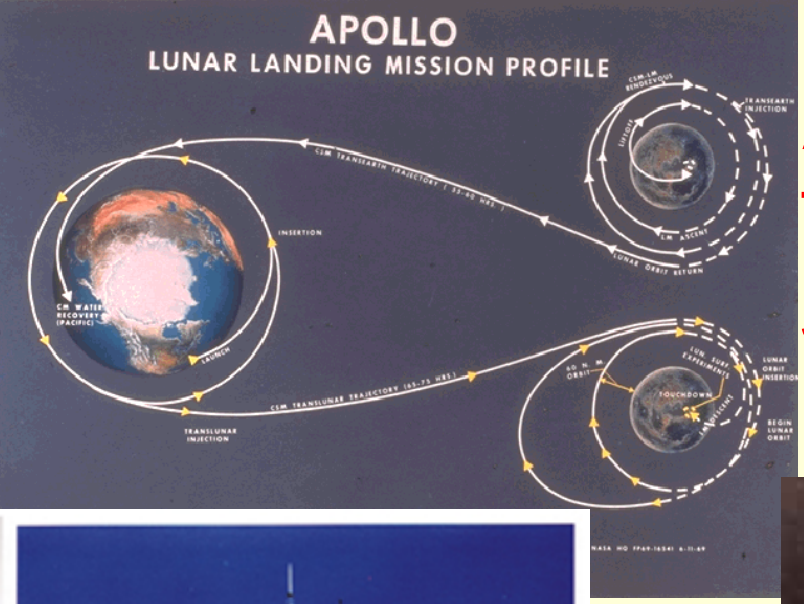
NASA: BACK TO THE MOON

Don Campbell

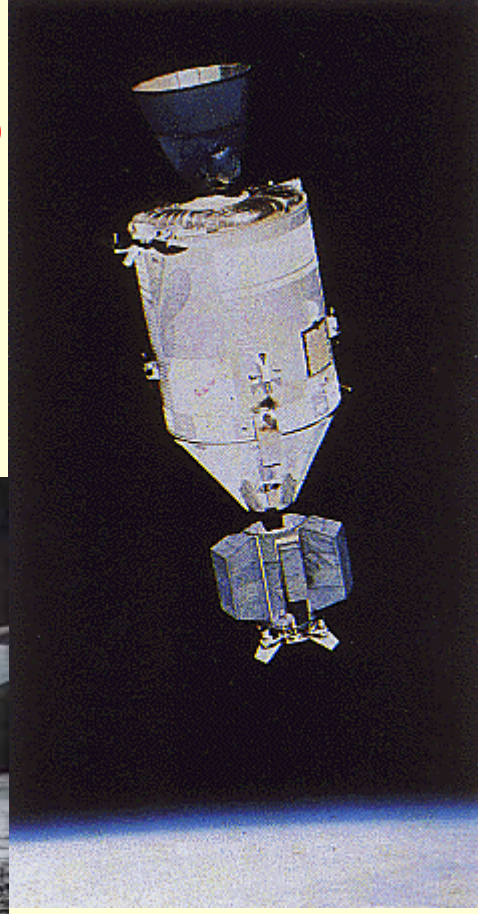
Cornell University

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth." John F. Kennedy, May 25, 1961



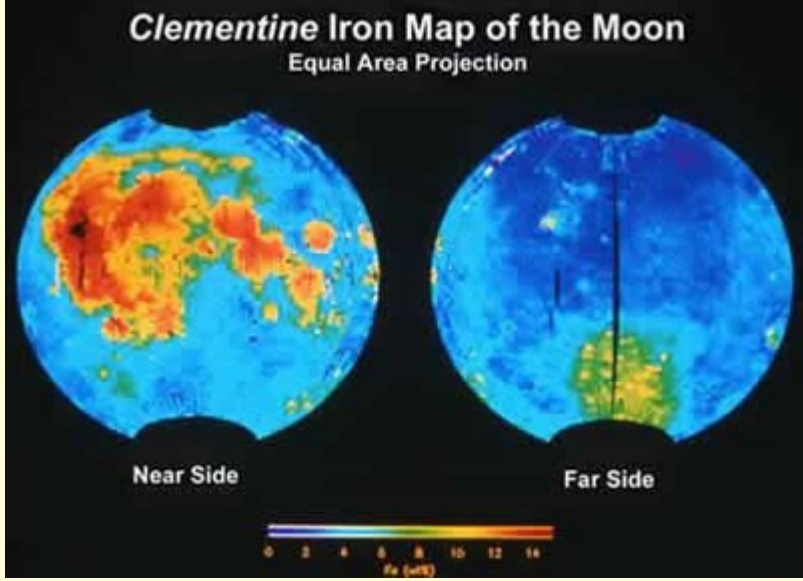
APOLLO missions to the MOON

July 1969 – Dec 1972



In the Shadow of the Moon

ONLY TWO US LUNAR MISSIONS SINCE APOLLO



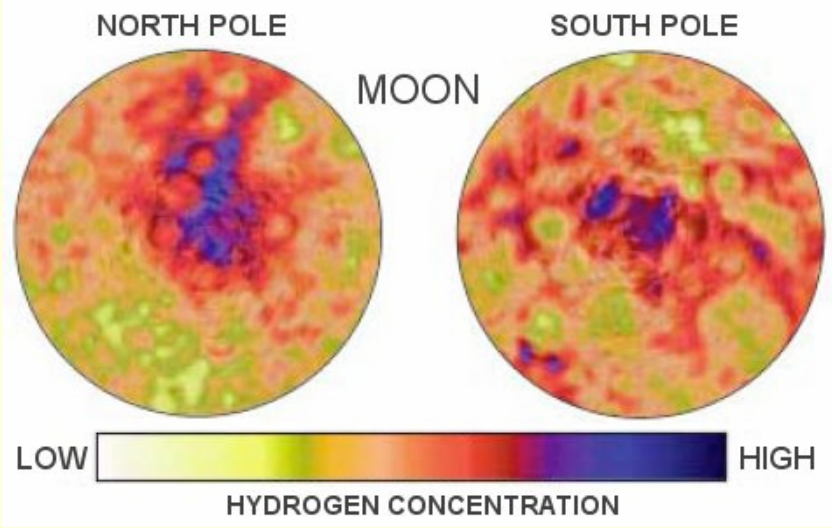
CLEMENTINE ORBITER IN 1994

– 2 months in orbit

Experimental DOD satellite

LUNAR PROSPECTOR ORBITER IN 1998
– 18 months in orbit

Discovery class mission – first NASA mission since Apollo



Non-US missions:

SMART-1 - European mission was in orbit for ~ three years, it impacted into Moon in early September, 2006

SELENE – Japanese mission set for launch Sept 12, 2007 (3 orbiters - mineralogy, gravity, topography and separate VLBI and relay satellites)

Chang'e 1 – Chinese orbiter set for launch in late 2007 (imaging, topography, mineralogy).

Chandrayaan-I - Indian mission to launch in April 2008 (surface probe, mineralogy, radar)

Luna-Glob – Russian mission (penetrators for sub-surface sampling and seismic network plus soft lander at one of the poles)

January 2004

President's Space Exploration Policy Directive titled

A Renewed Spirit of Discovery – The President's Vision for US Space Exploration

"Our third goal is 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. Using the Crew Exploration Vehicle, we will undertake extended human missions to the moon as early as 2015, with the goal of living and working there for increasingly extended periods."

George W. Bush at NASA Headquarters, January 14, 2004

NASA Response (Feb, 2004) – The Vision of Space Exploration

National committee established to make recommendations – the President's Commission on the Moon, Mars and Beyond (Aldridge Commission).

The Vision - Goal and Objectives

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

- **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;**

- **Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and**

- **Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.**

NASA's Vision for Space Exploration – the integration of human and robotic space exploration

Preliminary Level Zero Lunar Program Requirements

1. Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations.
2. Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare and support future human exploration activities:

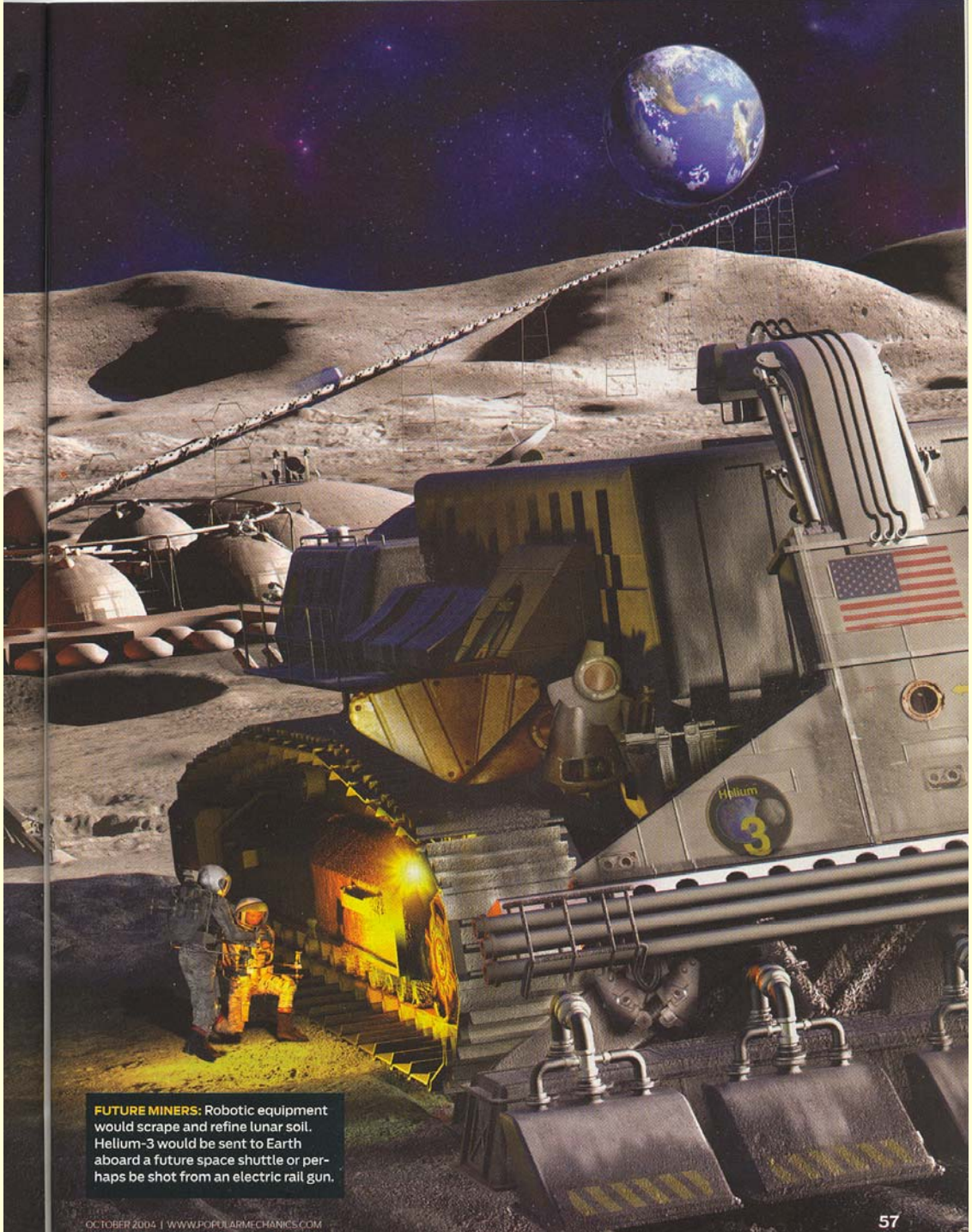
   . Mission objectives shall include landing site identification and certification on the basis of potential resources.

   . Measurements to be made to support applied science and research relevant to the Moon as a step to Mars, engineering safety and boundary conditions.

   . Technology demonstrations and system testing shall be performed to support development activities for future human lunar and Mars missions.
3. Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than 2020.
4. Use lunar exploration activities to further science and research.

Popular Mechanics

Article by Harrison Schmitt



FUTURE MINERS: Robotic equipment would scrape and refine lunar soil. Helium-3 would be sent to Earth aboard a future space shuttle or perhaps be shot from an electric rail gun.

SELECTED LUNAR RECONNAISSANCE ORBITER PAYLOAD Oct 2008 launch

"Lunar Orbiter Laser Altimeter" - will determine the global topography of the lunar surface at high resolution, measure landing site slopes and search for polar ices in shadowed regions.

"Lunar Reconnaissance Orbiter Camera" - high resolution camera

"Lunar Exploration Neutron Detector" - will map the flux of neutrons from the lunar surface to search for evidence of water ice and provide measurements of the space radiation environment which can be useful for future human exploration.

"Diviner Lunar Radiometer Experiment" - will map the temperature of the entire lunar surface at 300 meter horizontal scales to identify cold-traps and potential ice deposits.

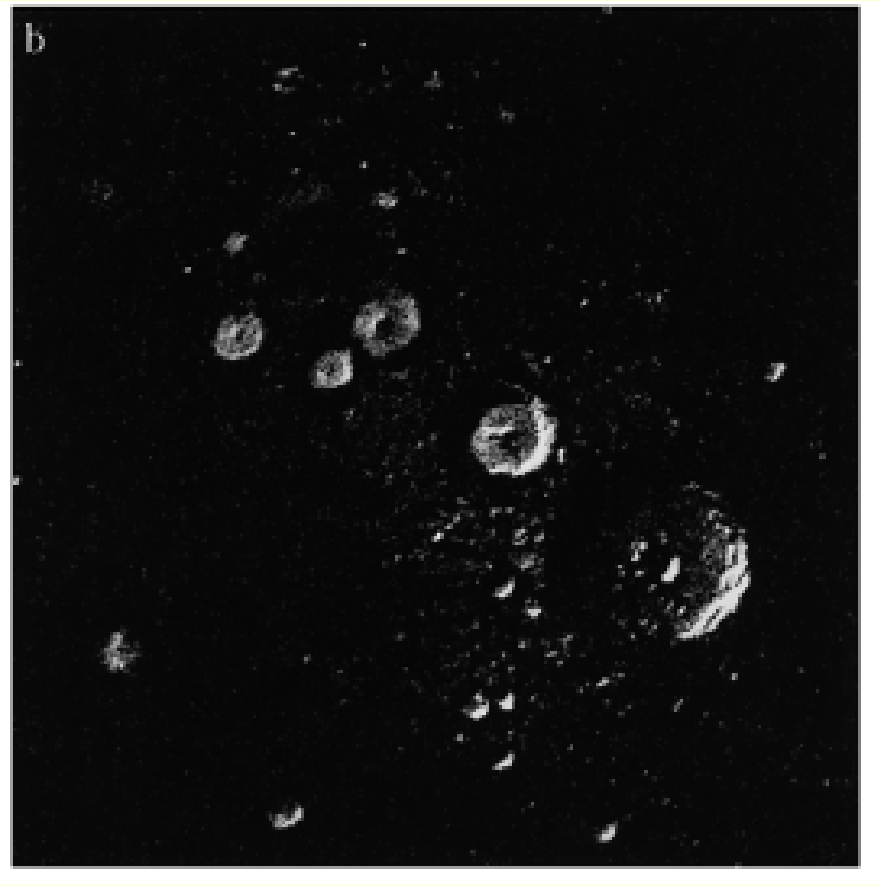
"Lyman-Alpha Mapping Project" - will observe the entire lunar surface in the far ultraviolet. LAMP will search for surface ices and frosts in the polar regions and provide images of permanently shadowed regions illuminated only by starlight.

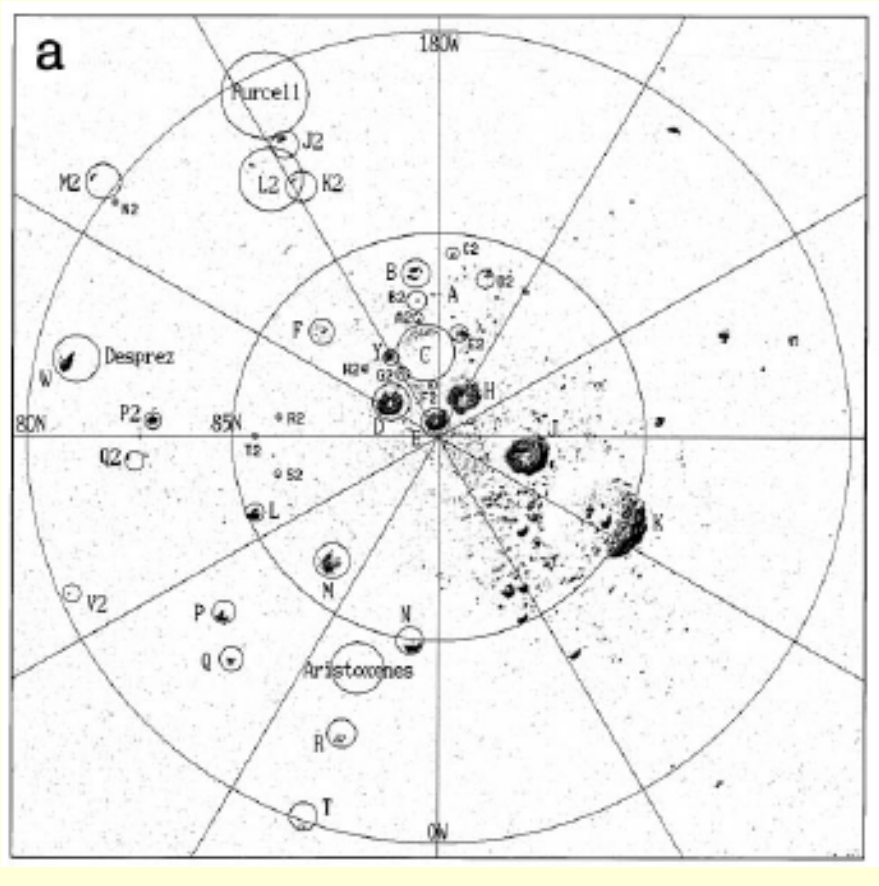
"Cosmic Ray Telescope for the Effects of Radiation"

"Demonstration radar imaging system" – image shadowed areas at poles.

IS THERE REALLY ICE AT THE LUNAR POLES?

Arecibo radar imagery at 1.5 km resolution of the “ice” deposits at the north pole of Mercury.

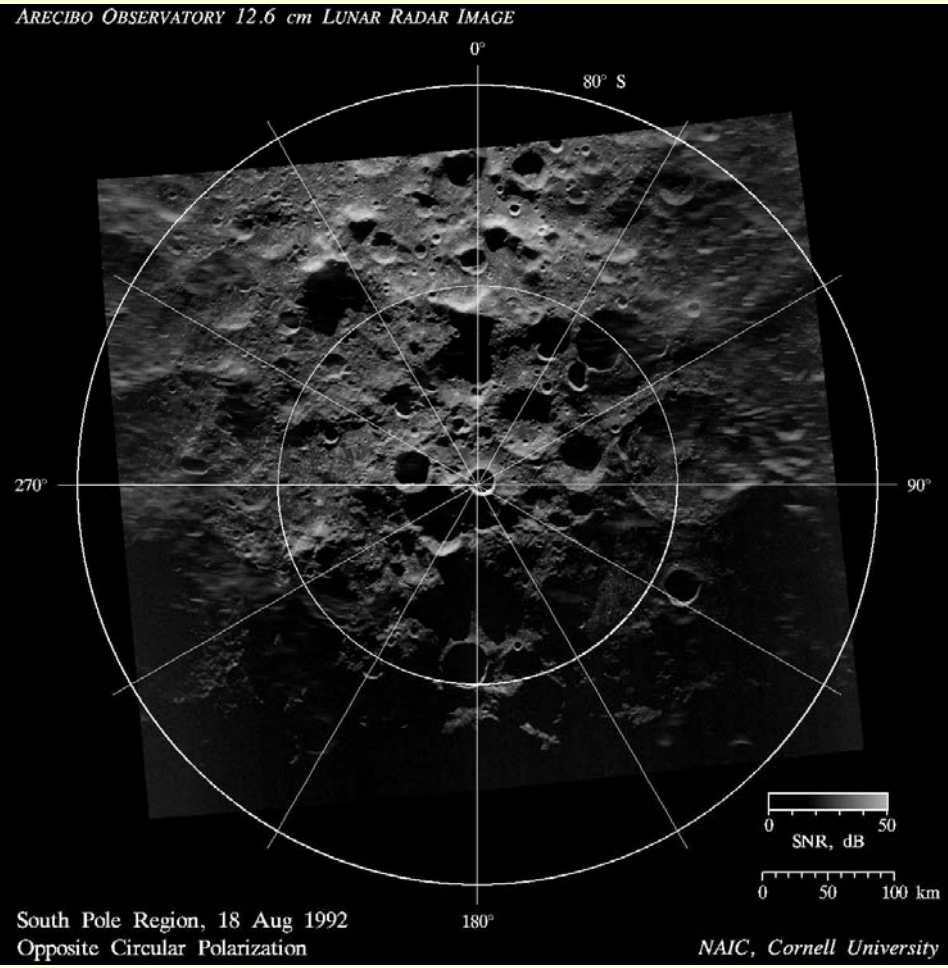




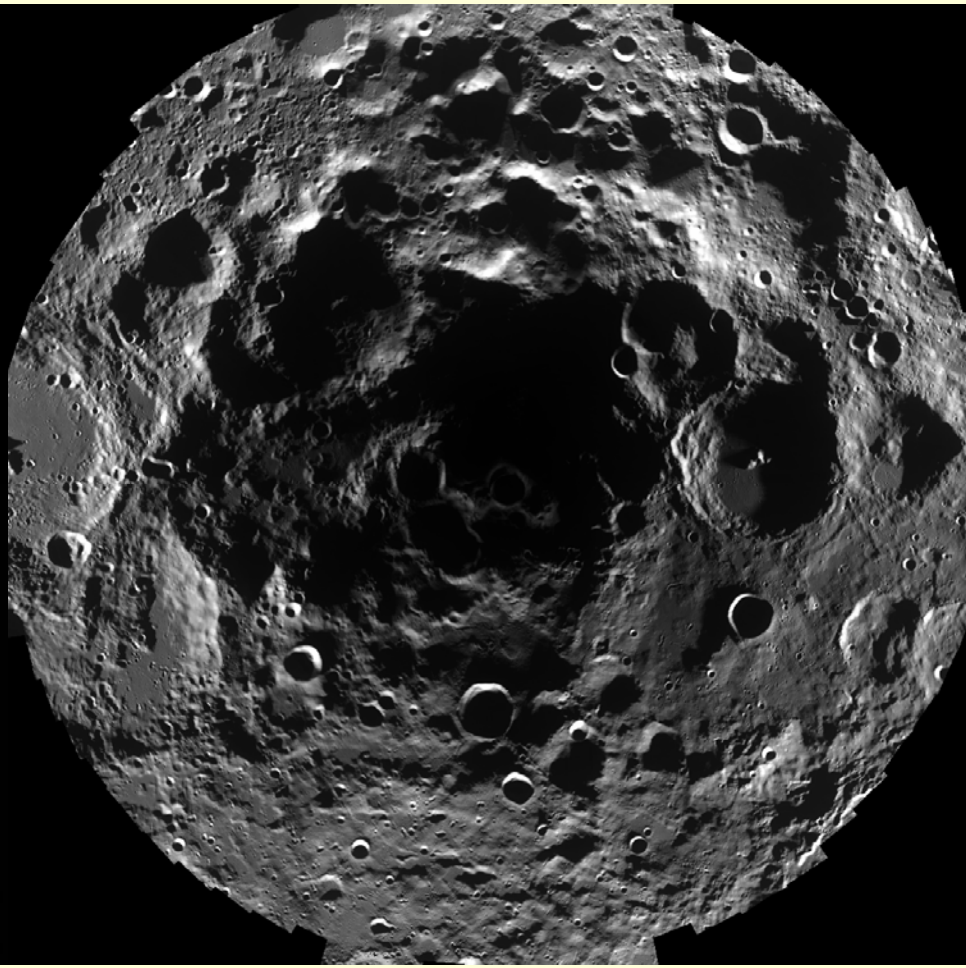
Harmon et al, Icarus, 149, 1-15, 2001

Lunar South Pole

Arecibo radar image at 13 cm (Stacy, 1993)



Clementine optical image of the south pole



ICE IN SHADOWED CRATERS AT THE POLES OF THE MOON?

Thick deposits similar to Mercury's - Highly controversial

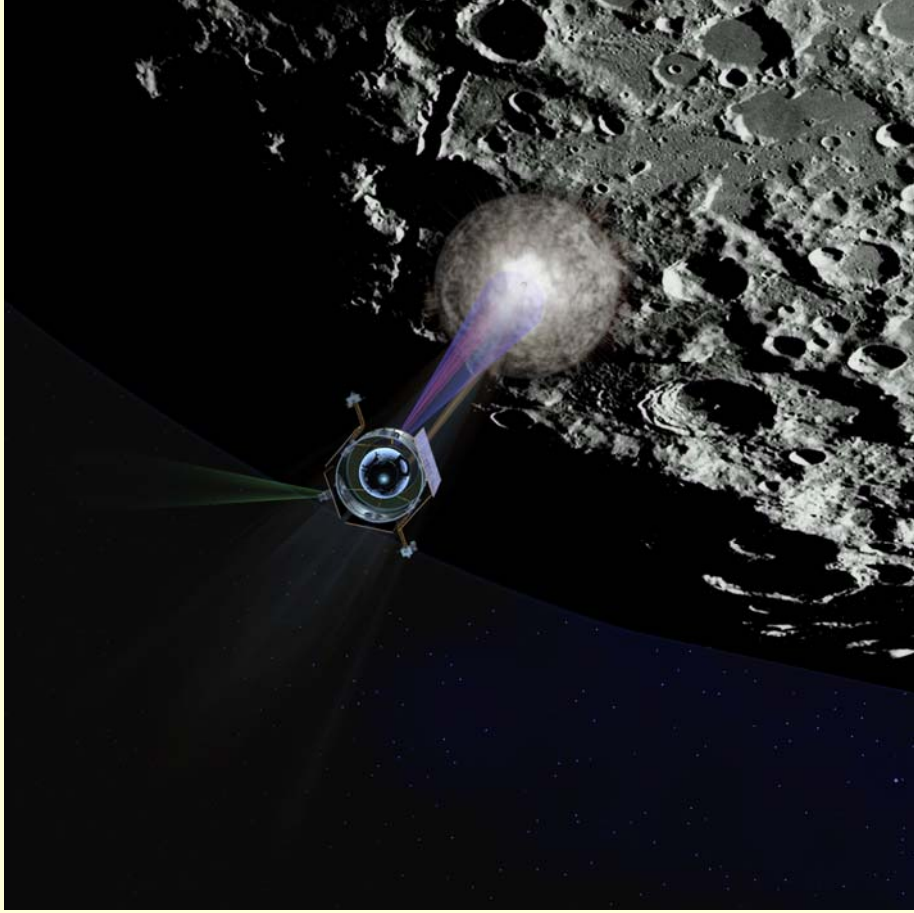
Clementine experimenters claim highly likely

Earth based radar investigators claim highly unlikely

Low concentration deposits (about 1% by weight in the lunar "soil")

Possible – Neutron Spectrometer on Lunar Prospector detected high concentrations of hydrogen at the poles. If in the form of water ice then about 1% concentration averaged over shadowed terrain.

LRO/LCROSS

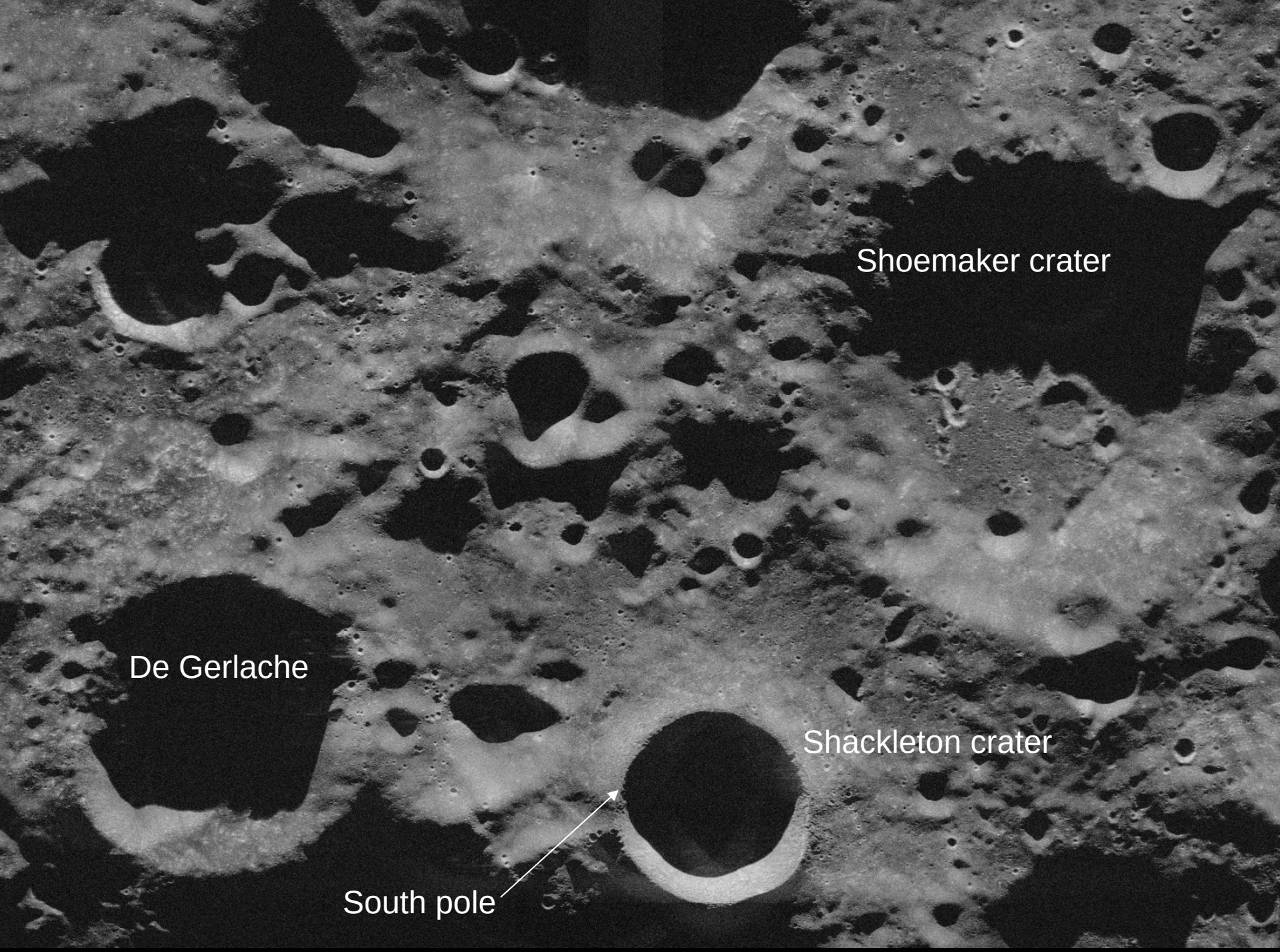


Atlas launch vehicle as of early 2006

=> much greater payload capacity

Result: LCROSS – Lunar Crater Observing and Sensing Satellite (NASA Ames)

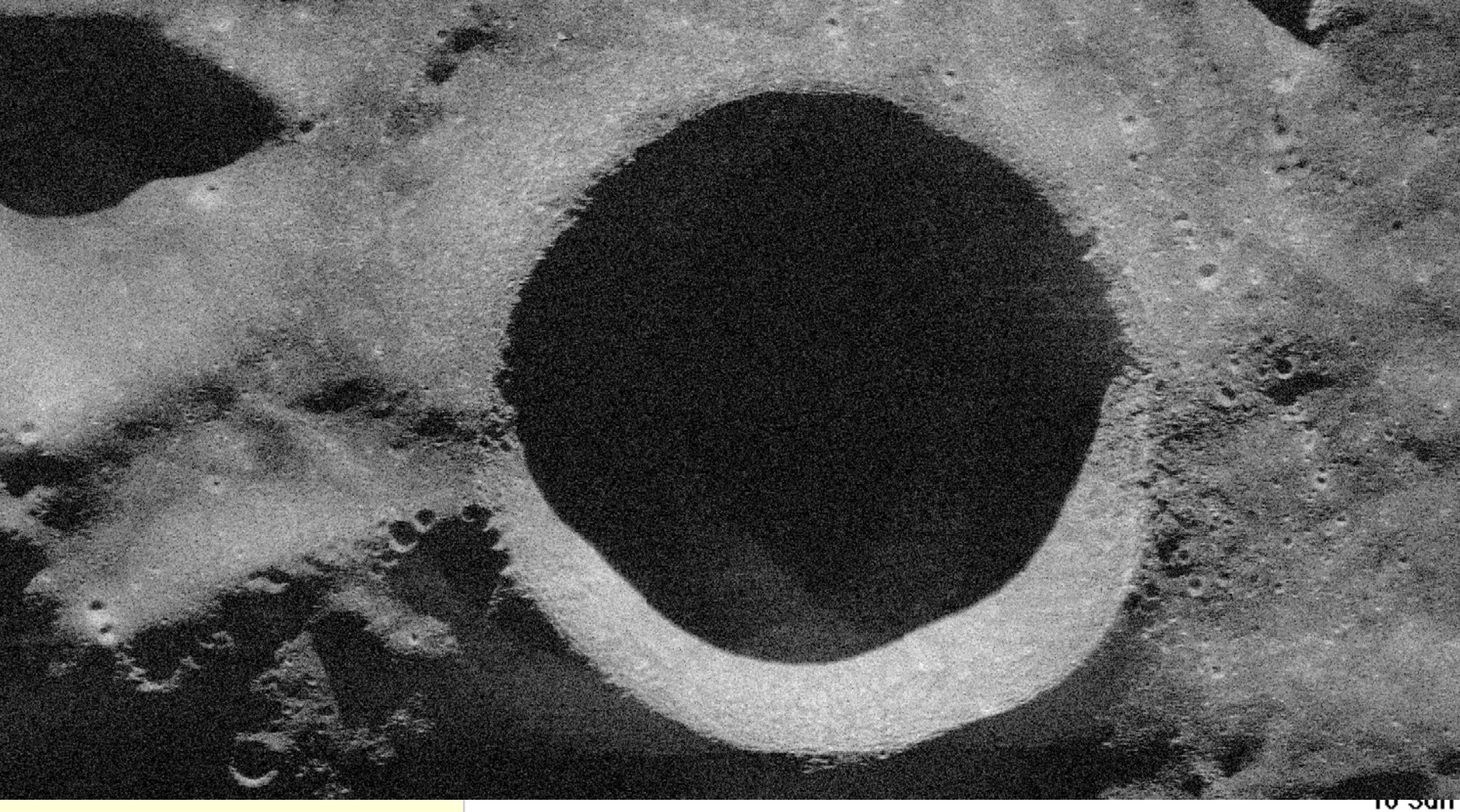
Idea: Impact Centaur second stage into a polar crater followed by a small spacecraft equipped with sensors designed primarily to look for evidence for water vapor in the impact plume. May be observable with Earth based telescopes.


Shoemaker crater
De Gerlache
Shackleton crater
South pole

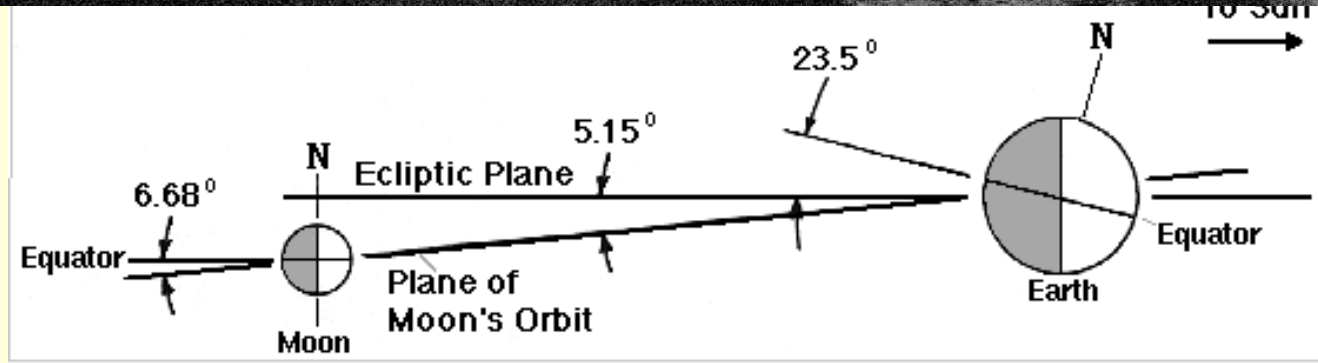
WHERE WILL A LUNAR BASE BE SITED?

“NASA's Lunar Architecture Team, chartered in May 2006, concluded that the most advantageous approach is to develop a solar-powered lunar base and to locate it near one of the poles of the moon. With such an outpost, NASA can learn to use the moon's natural resources to live off the land, make preparations for a journey to Mars, conduct a wide range of scientific investigations and encourage international participation.”

NASA release, Dec 2006

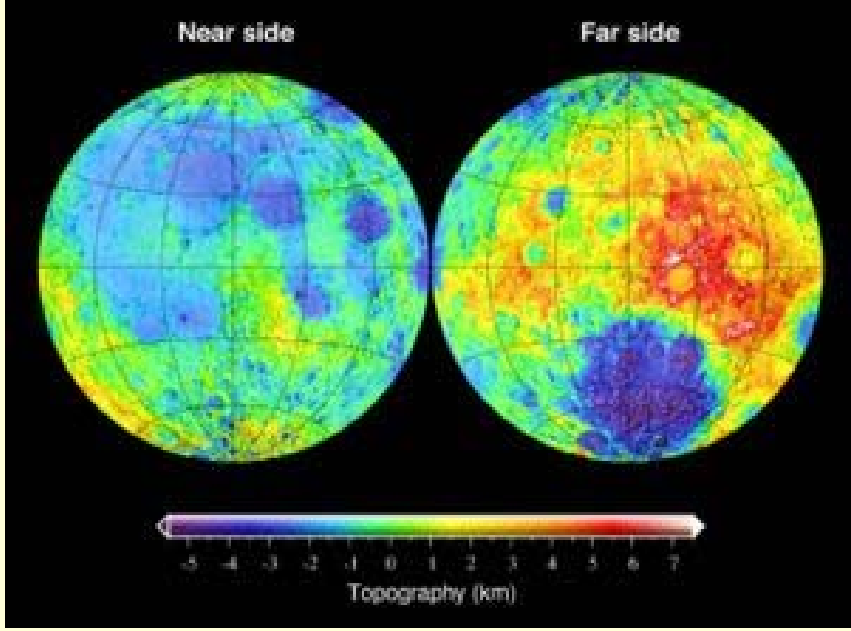


Arecibo/GBT radar image



(Diagram by Paul Spudis.)

WHY GO BACK TO THE MOON?



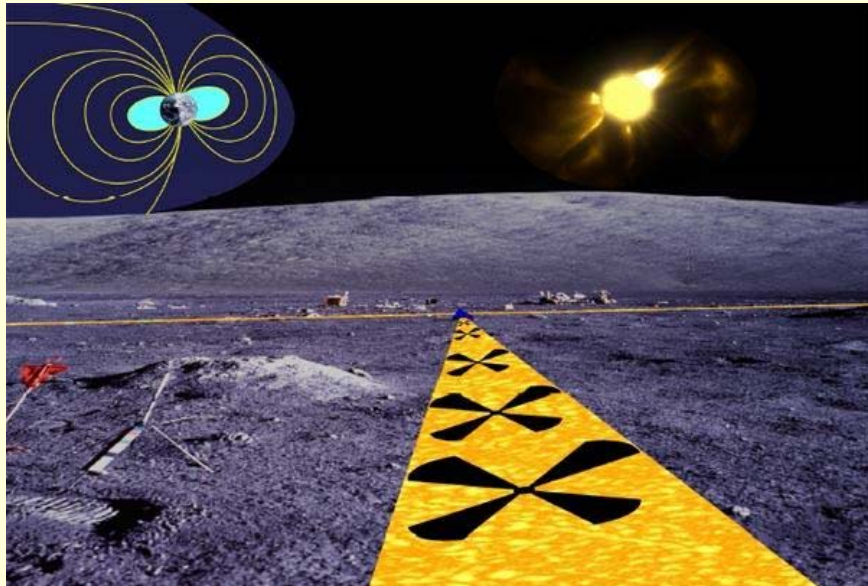
Extending the human presence in space

Gain experience in resource utilization

Science drivers:

- **Fundamental solar system science**
- **Planetary formation and processes**
- **The Moon as a platform for astronomical and Earth observations**

(see NRC report on the Scientific Context for the Exploration of the Moon)



Educational Opportunities

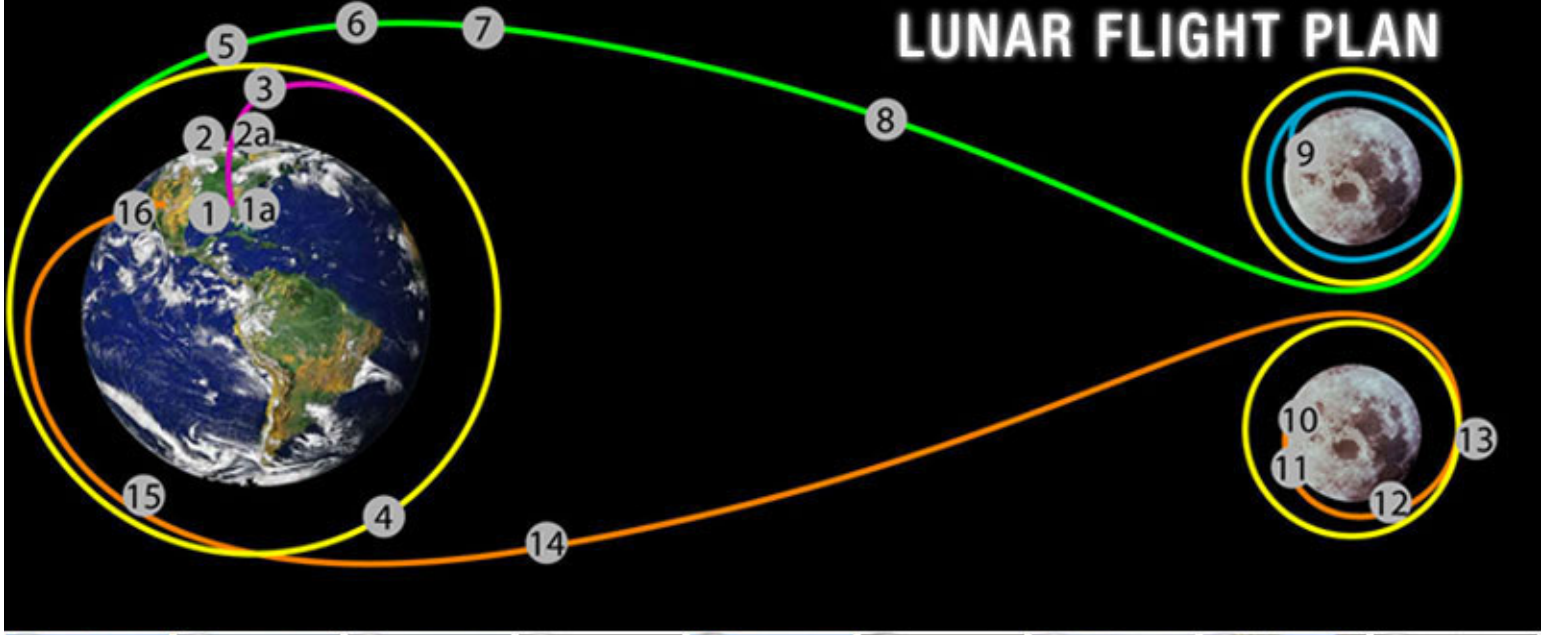
As NASA plans to return to the moon, plant growth will be an important part of space exploration. NASA scientists anticipate that astronauts may be able to grow plants on the moon in specialized plant growth chambers. Come participate and build your own lunar growth chamber in the NASA Engineering Design Challenge!

Through the NASA Engineering Design Challenge, elementary, middle and high school students will:

Design, build, and evaluate lunar plant growth chambers
Receive cinnamon basils seeds flown on STS-118
Test lunar growth chambers by growing and comparing both space-flown and earth-based control seeds

Visit http://www.nasa.gov/education/plantchallenge to register and to receive more information about the NASA Engineering Design Challenge. You can also sign up for the NASA Express listserv to receive e-mail updates about the challenge and other NASA education activities.

Join the NASA Engineering Design Challenge and be part of space exploration by growing seeds flown in space!



Cargo launch | Booster Separation | 2nd Stage | Cargo in Orbit | Crew Launch | 2nd Stage | Docking with Lander | Departure Stage | Stage Jettisoned

Lunar Orbit | Lunar Landing | Crew on the Moon | Ascent Stage | Rendezvous | Lander Jettisoned | Service Module Jettisoned | Re-entry | Parachute Landing

A cargo vehicle lifts off (1), ejects its boosters (2) and uses its second stage (3) to put cargo like the lunar lander in orbit (4). The crew vehicle lifts off (1a) and uses its second stage (2a) to reach orbit where it docks with the lander (5) and heads for the Moon using a departure stage (6). The departure stage is jettisoned (7) and the craft goes into lunar orbit (8). Four astronauts land (9), explore the surface for seven days (10) and blast off in an ascent stage (11).They rendezvous and dock (12) with the crew capsule and head back to Earth. The lunar ascent stage (13) and service module are jettisoned (14), the capsule re-enters Earth's atmosphere (15) and lands with parachutes (16).

Credit: NASA/John Frassanito and Associates