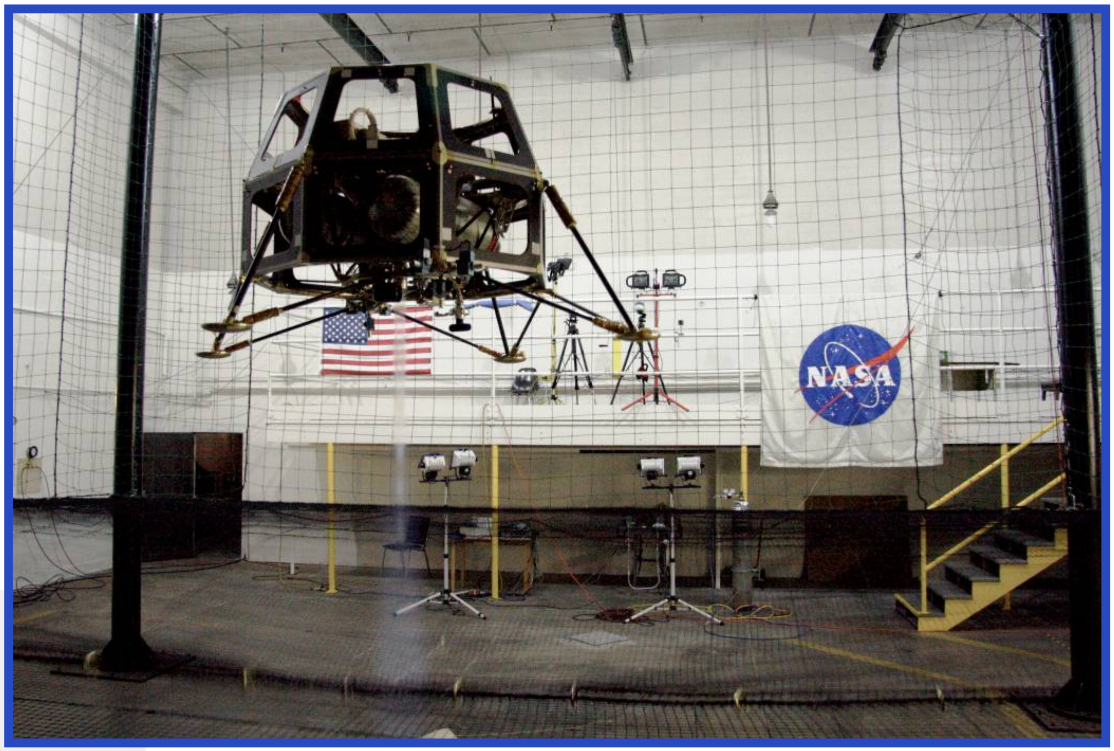


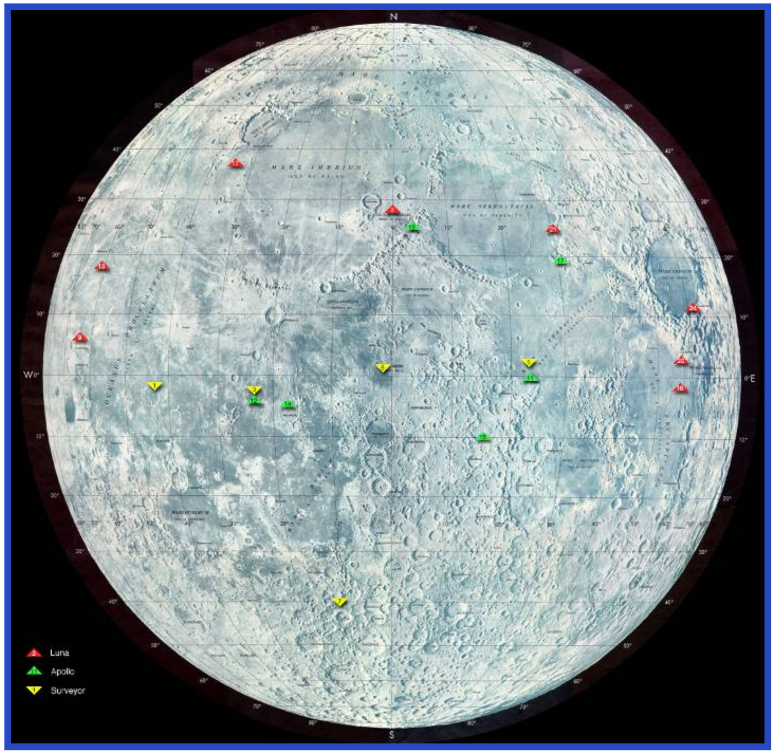
ILN's Schedule

- 12 March 2008: ILN Informational Briefing to Potential Partner Agencies at LPSC (Houston). Discussed ILN charter and WGs.

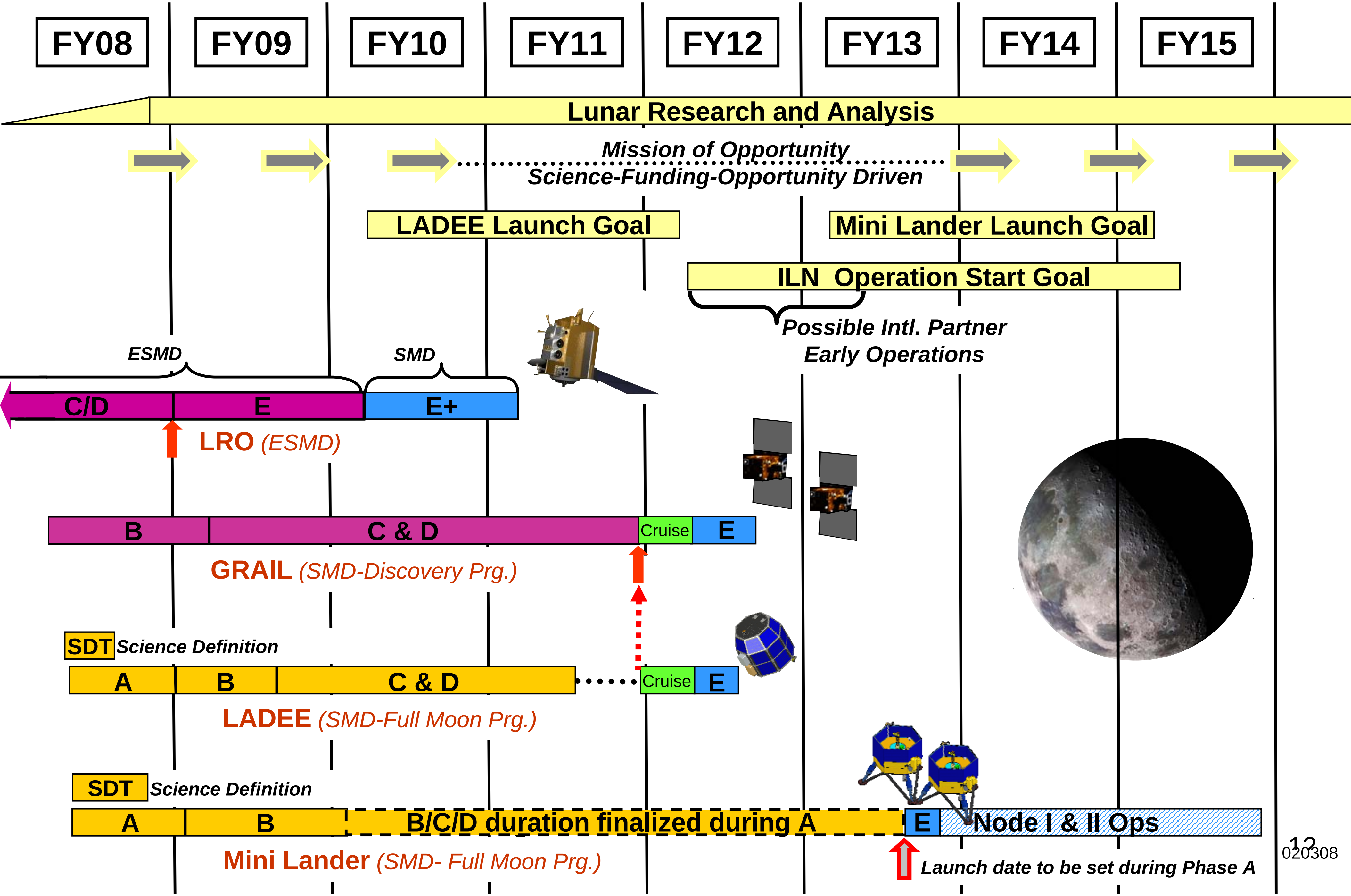
- 20 July 2008: ILN Charter Signing Ceremony (NASA/Ames). Form ILN Landing Site and Core Instrument Definition WGs.

- 20 December 2008: ILN Core Instrument Agreement (DC).





Lunar Missions Schedule



BACKUP SLIDES

LRO/LCROSS 2008-2010

Lunar Reconnaissance Orbiter (LRO):

- Lunar mapping, topography, radiation characterization, and volatile identification.
- 50 km polar orbit.

Lunar CRater Observation and Sensing Satellite (LCROSS):

- Investigate the presence of water at the South Pole via a kinetic impactor and shepherding spacecraft.

ALSEP Seismic Experiments

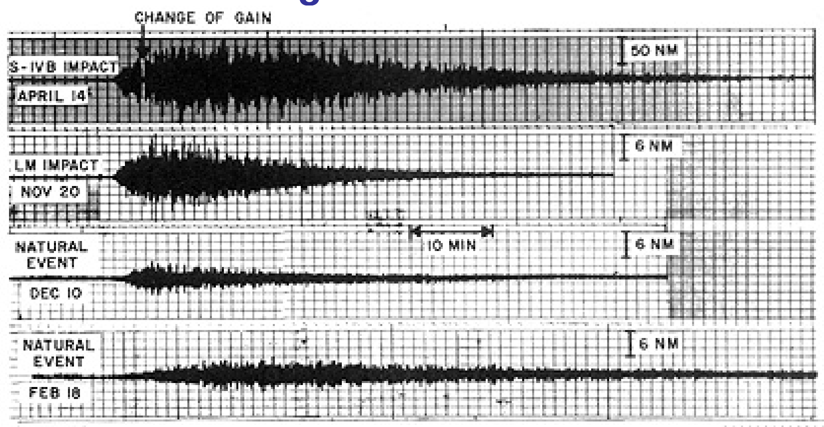
Apollos 11-16 carried passive seismic experiments (PSE) deployed on the lunar surface between 1969 and 1972. Data were recorded continuously from deployment until 1977 on four of the five stations.

Apollo 16 PSE

In addition, Ap 14 and 16 carried active seismic experiments, with a thumper and small mortars, and Ap 17 carried the lunar seismic profiling experiment which used slightly larger mortars to investigate the near surface structure (upper 3 km).

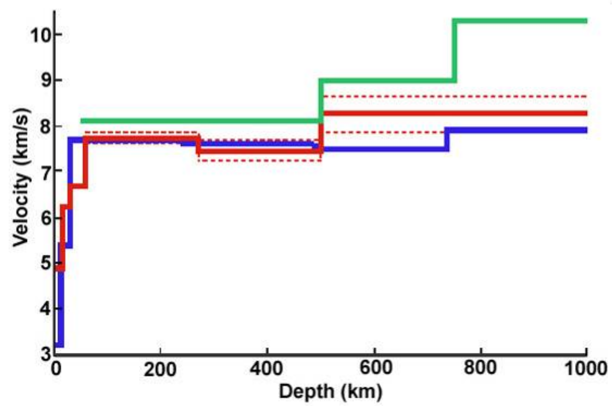
Man-made impacts

Natural Moonquakes

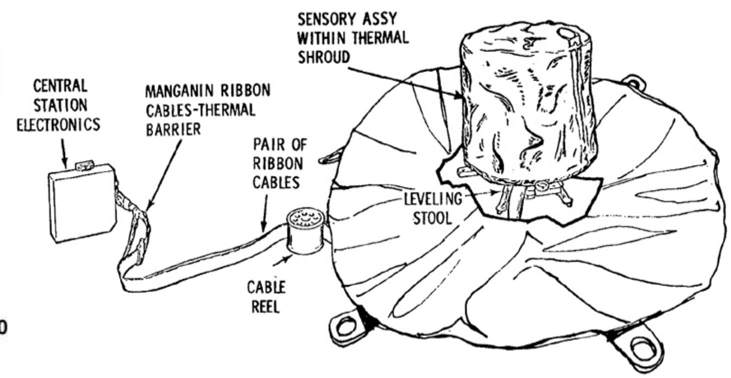


Events detected:

- **9 man-made impacts**
- **~1700 natural impacts**
- **3000+ deep moonquakes**
- **~30 shallow moonquakes**



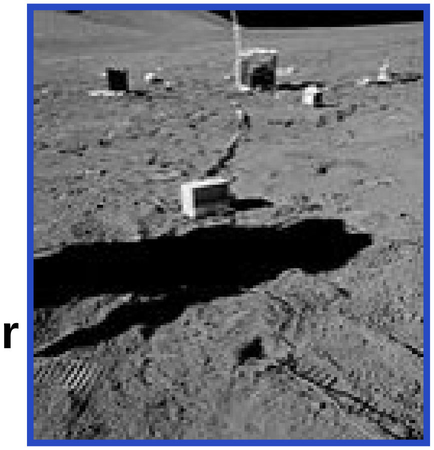
P-wave velocity models versus depth. Nakamura (1983) – red; Lognonné et al. (2003) – blue; Khan et al. (2000) – green (after Johnson et al (2005) LPSCXXXVI ab#1565).



PASSIVE SEISMIC EXPERIMENT

ALSEP Heat Flow

Heat-flow probes were deployed successfully at the Apollo 15 and 17 landing sites to measure the local subsurface thermal gradient and conductivity.



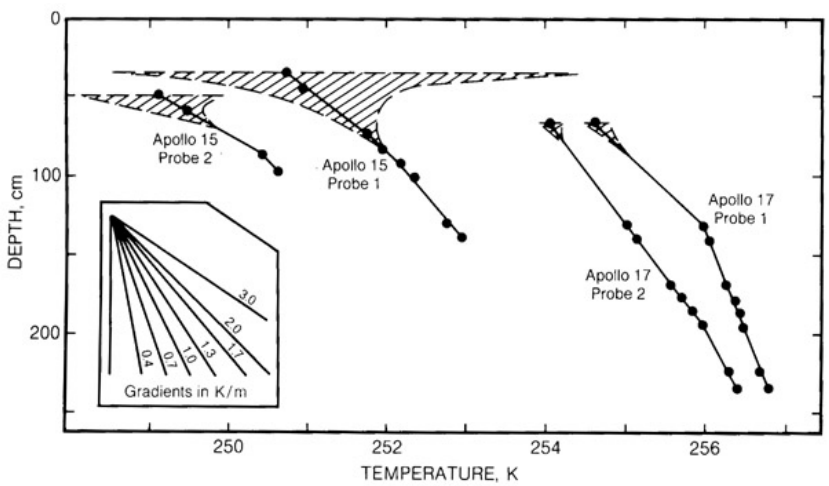
Apollo 15 HFE

Results:

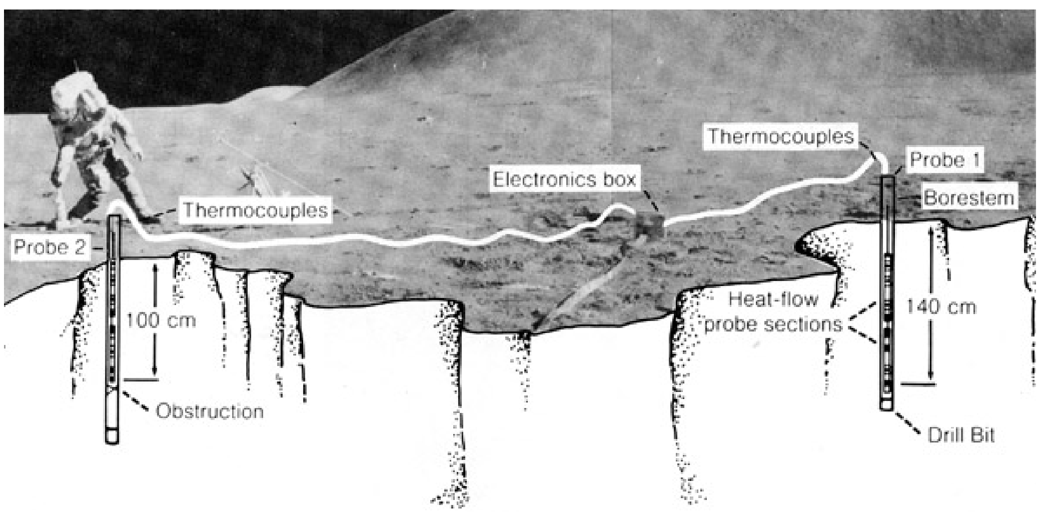
The upper 1- 2 cm has very low thermal conductivity (1.5X10^{-5} W/cm^2).

Thermometers buried below ~80 cm show no day/night variations.

The heat flow at the Apollo 15 site is apparently slightly greater than at the Apollo 17 site (21 vs. 16 mW/m^2) though both are considerably lower than terrestrial (87 mW/m^2). However, recent work has suggested that several factors, including the location of both sites near the highlands/mare border, local topography, and the impact on surface temperature of the precession of the lunar orbit, may significantly alter previous conclusions.

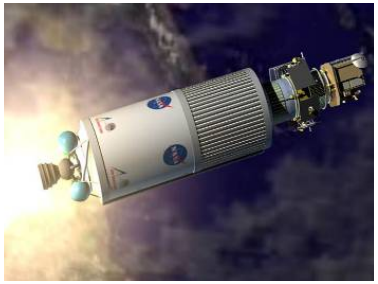


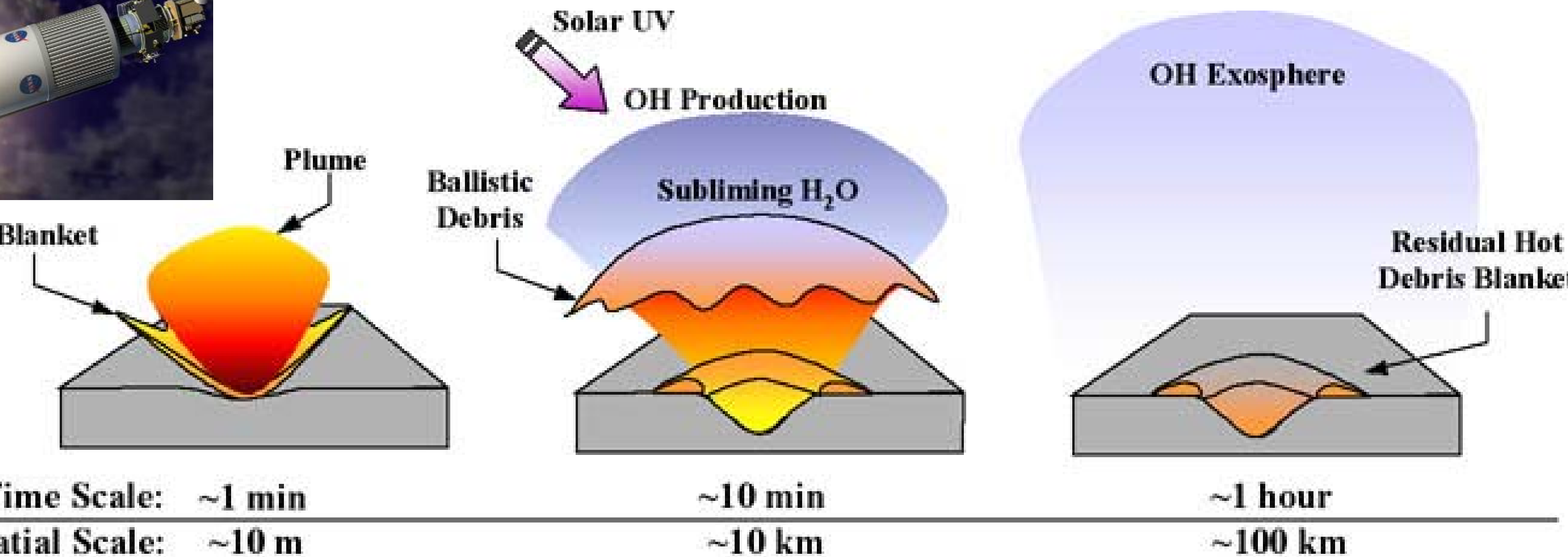
Temperature fluctuations in the lunar regolith as a function of depth (after Langseth and Keihm, 1977).



Placement of heat probes at Ap 15 site (Langseth et al 1972).

Lunar Crater Observation and Sensing Satellite (LCROSS)





- Bright Impact Flash
- Thermal OH Production
- Rapid Thermal Evolution

- Expansion of Plume
- Thermal Evolution
- H_2O ice sublimation
- Photo-production of OH

- Residual Thermal Blanket
- Expanding OH Exosphere

Ground-based, Earth-orbiting, and lunar-orbiting observatories will be able to observe and measure the impacts.
Expect impacts ~4 months after launch (early 2009)