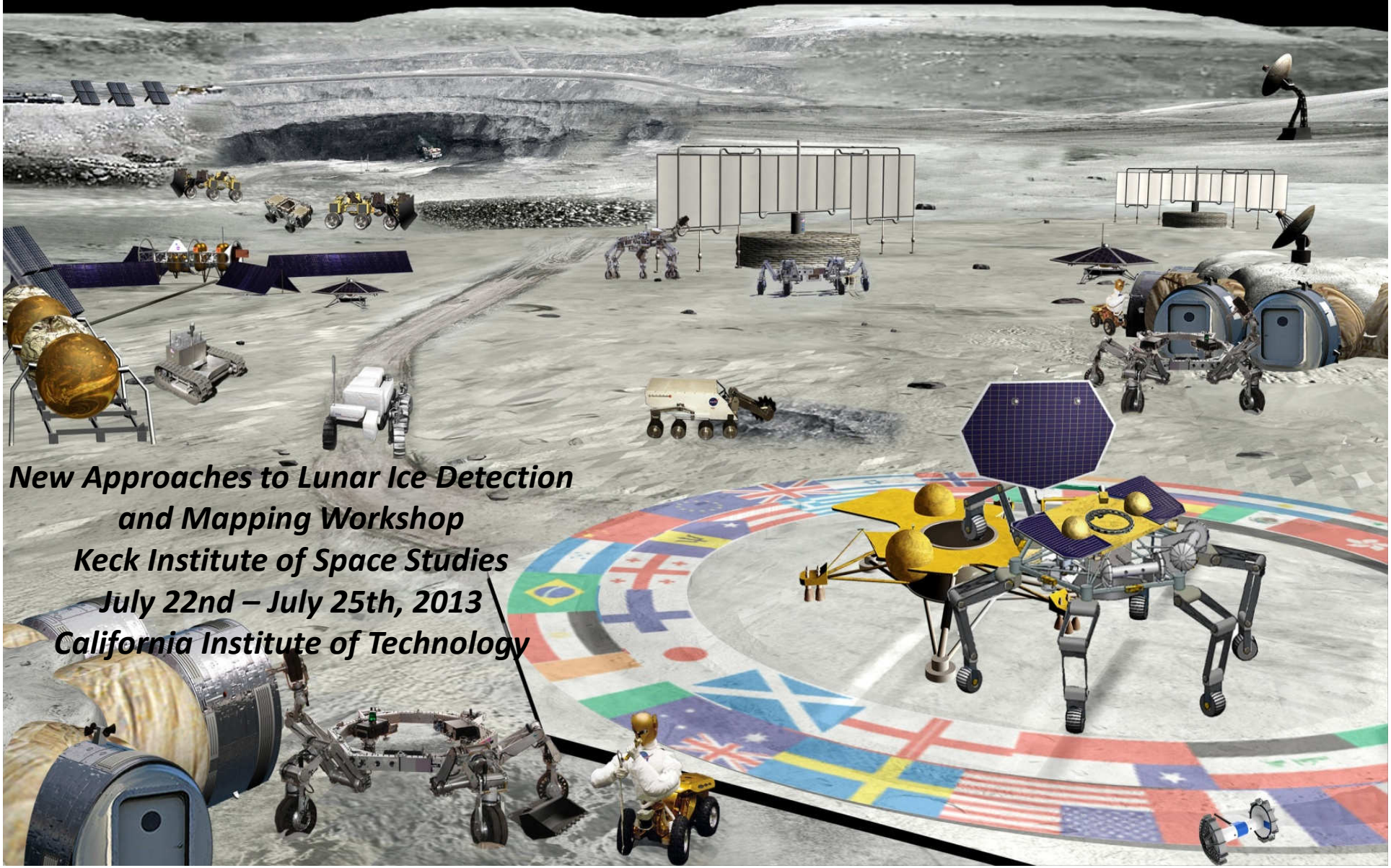
Future Lunar Missions: Plans and Opportunities

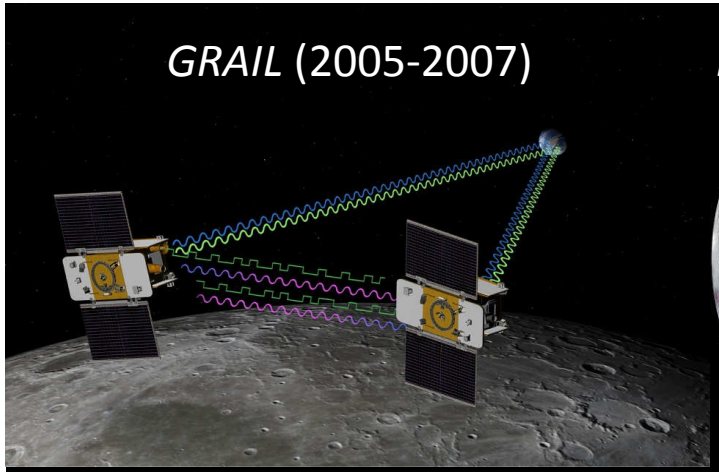
Leon Alkalai, JPL



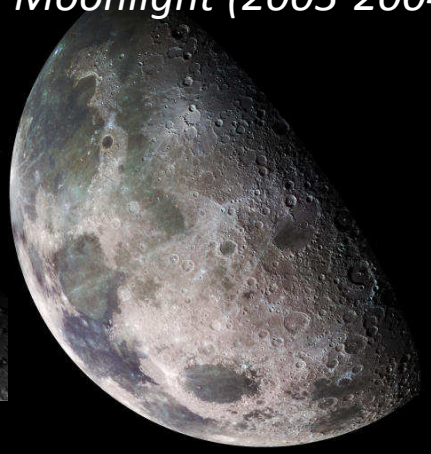
New Approaches to Lunar Ice Detection and Mapping Workshop
Keck Institute of Space Studies
July 22nd – July 25th, 2013
California Institute of Technology

Some Lunar Robotic Science & Exploration Mission Formulation Studies at JPL (2003 – 2013)

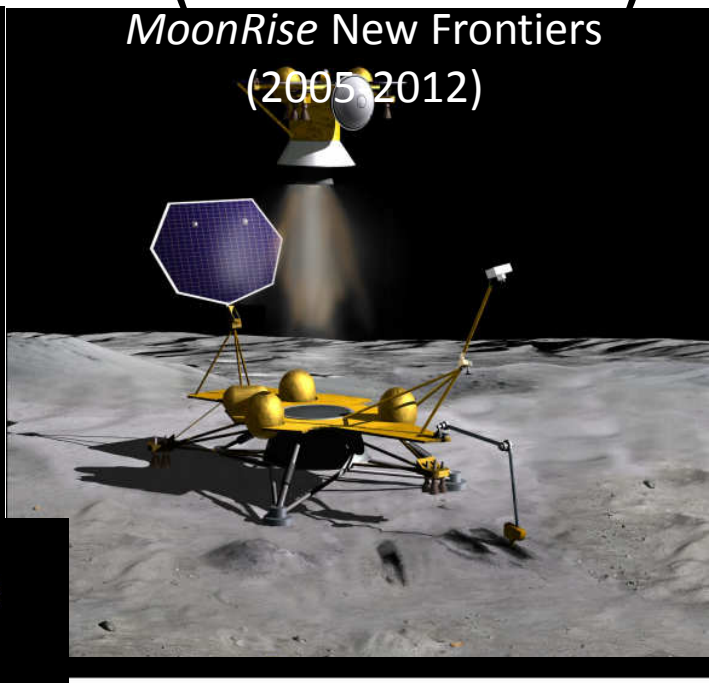
GRAIL (2005-2007)



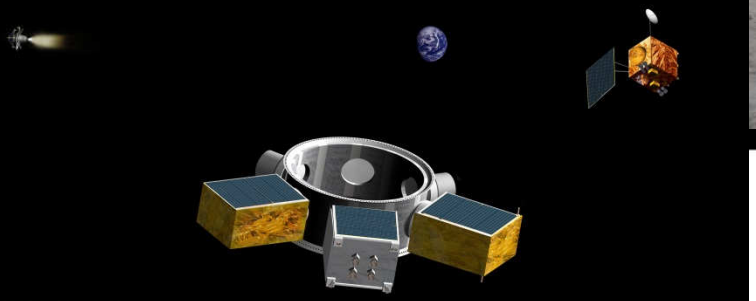
Moonlight (2003-2004)



MoonRise New Frontiers (2005, 2012)

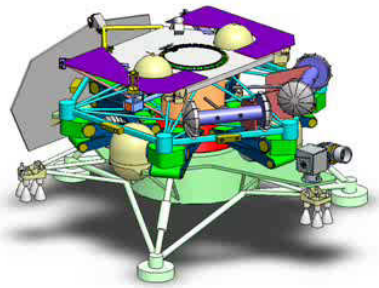


Lunette – Discovery Proposal Pre-Phase A Network of small landers (2005-2011)



Lunar Impactor (2006)

MIRANDA: cold trap access (2010)



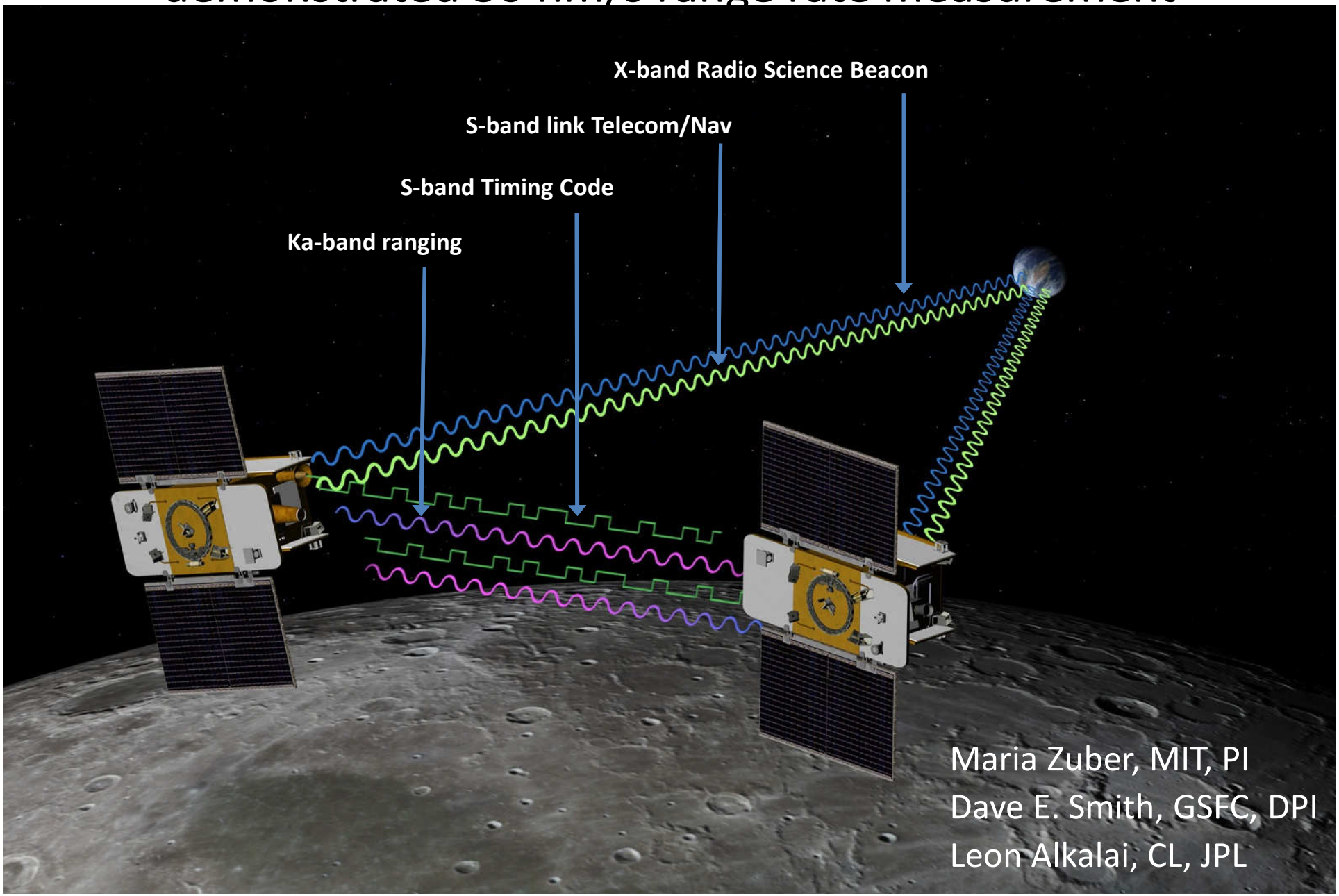
Other Lunar Science & Exploration Studies at JPL (2003 – 2013)

- Sample Acquisition and Transfer Systems (SATS)
- Landers: hard landers, soft landers, powered descent, hazard avoidance, nuclear powered lander and rover
- Sub-surface access: penetrators deployed from orbit, drills, heat-flow probe, etc.
- Surface mobility: Short-range, long-range, access to cold traps in deep craters
- CubeSats and other micro-spacecraft deployed e.g. gravity mapping
- International Studies & Discussions:
  - MoonLITE lunar orbiter and probes with UKSA
  - Farside network of lunar landers, with ESA, CNES, IPGP
  - Lunar Exploration Orbiter (LEO) with DLR
  - Lunar Com Relay Satellite with ISRO
  - Canadian Space Agency: robotics, surface mobility
  - In-situ science with RSA, landers, rovers
  - JAXA lunar landers, rovers
  - Korean Space Agency

Robotic Missions to the Moon: Just in the last decade: 2003 - 2013

• Smart-1	ESA	September 2003
• Chang'e-1	China	October 2007
• SELENE-1	Japan	September 2007
• Chandrayaan-1	India	October 2008
– M3, Mini-SAR	USA	
• LRO	USA	June 2009
• LCROSS	USA	June 2009
• Chang'e-2	China	October 2010
• GRAIL	USA	September 2011
• LADEE	USA	September 6th, 2013

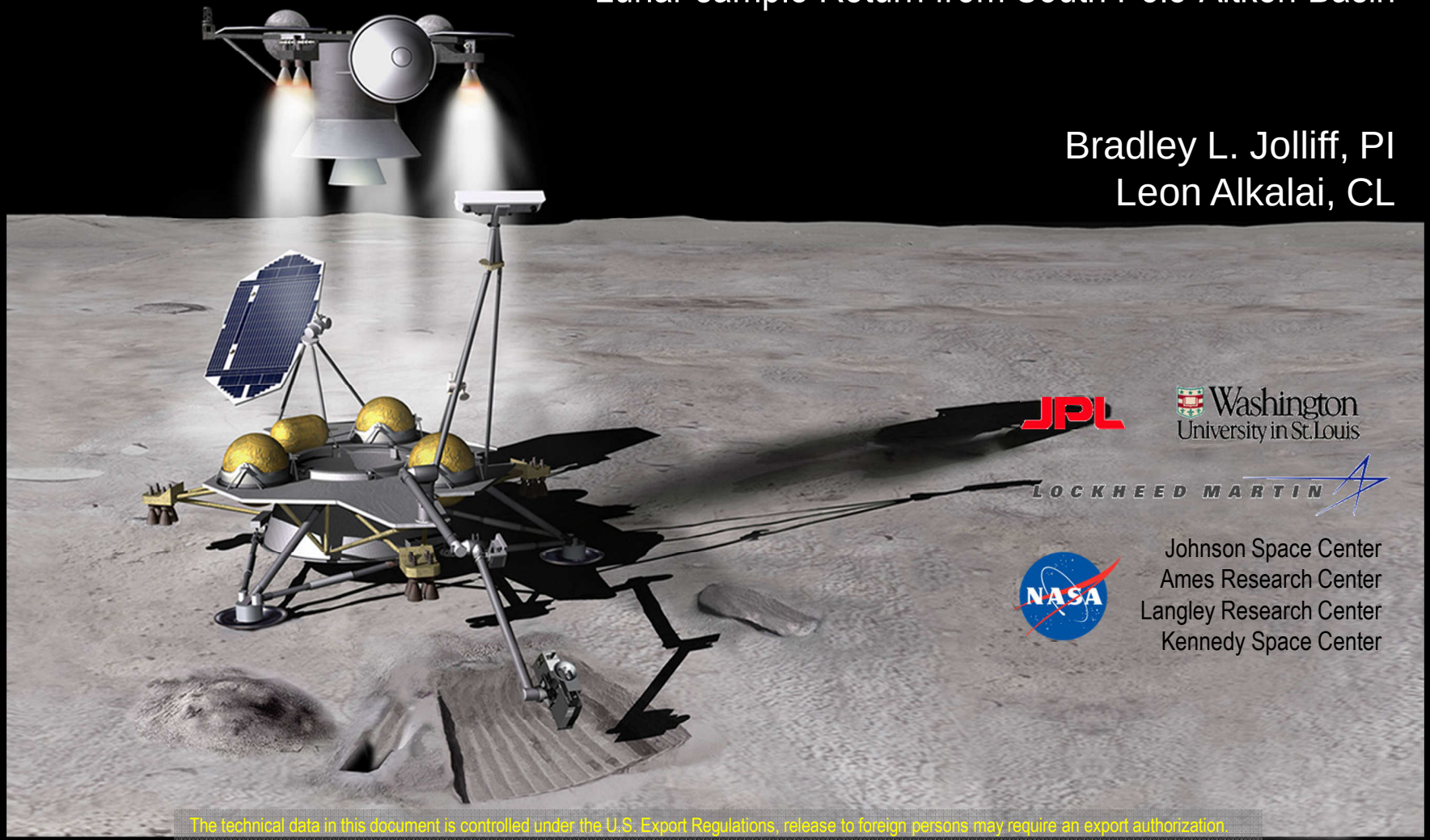
GRAIL: Gravity Recovery And Interior Laboratory demonstrated 30 nm/s range rate measurement



MoonRise

Lunar sample Return from South Pole-Aitken Basin

Bradley L. Jolliff, PI
Leon Alkalai, CL



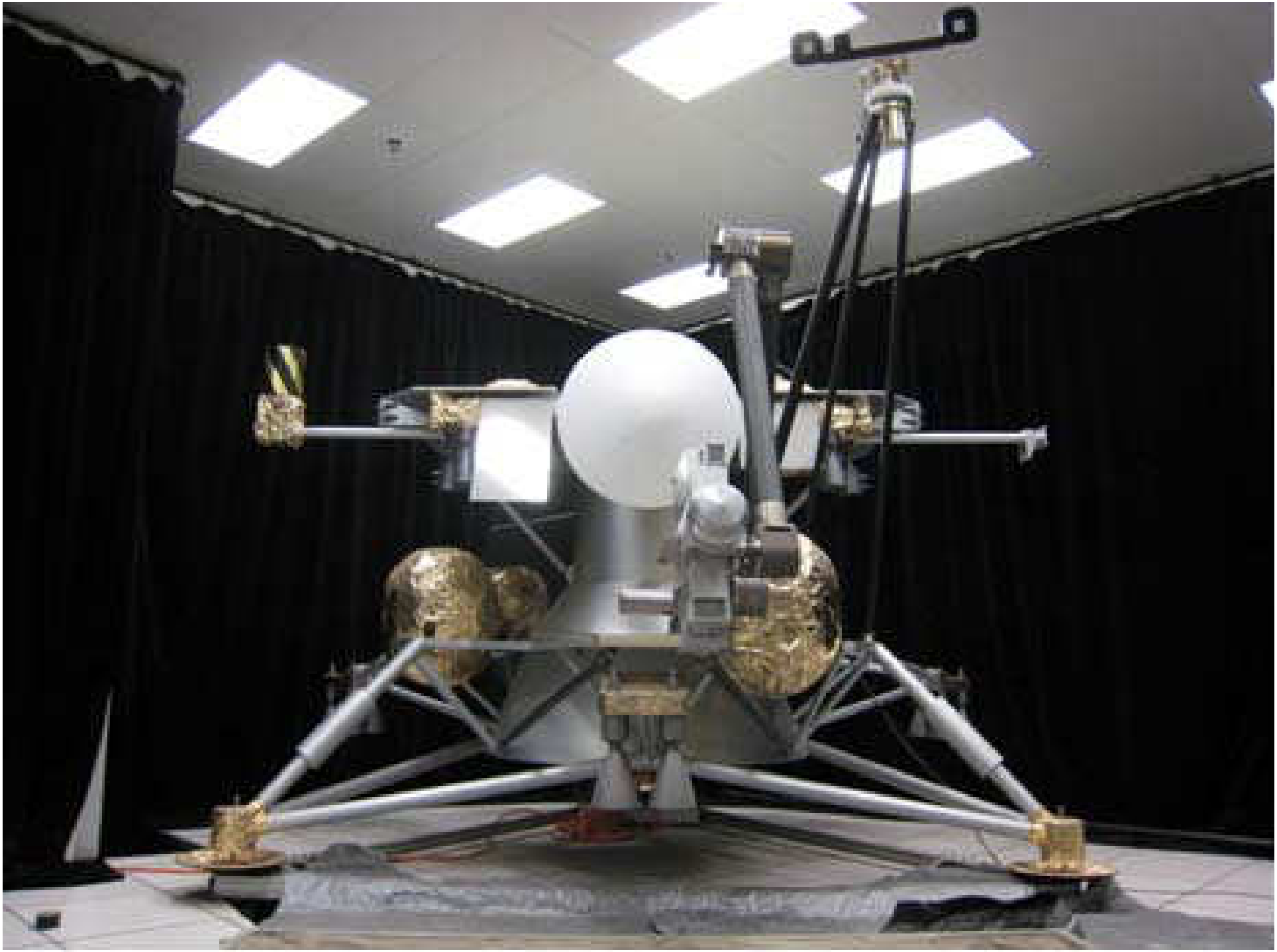
JPL

Washington University in St. Louis

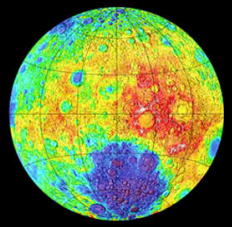
LOCKHEED MARTIN

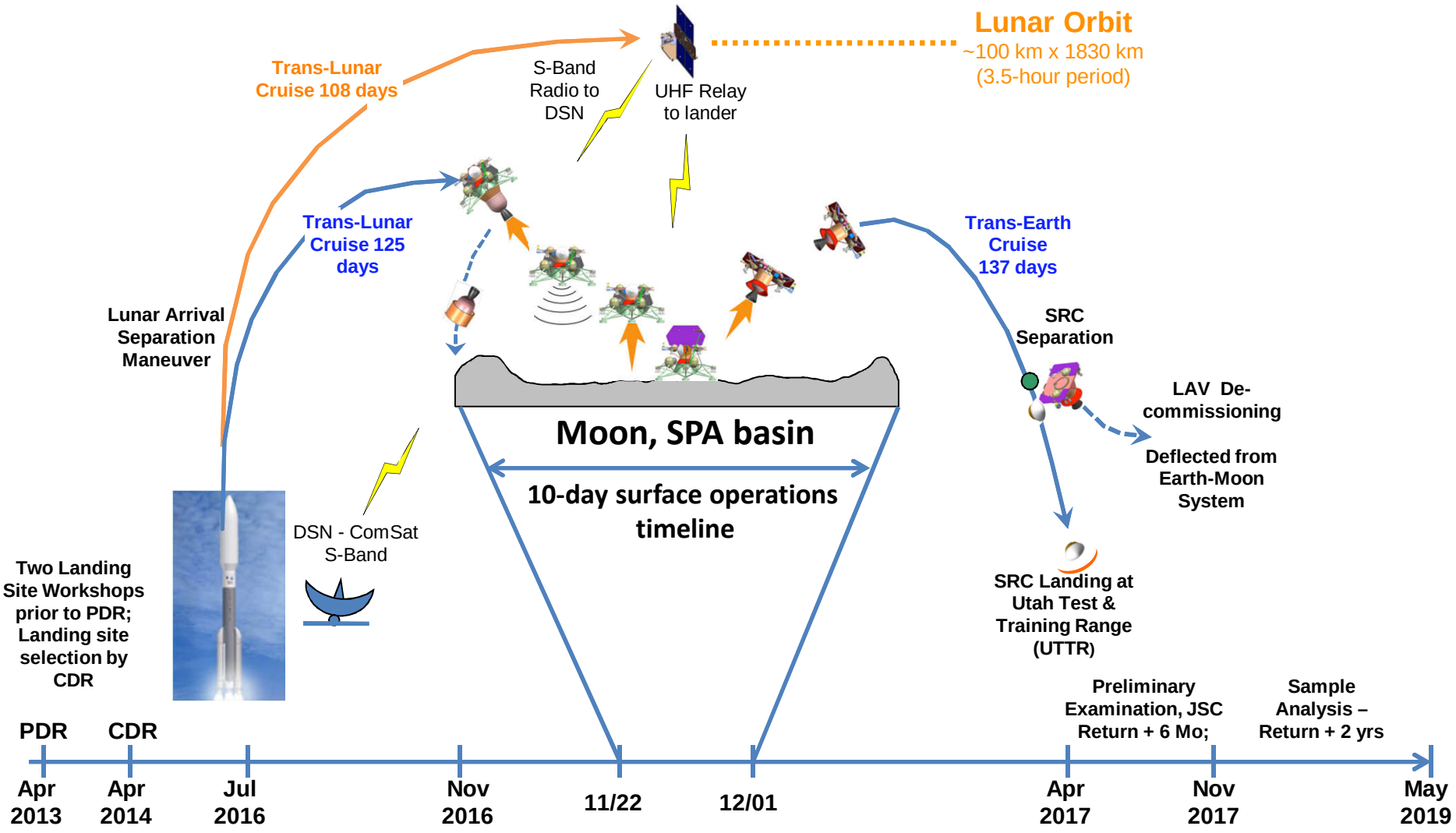
NASA

Johnson Space Center
Ames Research Center
Langley Research Center
Kennedy Space Center



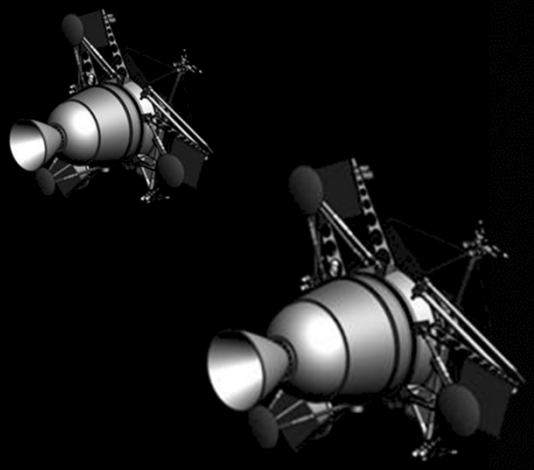
Overview of MoonRise Mission





Lunette

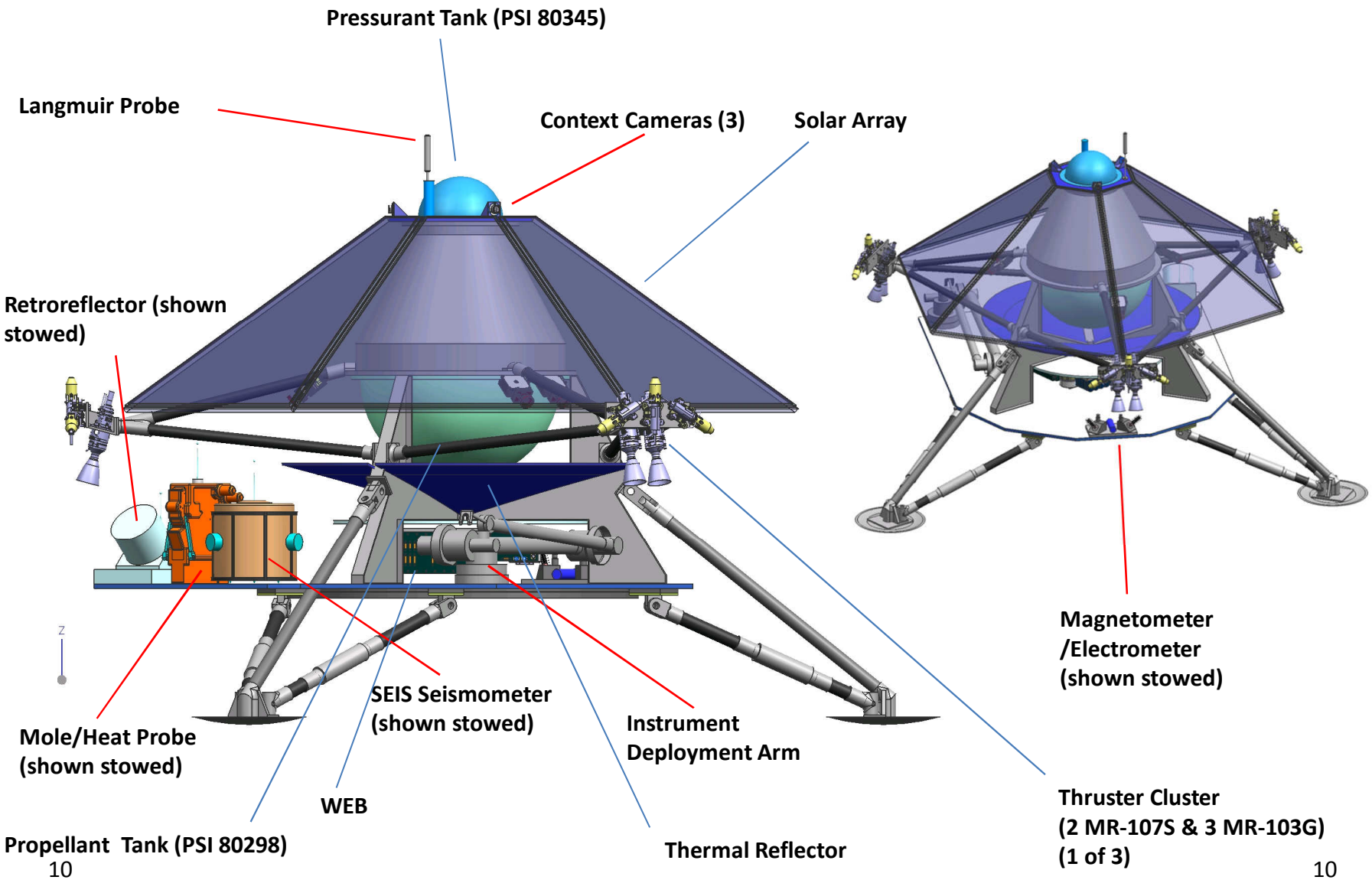
Lunar Geophysical Network



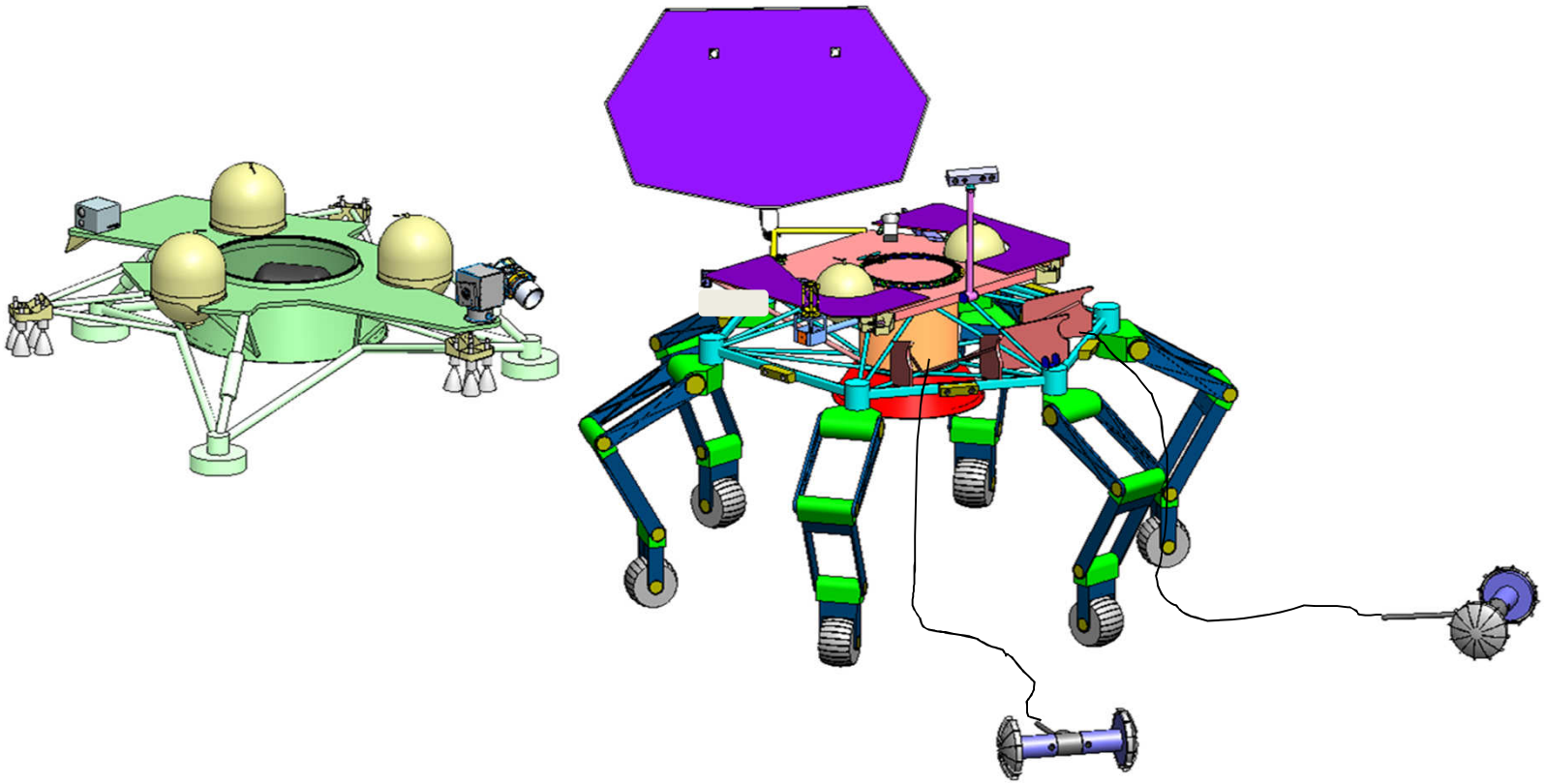
Clive Neal, PI, UND

John Elliott, CL, JPL

Lunette: Network of Small Lunar Landers



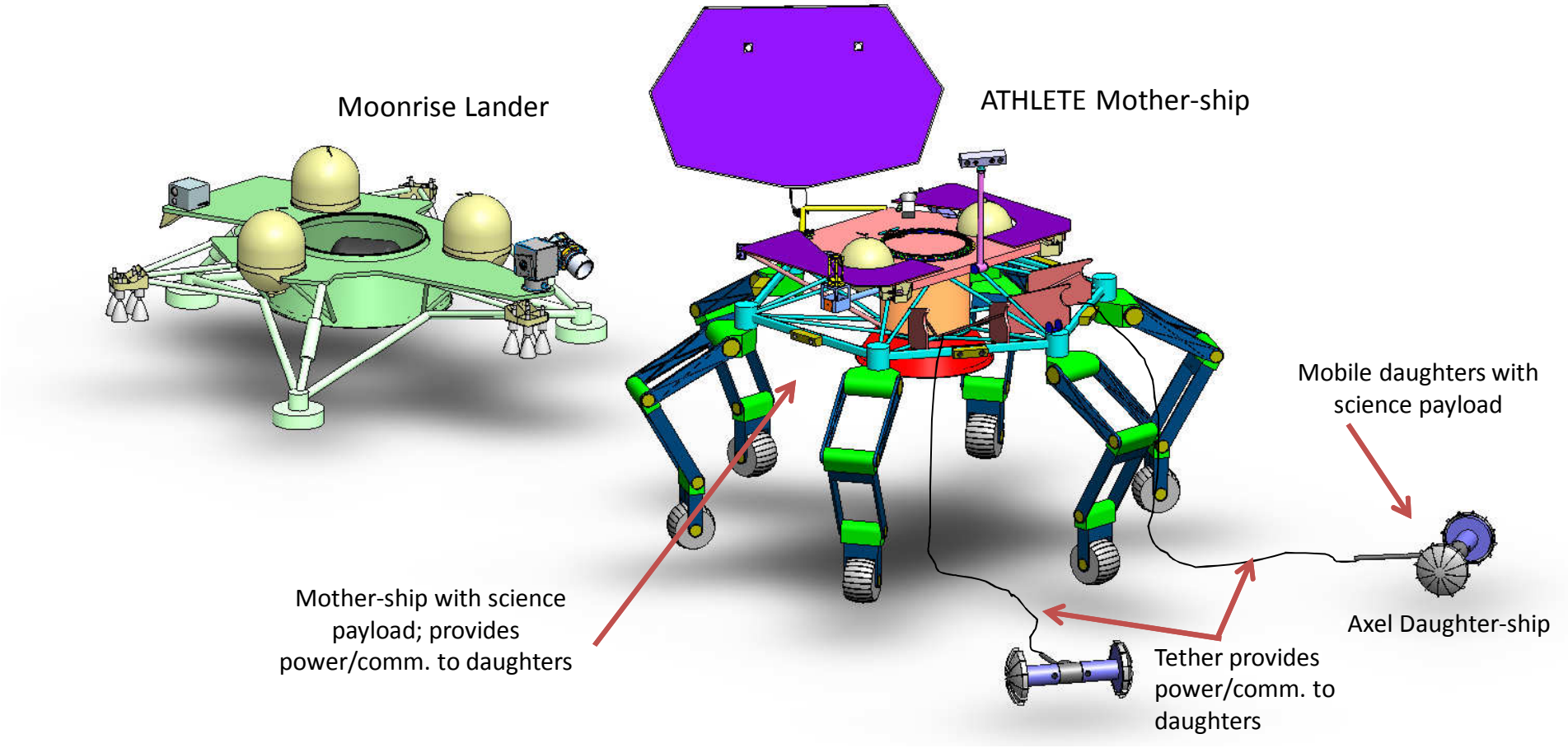
10



Moon Ice Resource Abundance & Natural Distribution Assessment (MIRANDA)

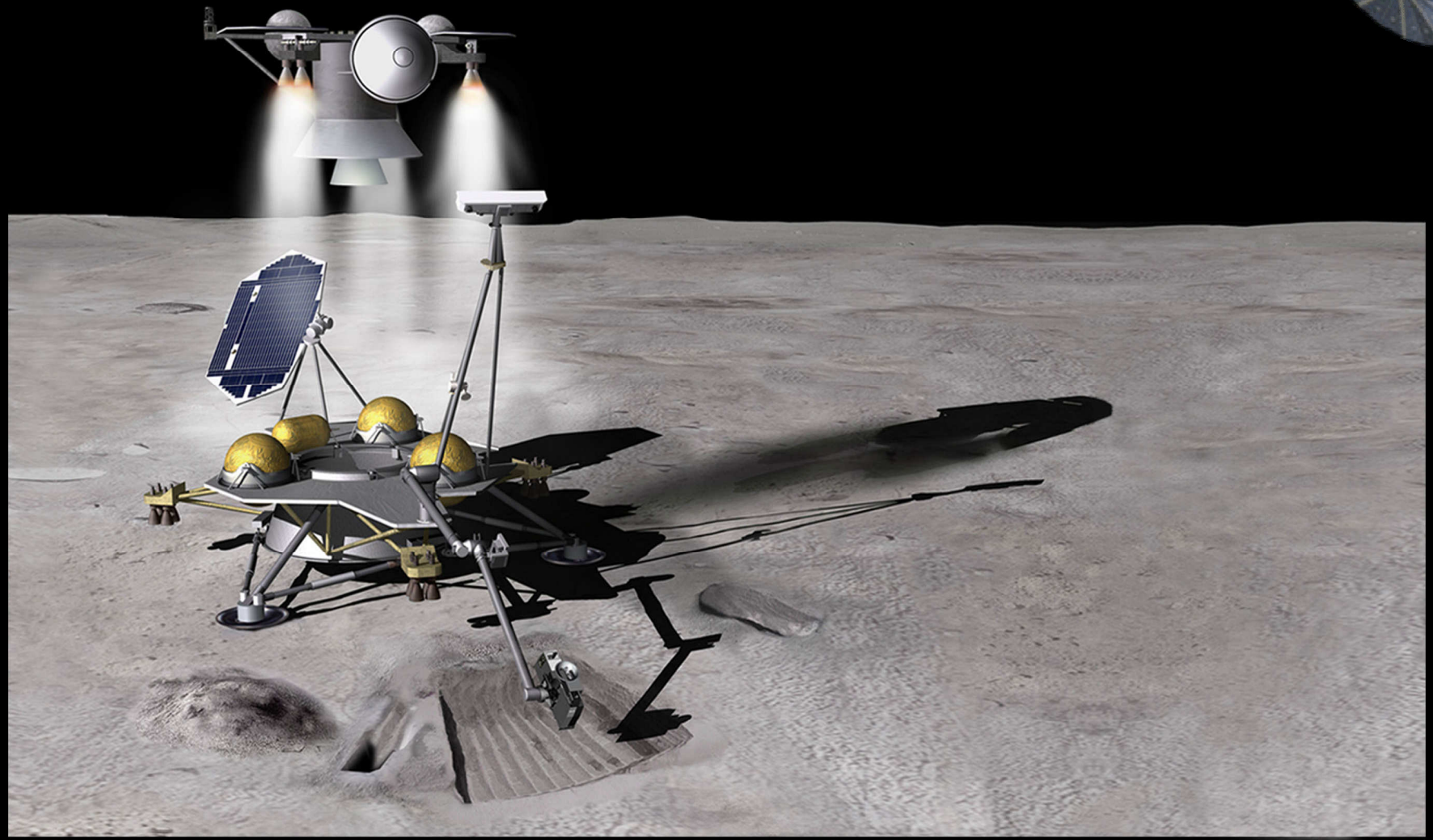
Leon Alkalai, Ben Solish & George Chen

Example of a Mother/daughter System



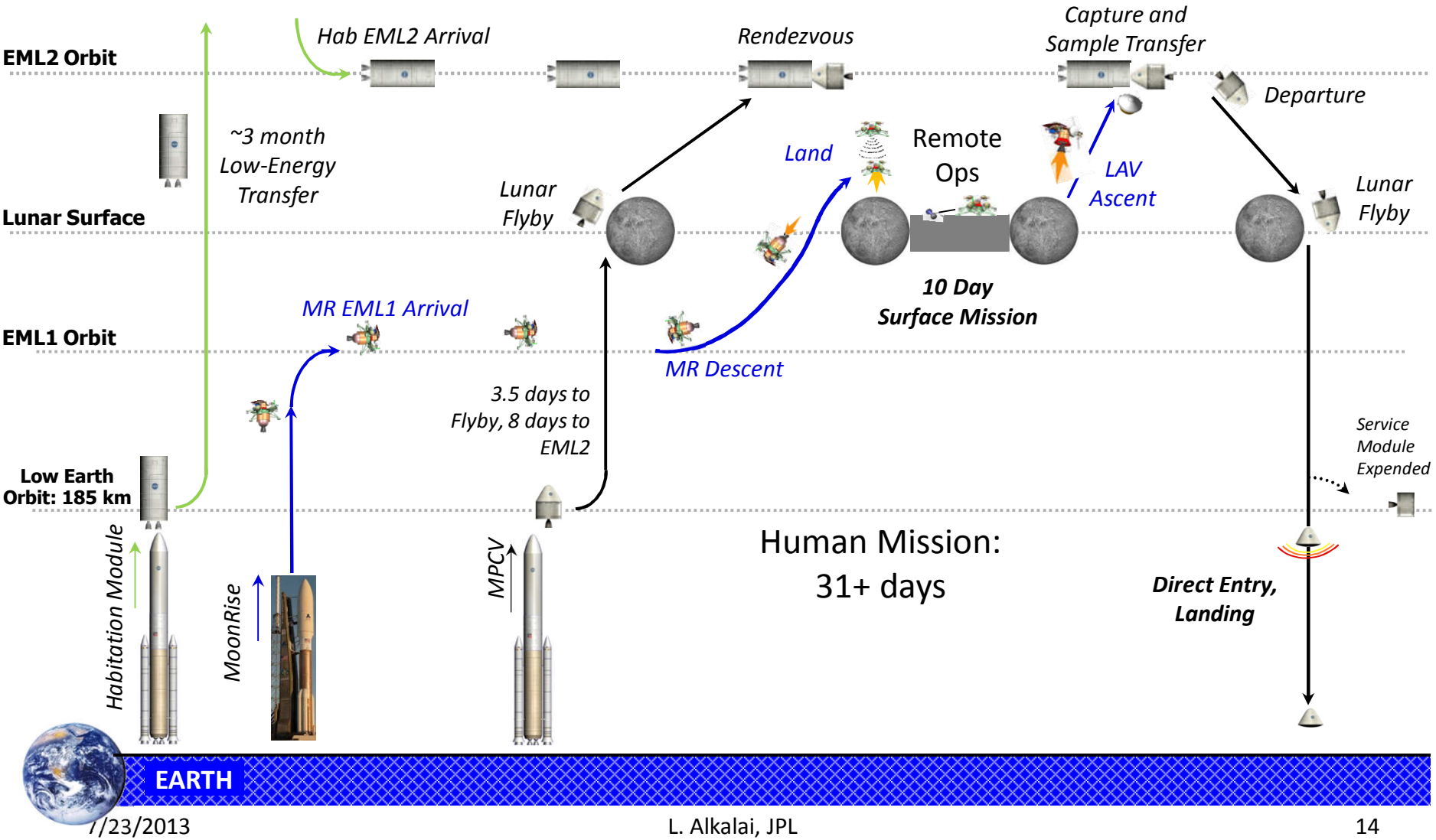
ORION/MoonRise:

Joint Human-Robotic
LUNAR Sample Return Mission Concept



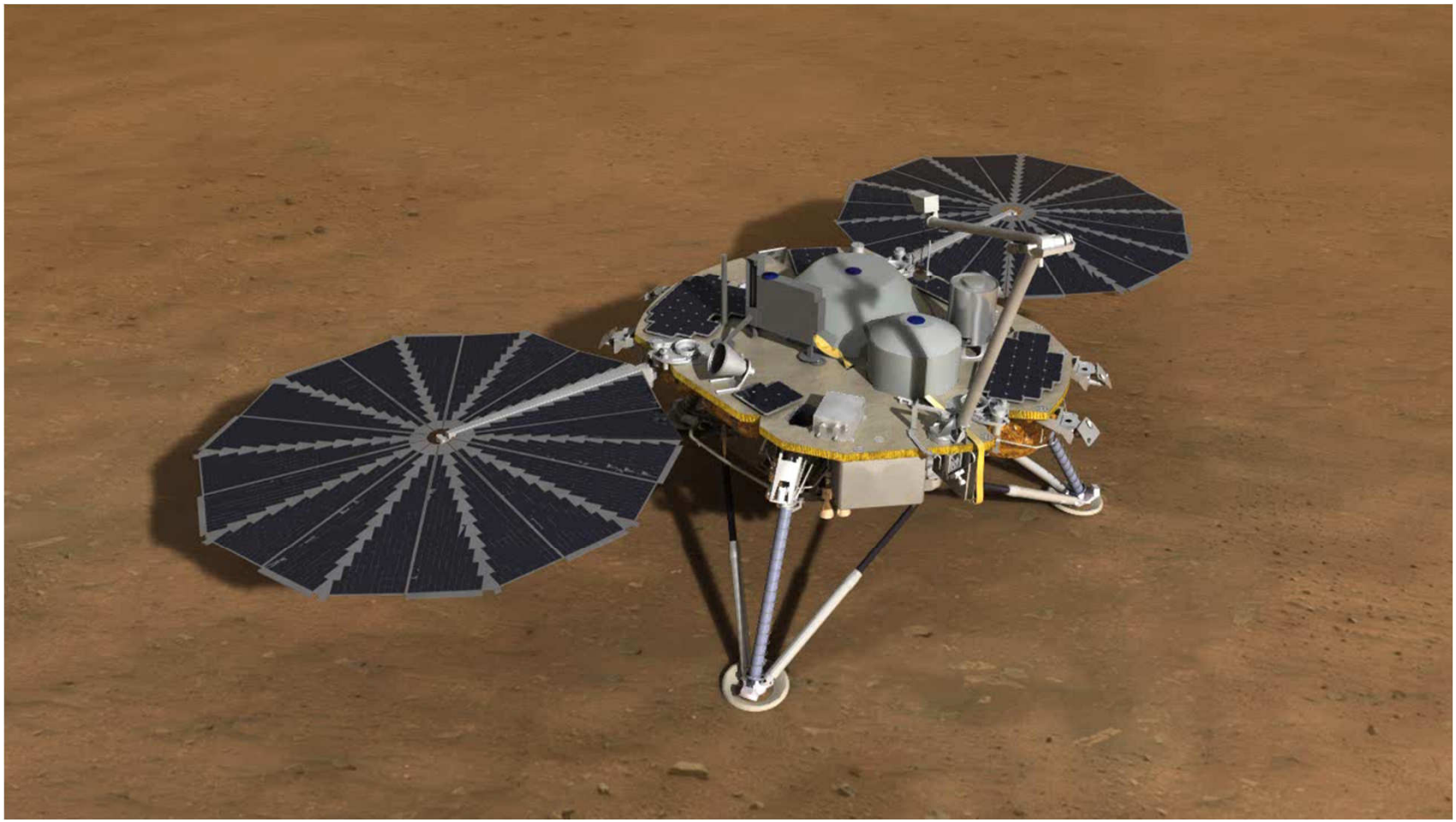
Orion/MoonRise: Mission Architecture

(LEAG 2012, IEEE Aerospace 2013)




InSight
NASA Discovery-12 Competition
Leon Alkalai, Capture Lead
JPL
JPL D-75337

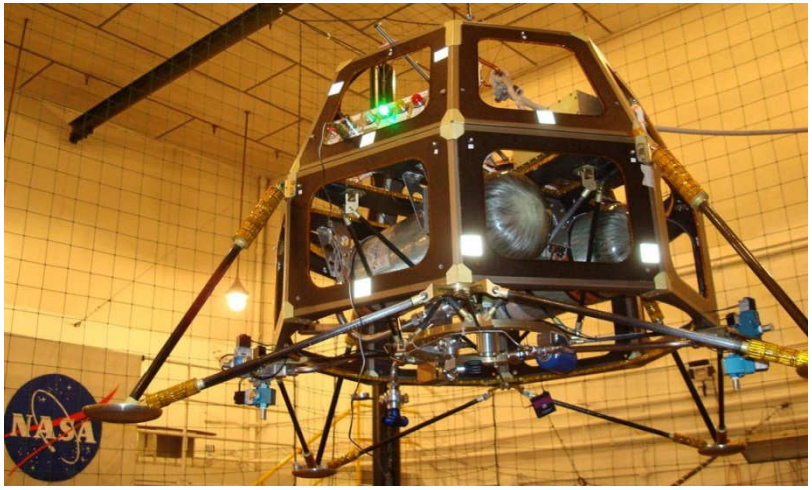
The next Mars Lander: *InSight* 2016
SEIS is sensitive to displacements of ~2.5x10^{-11}m



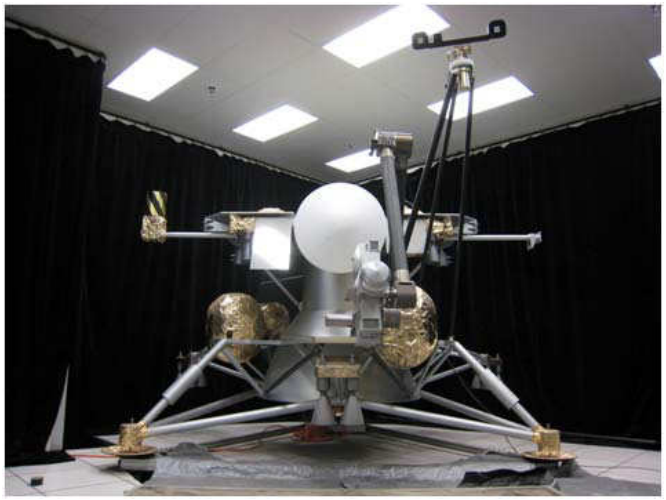
NASA Lunar Landers under development

JSC: Morpheus Lunar Lander

MSFC & APL: Mighty Eagle Lunar Lander



ARC: LANDEE



JPL: MoonRise Lander & Sample Return Vehicle (SRV)

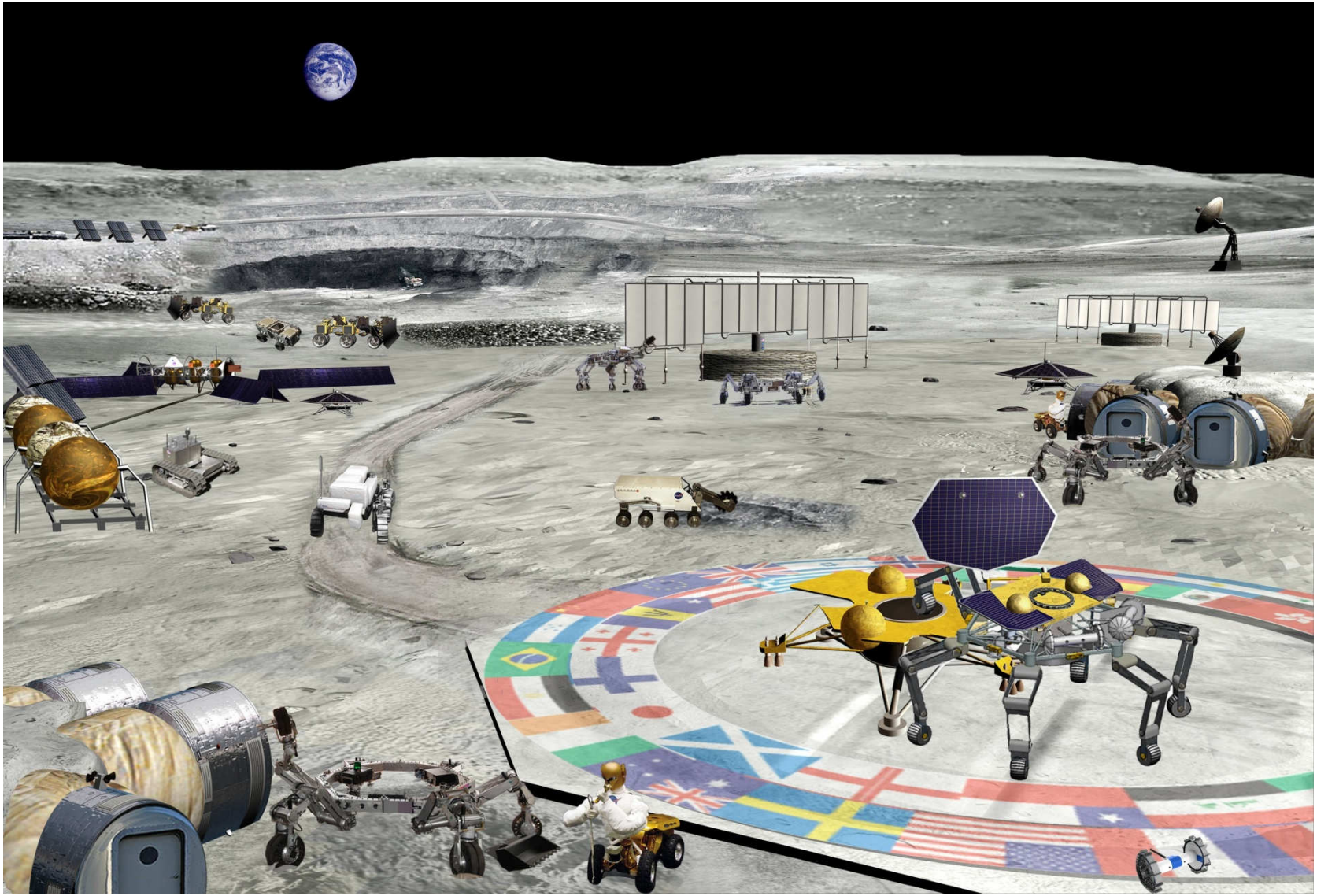
Google™ $30M Lunar X PRIZE

Sponsored by **Google** and managed by the **X PRIZE Foundation**

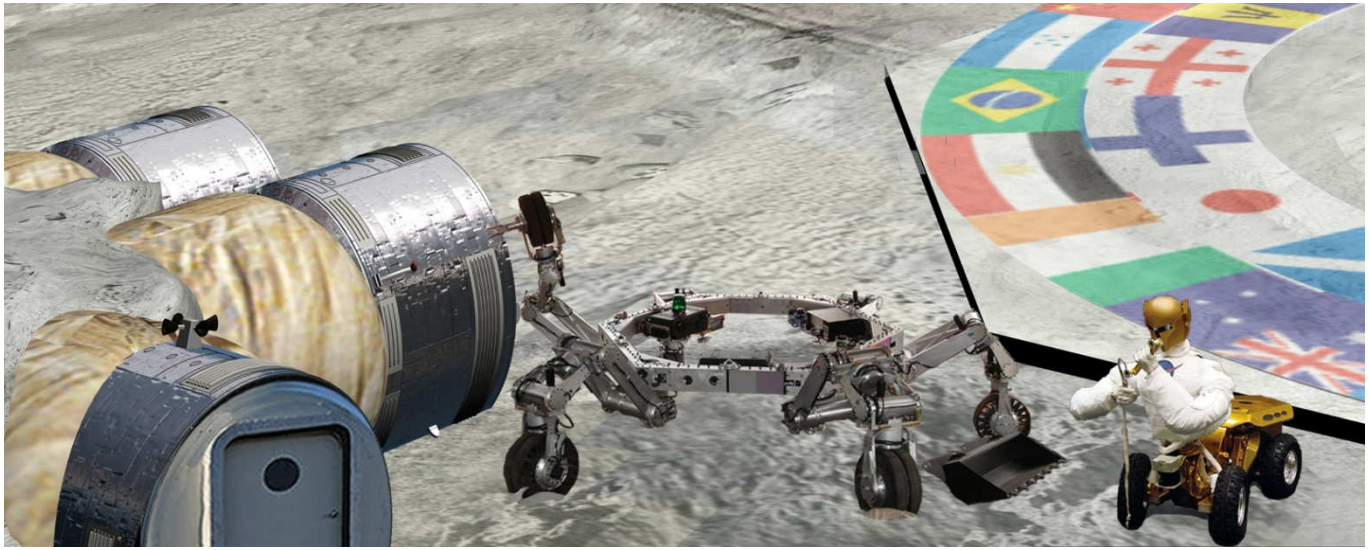
A follow-on challenge to the successful $10M **Ansari X PRIZE** for the first private spaceship

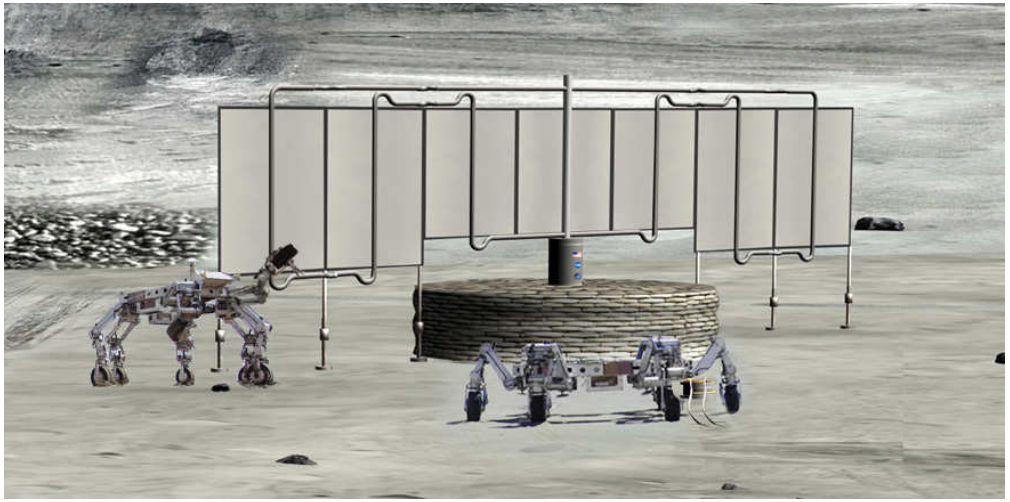
$20M Grand Prize to first private team to land on Moon, travel 500 meters and broadcast HD images and video to Earth

A Vision of a Permanent Robotic Village on the Moon



Robotic Assembly of Human Habitats, Infrastructure on the Moon





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Leon Alkalai et. al., "Orion/MoonRise: A Proposed Human & Robotic Sample Return Mission from the Lunar South-Pole Aitken Basin,"., IEEE Aerospace 2013, Big Sky.

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Jolliff, B. L., C. Shearer, D. Papanastassiou, **L. Alkalai**, R. Jaumann, G. Osinski, and the MoonRise Science Team (2010) MoonRise sample return from the South Pole-Aitken Basin. Lunar Exploration Analysis Group (LEAG) Annual Meeting, Sep. 14-17, Washington, DC.

Jolliff, B. L., **L. Alkalai**, C.M. Pieters, J. W. Head III, D. A. Papanastassiou, and E. B. Bierhaus, (2010) Sampling the South Pole- Aitken Basin: Objectives and site selection criteria. Lunar and Planetary Science 41, #2450.

Trebi-Ollennu, Ashitey , …, **Alkalai, Leon**, "*Lunar Surface Operation Testbed (LSOT)*", Aerospace Conference, 2012 IEEE, March 3-10, 2012, Big Sky, MT, USA.

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Elliott, J.O. and L. Alkalai, “Lunette: A Network of Lunar Landers for In-situ Geophysical Science”, Acta Astronautica 68 (2011), 1201-1207, April-May, 2011.

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Elliott, J.O., and L. Alkalai, “Lunette: A Low-Cost Concept Enabling Multi-Lander Lunar Science and Exploration Missions”, Acta Astronautica 66 (2010), 269-278, June, 2009.

Jones, M.A, J.O. Elliott, and L. Alkalai, “Systems Engineering Approach and Design Trades for the Lunette Geophysical Network Lander”, Paper No. 1211, Proceedings of the 2010 IEEE Aerospace Conference, Big Sky, MT, March 6-13, 2010.

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A. Trebi-Ollenu, A. L. Rankin, K. Tso, R. G. Deen, H. Aghazarian, E. A. Kulczycki, R. G. Bonitz, and **L. Alkalai**, "Instrument Deployment Testbed for Planetary Geophysical Exploration,", IEEE Aerospace, 2013, Big Sky, Montana.

Farside Explorer

"Farside explorer: Unique science from a mission to the farside of the moon," Mimoun, D., Wieczorek, M.A., **Alkalai, L**., Banerdt, W.B., et. al., Experimental Astronomy, Vo. 33, Issue 2-3, 2012, pp. 529 – 585.