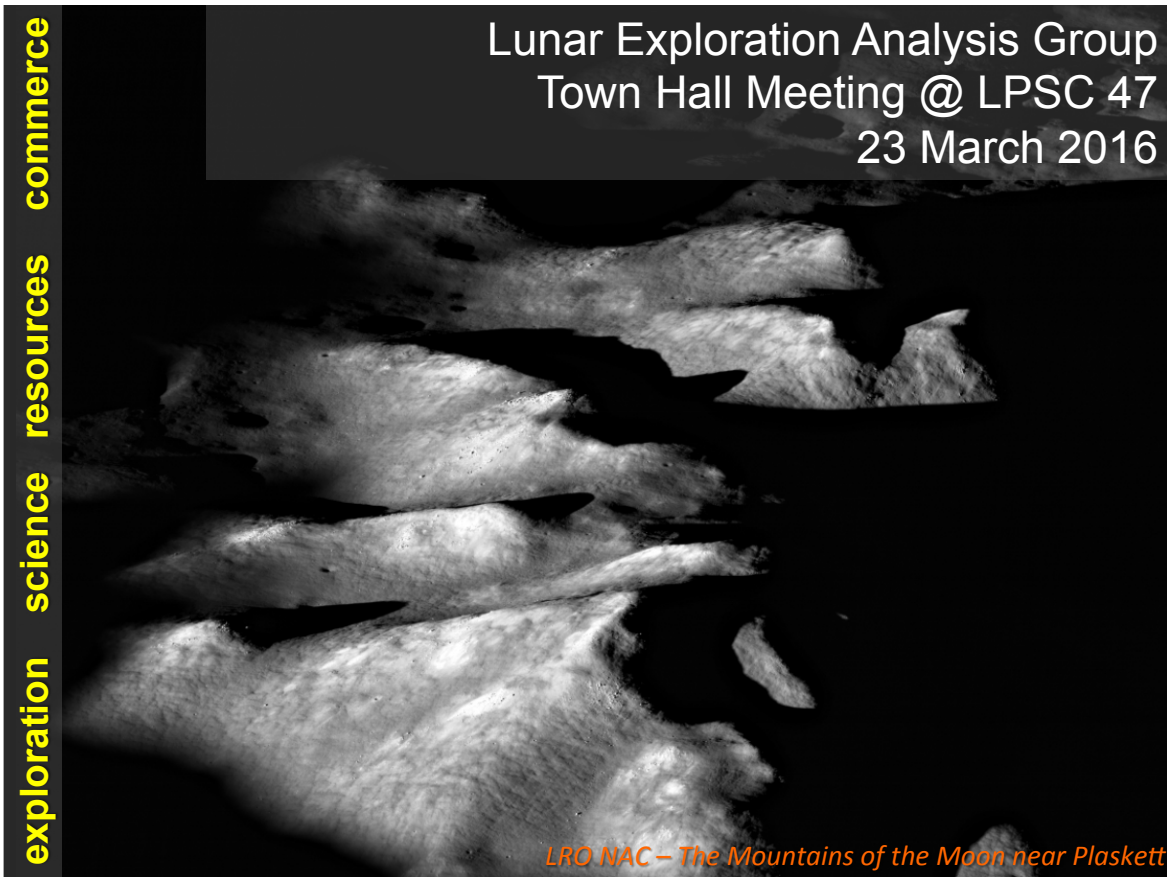


# LEAG Meeting 20-22 Oct. 2015

USRA HQ in Columbia, MD.
119 attendees.
Program with pdf talks are present at:
http://www.hou.usra.edu/meetings/leag2015/presentations/

Findings can be found at:
http://www.hou.usra.edu/meetings/leag2015/Meeting-Findings.pdf

**2016 LEAG Meeting 1-3 November (AFTER the L-DAP proposal deadline!) at USRA HQ, Columbia, MD**

# Special Finding on NF-4

LEAG strongly supports the release of a draft-for-comment of the New Frontiers Announcement of Opportunity (AO), the formal AO to be issued in January 2017. However, the inclusion of new theme "Ocean Worlds (Titan and Enceladus) is a major cause for community concern. Such targets for New Frontiers missions were not prioritized in the current Decadal Survey and they were not added by a transparent community-wide process to properly reevaluate the overarching strategy and priorities, such as was done by the NOSSE (New Opportunities in Solar System Exploration) report of 2008. Altering the New Frontiers candidate mission list by the inclusion of missions that were not considered by the Decadal Survey process undermines the credibility and balance of the entire Vision and Voyages report. LEAG is concerned that the addition of the Ocean Worlds missions to the New Frontiers AO without an opportunity for community input would set a bad precedent and erode community confidence in the Decadal process. LEAG urges PSD to find another programmatic means to accomplish Ocean Worlds science in concert with the existing New Frontiers and Discovery Programs.



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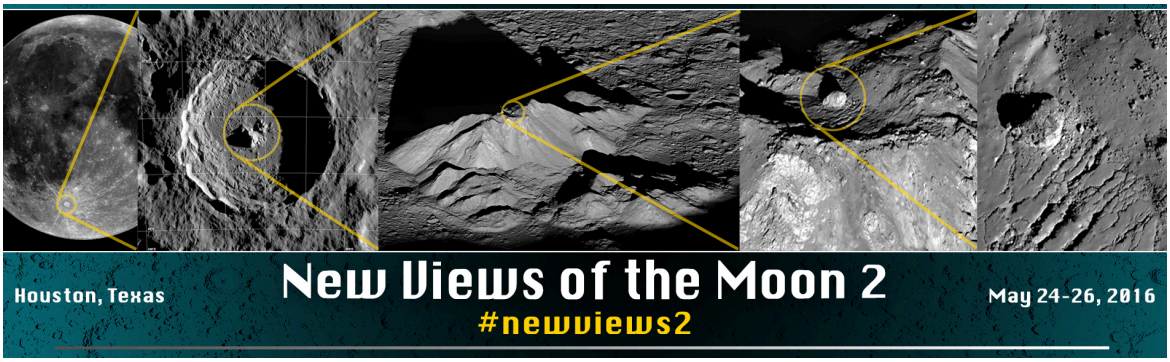
# LEAG Activities 2016

- **New Views of the Moon 2**
- Chapter co-leads identified and most have accepted;
- First workshop scheduled 24-26 May 2016 @ LPI. http://www.hou.usra.edu/meetings/newviews2016/




95 Abstracts



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# LEAG Activities 2016 (cont.)

- **Geological Astronaut Training SAT**
  - Dean Eppler and Jake Bleacher co-chairs;
  - Face-to-face meeting in 12-14 January at GSFC;
  - Report delivered to HEOMD and Astronaut Office by the end of March.

- **SKG-2-SAT (Review of SKG Document)**
  - Chip Shearer, Chair
  - First two telecon meetings are completed
  - Report due end of 1st September 2016.



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# LEAG Activities 2016 (cont.)

- **Human Exploration Proving Ground SAT**
  - Mark Jernigan and Clive Neal co-chairs;
  - Provide science objectives for the set of proving-ground missions to cis-lunar space;
  - Report delivered to JSC by the end of September.



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# LEAG

## 2015 LEAG Meeting Findings

**Lunar Capabilities Roadmap (LCR)**
**[SMD-PSD, HEOMD-AES]**

**Finding**. The participants of the 2015 LEAG meeting endorse the construction of a Lunar Capabilities Roadmap by LEAG, deduced from the Lunar Exploration Roadmap, that would highlight instrumentation and technologies critical for science and exploration of the Moon and potentially beyond.

**Background**. The LCR will be a strategic and living document that could:

- Facilitate design reference mission(s) concept(s) studies;
- Identify critical capabilities for early flight testing of unproven yet critical instruments and technologies;
- Leverage from existing national and international technology roadmaps;
- Leverage innovative business models as identified in the recently released NASA-funded Evolved Lunar Architecture study;
- Identify capabilities of benefit to SMD, HEOMD, and STMD that would benefit from collaborative development.



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# LEAG

- **LEAG Lunar Capabilities Roadmap**
  - Georgiana Kramer, David Lawrence (tentatively) co-chairs;
  - Soliciting community volunteers to help.
  - Aims to **highlight technologies that are needed in the near term** to advance Decadal Survey goals, address SKGs, and advance the LEAG Roadmap.
  - Interested in participating? Send an email neal.1@nd.edu stating how you can help with this very important effort.



LUNAR EXPLORATION ANALYSIS GROUP

# LEAG Website

- Started the process to update the web site.
- Need volunteers to finish the process!
- If interested, please contact neal.1@nd.edu



# Lunar Missions

Lunar Reconnaissance Orbiter – about to submit a third extended mission proposal.

ARTEMIS – looking at the Moon's interaction with the Sun.

Resource Prospector Mission.

Lunar Mission One.

South Korea 2018 orbiter.

Google Lunar X-Prize.

Russian/ESA plans.

Chang'E-4 launch – 2017. Farside SPA rover.

Chang'E-5 launch – 2018. Sample Return.

Cube Sat opportunities.




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# Special Issue(s) of Icarus

- 69 submissions to the special issue
- Volume I slated for July 16 (Issue 273)
- Papers in press at: URL here
- Thanks to the reviewers!

http://www.sciencedirect.com/science/journal/aip/00191035

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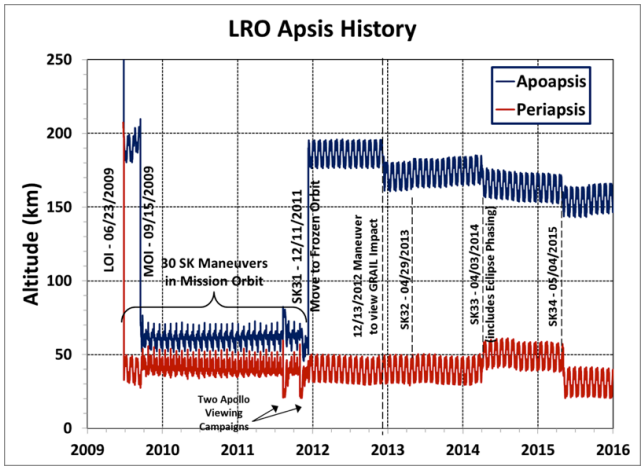
# LRO Spacecraft Status




- Spacecraft is healthy
- Currently in quasi-stable orbit, SP periapse of ~30 km
- *At least* 6 years of fuel left, <u>at current rate of consumption</u>
- *<u>LRO is in the Presidnet's budget this year!</u>*

# Senior Review

- Proposal due April 15, expect announcement this summer
- 2 years of operations (FY17-18)
- Exciting new science, new modes of operations for many of the instruments
- Return of Mini-RF is proposed

National Aeronautics and Space Administration

# HEOMD Update

**Ben Bussey**
*Chief Exploration Scientist*
*NASA Human Exploration & Operations Mission Directorate*

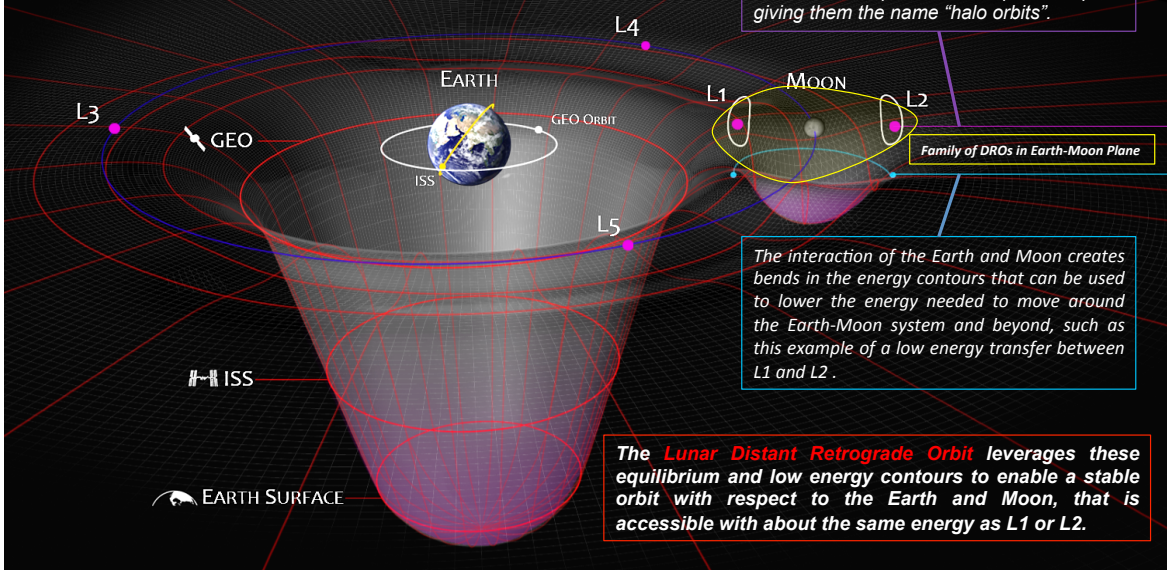
## Strategic Principles for Sustainable Exploration

- **FISCAL REALISM: Implementable in the *near-term with the buying power of current budgets* and in the longer term with budgets commensurate with economic growth*;***
- **SCIENTIFIC EXPLORATION*: Exploration enables science and science enables exploration;* leveraging scientific expertise for human exploration of the solar system.**
- **TECHNOLOGY PULL AND PUSH: Application of high TRL technologies for near term missions, while focusing sustained investments on *technologies and capabilities* to address the challenges of future missions;**
- **GRADUAL BUILD UP OF CAPABILITY: *Near-term mission opportunities* with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time;**
- **ECONOMIC OPPORTUNITY: Opportunities for *U.S. commercial business* to further enhance their experience and business base;**
- **ARCHITECTURE OPENNESS AND RESILENCE: Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions;**
- **GLOBAL COLLABORATION AND LEADERSHIP: Substantial *new international and commercial partnerships,* leveraging current International Space Station partnerships and building new cooperative ventures for exploration; and**
- **CONTINUITY OF HUMAN SPACEFLIGHT*: Uninterrupted expansion of human presence into the solar system* by establishing a regular cadence of crewed missions to cislunar space during ISS lifetime.**

# Cislunar Space:
# How the Earth and the Moon Interact

*The contours on the plot depict energy states in the Earth-Moon System and the relative difficulty of moving from one place to another.*

*A spacecraft at L2 is actually orbiting Earth at a distance just past the Moon, however if you look at it from the Moon, the orbit will look like an ellipse around a point in space giving them the name "halo orbits".*

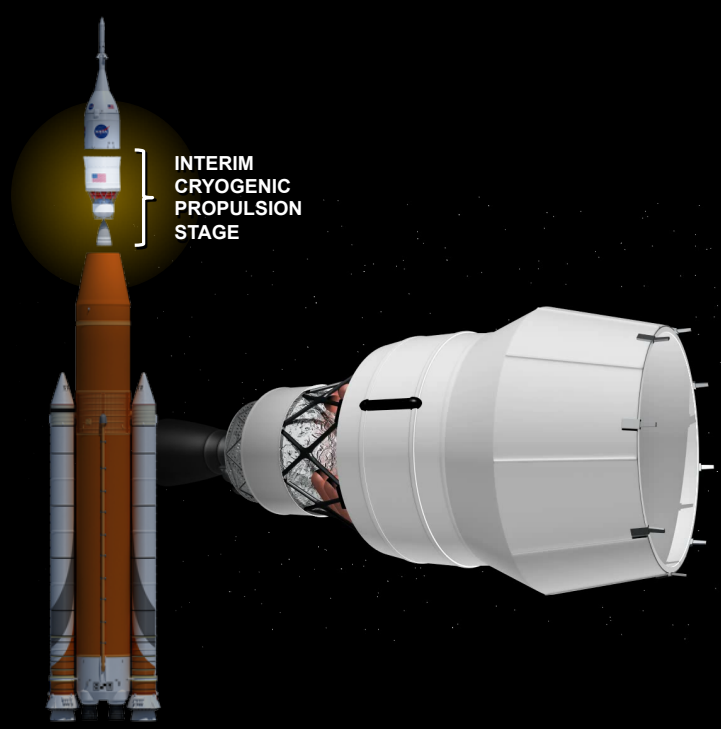


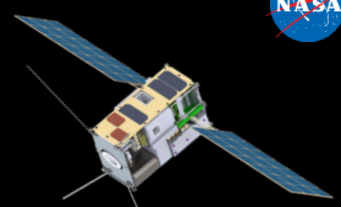

*Family of DROs in Earth-Moon Plane*

*The interaction of the Earth and Moon creates bends in the energy contours that can be used to lower the energy needed to move around the Earth-Moon system and beyond, such as this example of a low energy transfer between L1 and L2 .*

***The Lunar Distant Retrograde Orbit leverages these equilibrium and low energy contours to enable a stable orbit with respect to the Earth and Moon, that is accessible with about the same energy as L1 or L2.***

# Secondary Payloads

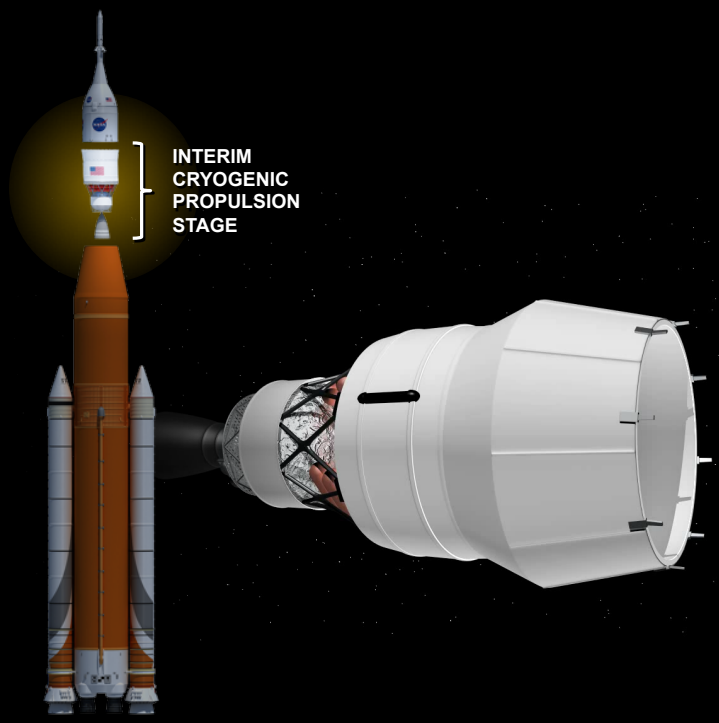


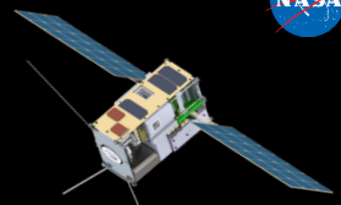



## 13 CUBE SATS SELECTED TO FLY ON EM-1

- Lunar Flashlight
- Near Earth Asteroid Scout
- Bio Sentinel
- LunaH-MAP
- CuSPP
- Lunar IceCube
- Skyfire
- JAXA SLSLIM
- ESA ArgoMoon
- JAXA EQUULEUS
- STMD Centennial Challenge Winners

## Secondary Payloads



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- ESA ArgoMoon
- JAXA EQUULEUS
- STMD Centennial Challenge Winners

# Lunar Flashlight Overview

*Looking for surface ice deposits and identifying favorable locations for in-situ utilization in lunar south pole cold traps*

**Measurement Approach:**

- *Lasers in 4 different near-IR bands illuminate the lunar surface with a 3° beam (1 km spot).*
- *Light reflected off the lunar surface enters the spectrometer to distinguish water ices from regolith.*

***Orbit:***

- **Elliptical:** 20-9,000 km
- **Orbit Period:** 12 hrs
- **Sci Pass:** ~10min

***Teaming:***

- ***JPL-MSFC***
- ***S/C (6U - 14 kg): JPL***
- ***Mission Design & Nav: JPL***
- ***Propulsion: Green Prop (MSFC)***
- ***Payload: 1-2 micron Spectrometer***
- ***I&T: JPL***

***Phases***

- **Launch:** SLS EM1
- **Schedule:** Launch July, 2018
- **LOI:** Launch +6 months
- **Design Review:** July, 2016
- **Phase E:** >1 year

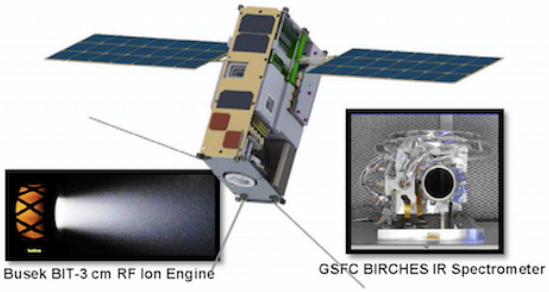
**Jet Propulsion Laboratory**
California Institute of Technology

# Lunar IceCube

## Objectives & Technical Approach:

- A 6U CubeSat mission to prospect for water in ice, liquid, and vapor forms and other lunar volatiles from a low-perigee, inclined lunar orbit using a compact IR spectrometer. Lunar IceCube 6U will:
  - be deployed during lunar trajectory by the SLS on EM-1
  - use an innovative RF Ion engine to achieve lunar capture and a science orbit of 100 km perilune
  - fully characterize water and other volatiles with high spectral resolution (5 nm) and wavelength range (1 to 4 μm)

Lunar IceCube in Flight Configuration




## Team: *University, Aerospace Industry, Government*

- **Morehead State University Space Science Center**
  Ben Malphrus (PI), Bob Twiggs, Jeff Kruth, Kevin Brown, Roger McNeil, intrepid graduate and undergraduate STEM students
- **The Busek Company**
  Kurth Hohman, Vlad Hruby, Mike Tsay
- **NASA Goddard Spaceflight Center**
  **Science Team:** Pamela Clark, Dennis Reuter, Robert MacDowall, Clifford Brambora, Deepak Patel, Ian Banks
  **Navigation and Tracking:** David Folta
- **NASA Goddard Spaceflight Center and Catholic University of America**
  Pamela Clark (Science PI)

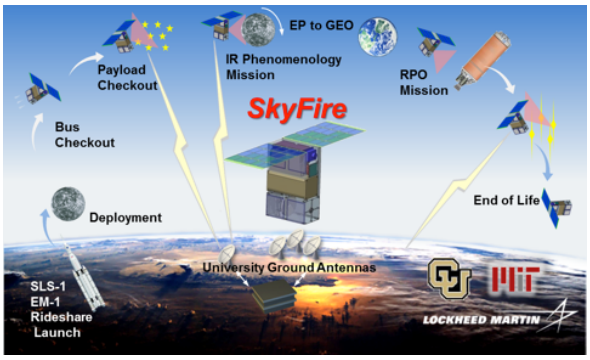
## Schedule:

- Initiate Program: Q1 2015
- TIMs, Reviews, Milestones
  As per Requirement
- Launch/LEOP
  SLS Maiden Flight
- Lunar Transit
  Launch +6 Months
- Science Orbit/Mission
  Arrival +3 Months
- Disposal: Q1 2020

# Small Satellite Missions: Lockheed Martin SkyFire

## Objectives & Technical Approach:

- Lockheed Martin is building the SkyFire cubesat as a technology development platform that will be co-manifested with additional cubesats on the SLS-1 EM-1 test flight
- Following separation from SLS, SkyFire will fly by the moon taking infrared sensor data in order to enhance our knowledge of the lunar surface
- Using electrospray propulsion, the spacecraft orbit will be lowered to the GEO 'graveyard' orbit for more science and technology mission objectives
- SkyFire will leverage Lockheed Martin's successful additive manufacturing experience for deep space missions




## Teammates:

- The Lockheed Martin spacecraft team will consist of the 'Digital Generation' of young spacecraft engineers working with members of the university community
- With SkyFire, LM achieves the multiple benefits of workforce and technology development in partnership with NASA
- Key technology team members:
  - Massachusetts Institute of Technology (MIT)/Accion
  - University of Colorado

## Lockheed Martin Contacts:

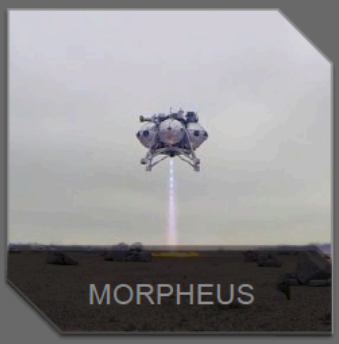
Program Manager – John Ringelberg
John.c.Ringelberg@lmco.com
Contracts POC - Caitlin Foster
Caitlin.e.Foster@lmco.com

# Lunar CATALYST

Lunar CArgo Transportation And Landing bY Soft Touchdown

## BRINGING THE MOON INTO EARTH'S ECONOMIC SPHERE

Accelerating private-sector lunar landing capabilities with NASA expertise using public-private partnerships

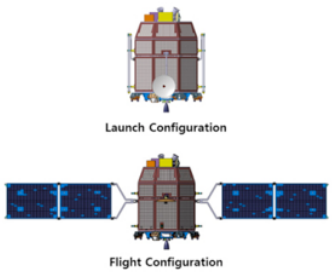




Three companies selected for no exchange of funds support

- Astrobotic Technology
- Masten Space Systems
- Moon Express

## Korea Pathfinder Lunar Orbiter (KPLO)

- **Korea is planning a lunar orbiter in the late 2018 timeframe**
- **NASA (HEOMD) is negotiating payload space for NASA-selected instrument(s)**
- **What instruments NASA chooses will depend on what KARI chooses to fly**
- **Details still fluid but a promising potential opportunity for the lunar science community to acquire new lunar data that supports exploration**

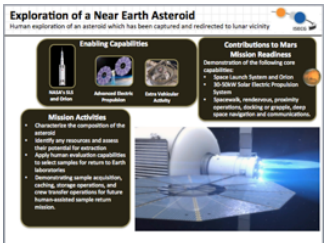


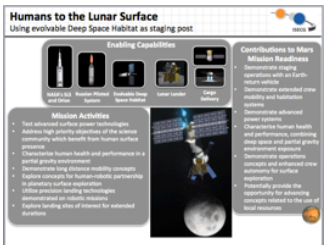

<Conceptual Design of Korea Pathfinder Lunar Orbiter>

## Science White Paper – Concept & Scope

- **Describe an international view of the science that could be enabled by human missions in the GER**
  - Engage the scientific communities in identifying these opportunities
  - Target the same stakeholder community as the GER
  - Focus on human missions and human/robotic concepts
  - Incorporate activities that have feed-forward benefits to Mars exploration

- **Incorporate interdisciplinary scientific topics that**
  - Encompass all relevant science communities and disciplines: planetary science, space science, life sciences, astrobiology, astronomy, physical sciences, etc.
  - Span all destinations (LEO, cis-lunar space, Moon, asteroids, Mars)
  - Incorporate input from the international science communities


## Science Advisory Group Membership

- **Co-chairs:**
  1. Ben Bussey (NASA, USA) ben.bussey@nasa.gov
  2. Jean-Claude Worms (ESF, France) jcworms@esf.org

- **Members**
  3. Gilles Clement (Univ. of Lyon, France) gilles.clement@inserm.fr
  4. Ian Crawford (Univ. of London, UK) i.crawford@ucl.ac.uk
  5. Mike Cruise (Univ. of Birmingham, UK) a.m.cruise@bham.ac.uk
  6. Masaki Fujimoto (JAXA, Japan) fujimoto@stp.isas.jaxa.jp
  7. Dave Hart (Univ. of Calgary, Canada) hartd@ucalgary.ca
  8. Ralf Jaumann (DLR, Germany) Ralf.Jaumann@dlr.de
  9. Clive Neal (Notre Dame Univ., USA) neal.1@nd.edu
  10. Gordon Osinski (Univ. of West. Ontario, Canada) gosinski@uwo.ca
  11. Masaki Shirakawa (JAXA, Japan) shirakawa.masaki@jaxa.jp
  12. Tim McCoy (Smithsonian, USA) mccoyt@si.edu
  13. Maria Cristina De Sanctis (INAF, Italy) mariacristina@iaps.inaf.it

- **Executive Secretary**
  - Greg Schmidt (SSERVI, USA) gregory.schmidt@nasa.gov

## SWP Science Topics

- **Living and working in space**
  - Overarching questions:
    - How do we become a spacefaring species?
    - How do we sustain life outside Earth?
  - Disciplines involved, e.g.
    - Human physiology, life sciences and life support
    - Prospecting and utilising local resources

- **Our place in the universe**
  - Overarching question:
    - How do terrestrial planets form and evolve?
    - How does life evolve in the planetary environment?
  - Disciplines involved, e.g.
    - Astronomy
    - Planetary geology
    - Solar physics, space physics
    - Astrobiology (understanding the building blocks of life)



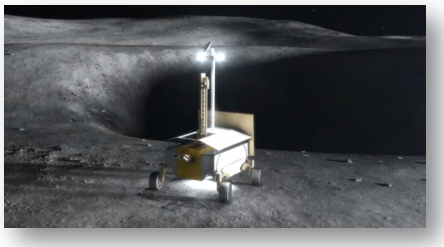
# SSERVI

- Next SSERVI Call out towards the end of April.
- Exploration Science Forum 20-22 July 2016. Abstract deadline 12 April 2016

# Simplified view of Resource Prospector

Get there…

- Launch
- Lunar Transfer
- Lunar Orbit
- Descent & Landing
- Quick Checkout
- Roll-off Lander
- Quick Checkout
- Begin Surface Ops



Find & Excavate Volatiles…

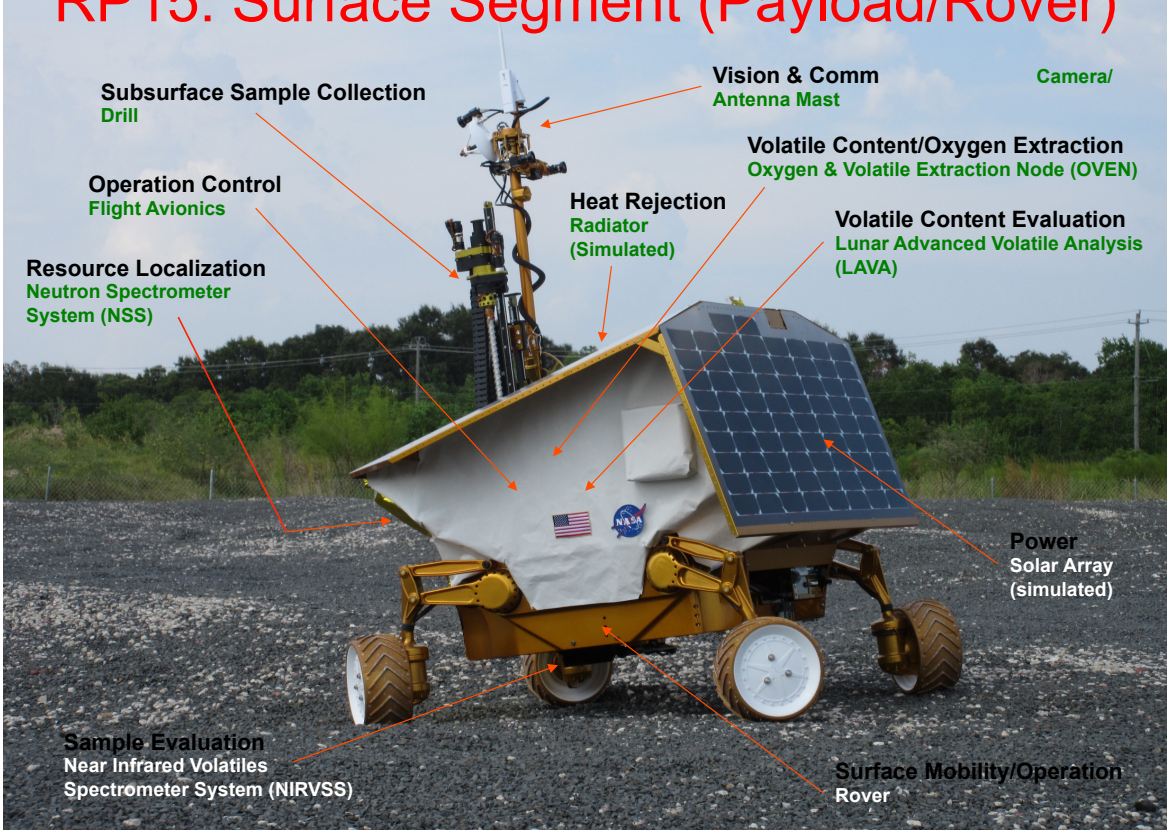
- **Map surface** — Use the Neutron Spec & Near-IR Spec to look for Hydrogen-rich materials
- **Enter permanent shadows** — Go to the areas with highest concentrations of volatiles, Permanently Shadowed Regions (PSRs)
- **Expose regolith** — Use the Drill Subsystem to expose material from 1[m] depth to examine with Near-IR Spec

Collect and Process the volatiles…

- **Capture regolith** — Use the Drill Subsystem to capture samples from up to 1[m] depth
- **Heat regolith** — Heat samples (150-450 degC) in the OVEN Subsystem
- **Identify Volatiles** — Determine type and quantity of volatiles in the LAVA Subsystem, (H2, He, CO, CO2, CH4, H2O, N2, NH3, H2S, SO2)
- **Show me the water!** — Image and quantify the water created using the LAVA Subsystem

LUNAR EXPLORATION ANALYSIS GROUP

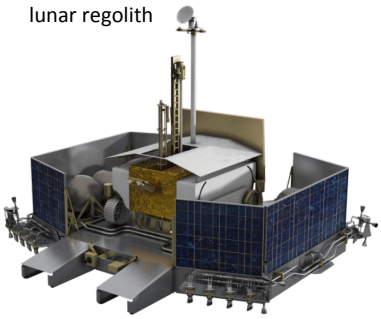
# RP15: Surface Segment (Payload/Rover)



# Resource Prospector (RP) Overview

**Mission:**

- Characterize the nature and distribution of water/volatiles in lunar polar sub-surface materials
- Demonstrate ISRU processing of lunar regolith



**Project Timeline:**

- ✓ FY13: Pre-Phase A: MCR (Pre-Formulation)
- ✓ FY14: Phase A (Formulation)
- ✓ FY15: Phase A (Demonstration: RP15)
- FY16: Phase A (Risk Reduction)
- FY17: Phase B: SRR/MDR
- FY18: PDR (Implementation)
- FY19: CDR (Critical design)
- FY20: I&T
- FY21: RP launch

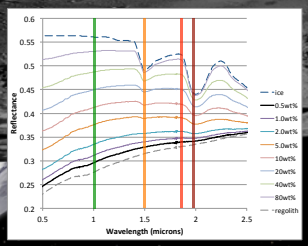
**RP Specs:**

Mission Life: 6-14 earth days
*(extended missions being studied)*
Rover + Payload Mass: 300 kg
Total system wet mass (on LV): 5000 kg
Rover Dimensions: 1.4m x 1.4m x 2m
Rover Power (nom): 300W
Customer: HEOMD/AES
Cost: ~$300M (excl LV)
Mission Class: D-Cat3
Launch Vehicle: Falcon 9 v1.1

LUNAR EXPLORATION ANALYSIS GROUP

# Lunar Flashlight

*Looking for surface ice deposits and identifying favorable locations for in-situ utilization in lunar south pole cold traps*




**Mission Approach**

- JPL-MSFC Team
- 6U spacecraft, 14 kg
- Launch on SLS EM-1 in 2018
- Chemical propulsion system
- 1-2 micron spectrometer
- Elliptical orbit (20-9,000 km, 12 hr period)
- Science phase: ~10min passes, 60 orbits

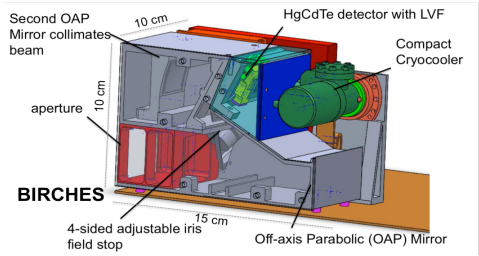
**Measurement Approach**

- Active multiband reflectrometry using lasers in 4 near-IR water

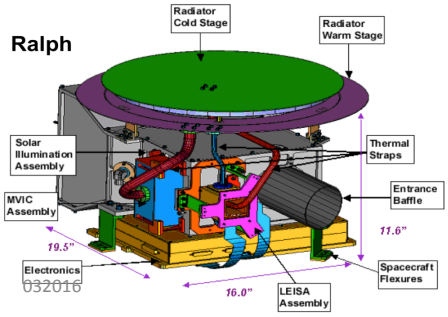
# Lunar Ice Cube – 6-month mission

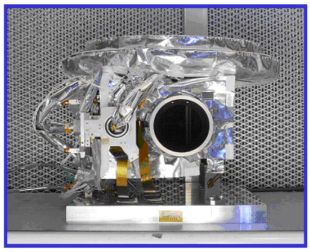
**Mission Payload BIRCHES: Broadband IR Compact High Resolution Exploration Spectrometer**

- Broadband (1 to 4 um) IR spectrometer with HgCdTe and compact line separation (LVF)
- Compact microcrycooler to ≤ 120K to provide long wavelength coverage
- compact optics box designed to remain below 220K
- OSIRIS Rex OVIRS heritage design




| Property | Ralph | BIRCHES |
|---|---|---|
| Mass kg | 11 | 2.5 |
| Power W | 5 | #10-15 W |
| Size cm | 49 x 40 x 29 | 10 x 10 x 15 |
| # includes 3 W detector electronics, 1.5 W iris controller, 5-10 W cryocooler | | |



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LUNAR EXPLORATION ANALYSIS GROUP


**Seattle, WA is the place and it's all about space at LunarScene 2016!**

We've combined our highly regarded technical workshops on Lunar Surface Applications and LunarCubes with our Space Entrepreneur workshop and Hack the Moon hackathon for one spectacular, 10 day event.

**September 26-27, 2016**
**The 6th International Workshop on Lunar Surface Applications**
There are major opportunities for scientists and space entrepreneurs alike to get new hardware and instruments flying relatively soon and at low cost through privately funded platforms. Learn more about the latest technology, and the recent science and business plans that will fuel the Lunar Renaissance and open the Lunar Frontier, as private companies continue their push to explore space.

**September 28-29, 2016**
**The 6th International Workshop on LunarCubes**
Join the best space scientists, engineers, entrepreneurs and investors from around the world to discuss, explore, and redefine the technology, collaboration and commercial strategies required to make the most of LunarCubes, an unprecedented opportunity in space exploration.

**September 30, 2016**
**Entrepreneur Day**
Let's hear it for the Entrepreneur! Topics include Entrepreneurship for the Lunar Frontier, Collaboration & Partnerships in New Space and Funding for Space Companies - Tried and True vs. All That's New. This is a hands on training day with experts in the field ... crowd funding, crowd sourcing, and equity funding are just a few of the topics that will be discussed.

**October 1-2, 2016**
**Hack the Moon**
At Hack the Moon, students and space enthusiasts have the opportunity to come up with creative solutions to space-related problems, while New Space startups can create and launch their own successful Kickstarter campaigns. This is a hands on workshop - create one or more solutions to a real space problem and you and your team will be eligible for prizes.

**Join us September 26 - October 2, 2016 for the Lunar Workshop of The Year - LunarScene 2016!**

**REGISTRATION OPENING SOON at**
**www.lunarcubes.com and www. lsaworkshops.com**

pamela.e.clark@jpl.nasa.gov

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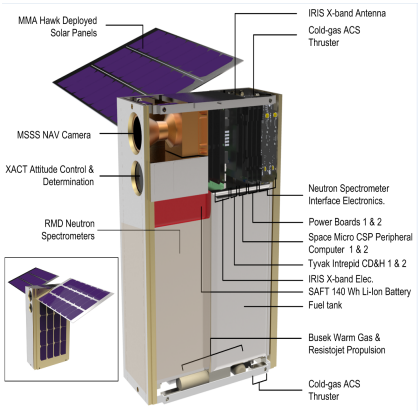
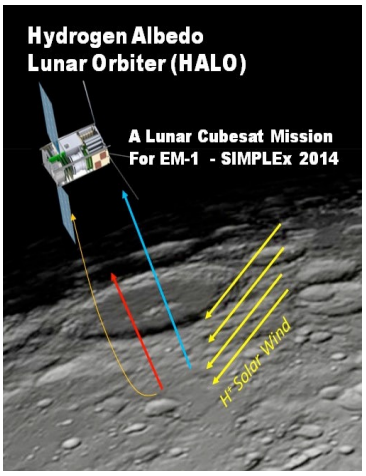
## Small Innovative Missions for Planetary Exploration (SIMPLEx-2014) – New Award in FY15




**Lunar Polar Hydrogen Mapper (LunaH-Map )**
PI: Craig Hardgrove
ASU School of Earth and Space Exploration

## Simplex Cubesats Approved for Tech Development (1 year) Study ONLY




**Hydrogen Albedo Lunar Orbiter (HALO)**
PI: Michael Collier, NASA GSFC

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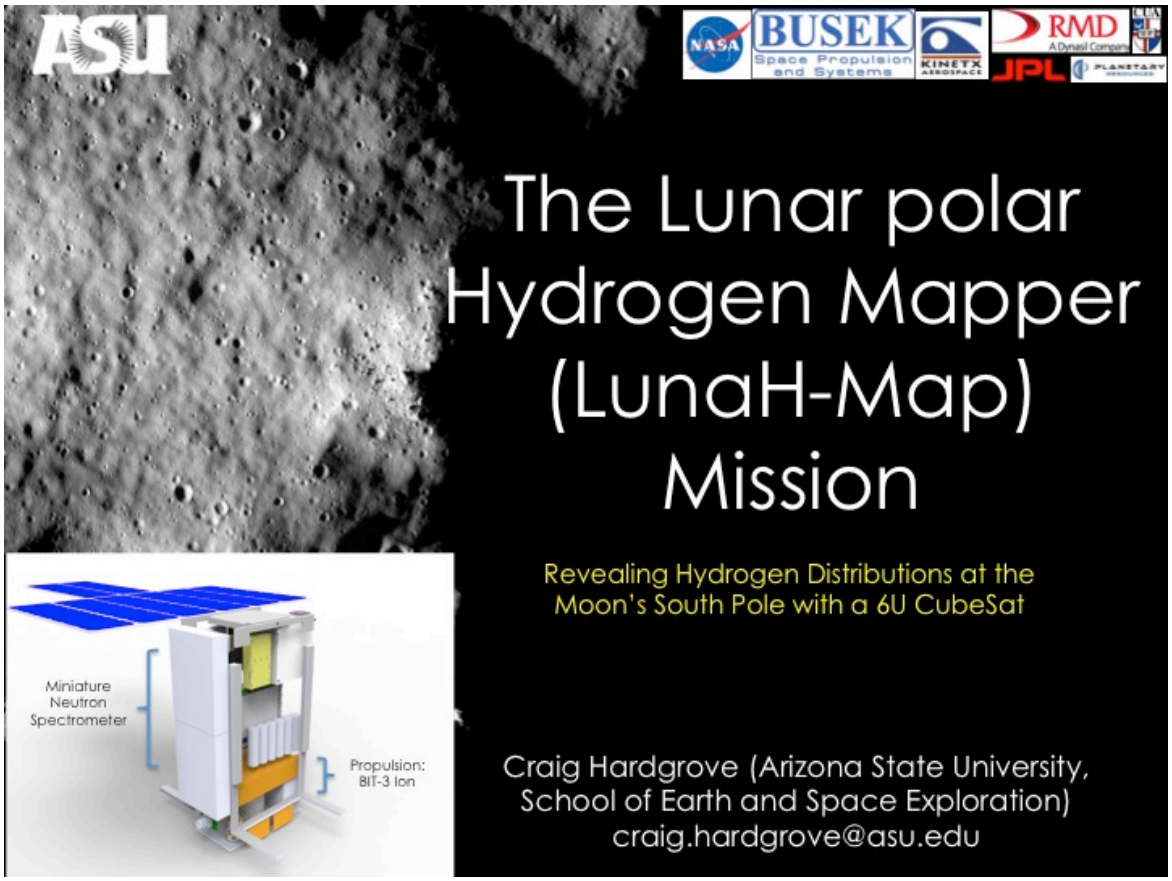

Institut für Planetologie
Westfälische Wilhelms-Universität Münster

# Nomenclature Survey

Hiesinger@uni-muenster.de

Experimentelle & Analytische Planetologie Experimental & Analytical Planetology
**Geologische Planetologie Geological Planetology**
Physikalische Planetologie Physical Planetology

# Nomenclature Survey

- Collect opinions on naming:
  - Small-scale features
  - Making Astronaut-given names official
- Instruct the lunar nomenclature task group
- Website: https://www.surveymonkey.com/r/DV2FQL6
- Deadline: 05/01/2016



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# Nomenclature Survey

Dear lunar scientists,

High-resolution LROC images and other data sets now allow for unprecedentedly detailed investigations of the lunar surface. With that comes the potential need for naming small-scale (<100 m) surface features that were so far excluded from naming. In addition, it has been proposed to make the Apollo-era unofficial names given to locations by the astronauts (e.g., Mount Marilyn, http://lroc.sese.asu.edu/posts/863) a part of the official IAU nomenclature to honor the tremendous contributions of the astronauts to the field of lunar science.
As a member of the IAU lunar nomenclature Task Group, I would like to gather opinions from the lunar science community on these topics. It is my hope that showing a strong preference within the lunar science community will allow me to better serve the community's needs.

*Here is some background information provided by Chuck Wood, lunar scientist and chair of the IAU's Task Group for Nomenclature:*
During the Apollo era new high-resolution photography and astronaut operations on the surface generated many new names for surface features. Hundreds of 20-100 km scale craters on the farside and around the limb received formal IAU-approved names. Production of the Lunar Topophotomaps and other special high-resolution maps led to IAU's acceptance of the use of first names for about a hundred small crater-like features (some are volcanic pits) such as Vera, Priscilla and Ina. Generally these minor features are smaller than 2 km across.
Now LRO and other very high resolution orbiting spacecraft are depicting features at the meter scale. Just as for larger features a nomenclature system could be useful for these small features. The only existing system is the use of first names as mentioned above, but other schema can be considered. Some first questions are what types of small features should be named (e.g. impact melt ponds, melt flows, pits, etc.), how many might be named, and what ideas are there for naming systems? Of course, for many years, scientists have described small, unnamed features by using A, B. C or numbers to informally designate them in publications, and that solution can continue.
The IAU has considered astronaut-given names two or three times, most recently a year or so ago. Originally, in 1970, the IAU worked with astronauts to accept 78 astronaut-given names (see https://the-moon.wikispaces.com/Landing+Sites) to commemorate the amazing feats of Apollo. I understand that the IAU and the astronauts agreed that the other names (about 100 or so) would remain informal. Most recently the IAU WGPSN rejected a request to make formal all remaining Apollo era astronaut names. A major reason was that some of those names duplicated existing names, were personal names, or otherwise did not fit within IAU naming rules. It was pointed out that many of these names - like all of the USGS formation names (e.g. Cayley Formation) - have been widely used for decades even though they are all informal. In my mind these names have a historic life of their own and do not need to be formalized.

*Here are Harald Hiesinger's thoughts:*
I was encouraged by Chuck to solicit suggestions for reasonable and practical naming schemes from the lunar science community as input for the Task Group. Thus, please let us know about your favorite naming scheme.
Concerning the last topic, my point of view is that the unofficial names for features that have not already been named should be made official. I feel that making the astronaut-given names official is the appropriate thing to do to honor the astronauts and their contributions. It is also high time to make this step, considering the ages of most astronauts.



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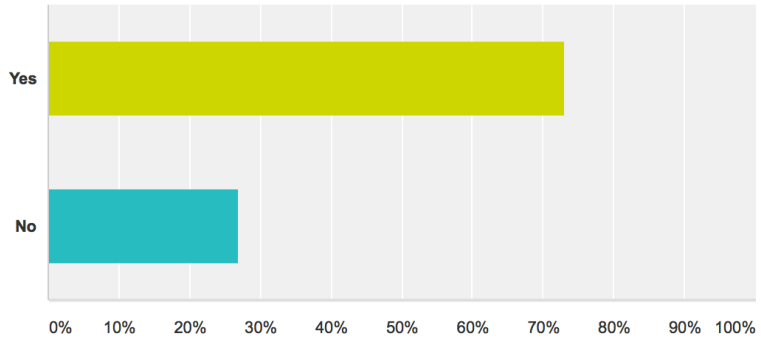
# Nomenclature Survey: Status

## Should small (<100 m) lunar features be named?

Answered: 37 Skipped: 2




| Answer Choices | Responses | |
|---|---|---|
| Yes | 72.97% | 27 |
| No | 27.03% | 10 |
| Total | | 37 |

Comments (21)



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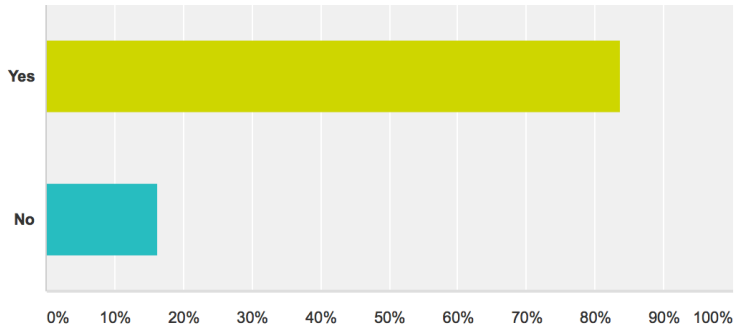
# Nomenclature Survey: Status

**For still unnamed features, should unofficial Apollo-era names by astronauts be made official?**

Answered: 37 Skipped: 2




| Answer Choices | Responses | |
|---|---|---|
| Yes | 83.78% | 31 |
| No | 16.22% | 6 |
| Total | | 37 |

Comments (17)



# Networking Session Tonight!

- 5:30-7:00 PM in the Poster Hall.
- The Next Generation of Lunar Scientists and Engineers can meet the "more established" members of the lunar community in a relaxed atmosphere.

# LROC @ NASM


A NEW MOON RISES VIEWS FROM THE
LUNAR RECONNAISSANCE ORBITER CAMERA

https://airandspace.si.edu/exhibitions/lroc/online/

http://lroc.sese.asu.edu/images/nasm



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