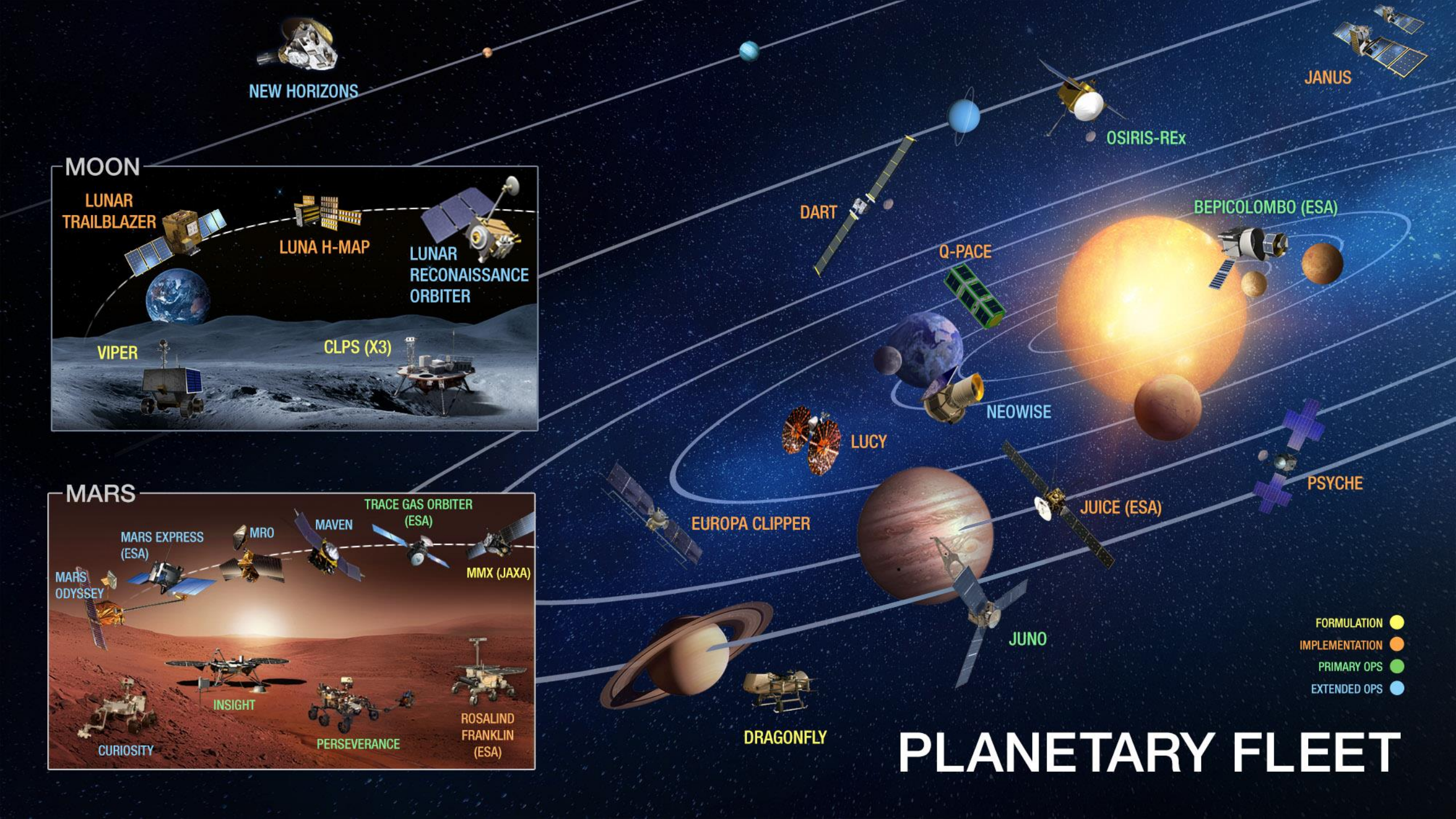
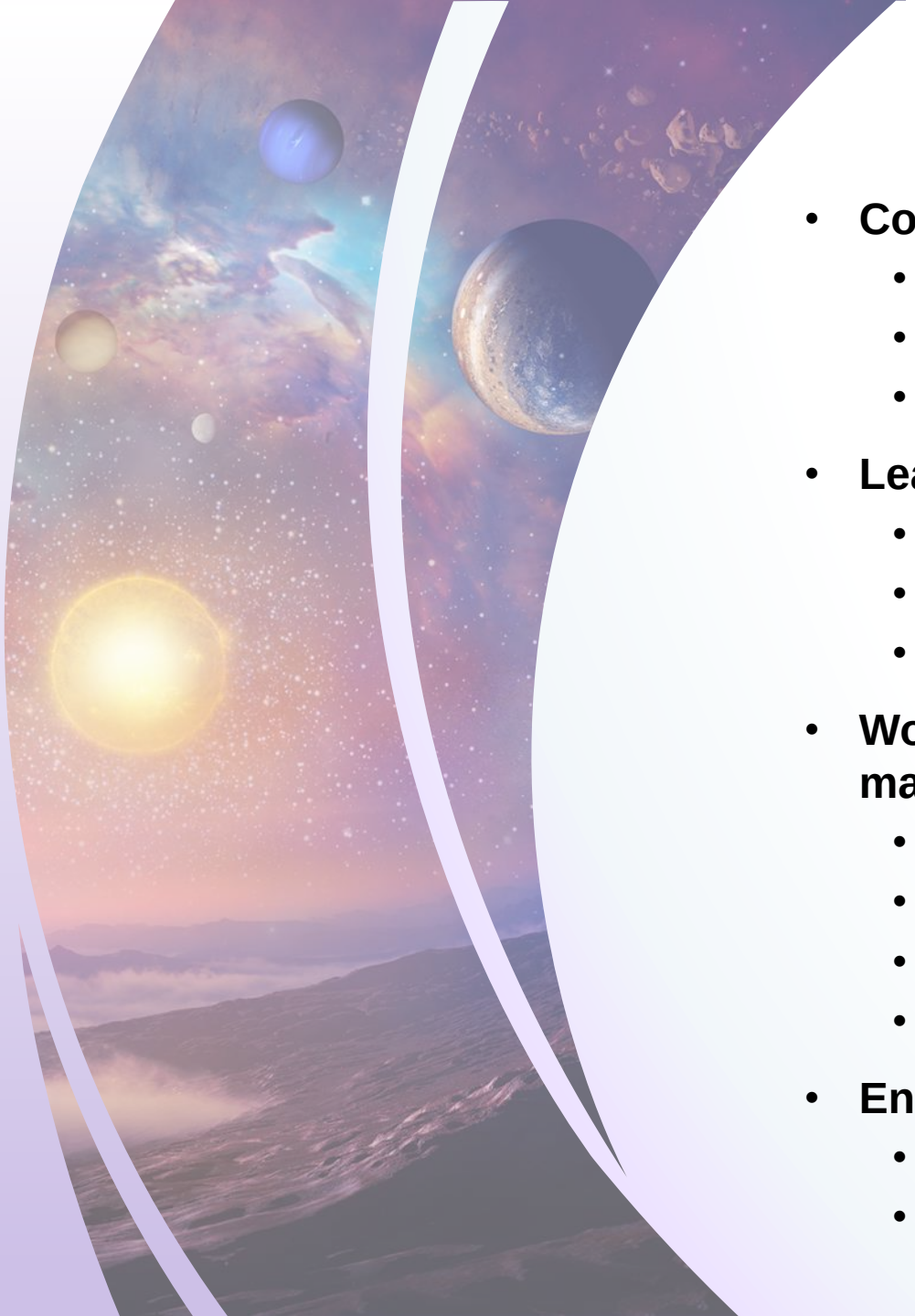

Lori Glaze/Sarah Noble

Planetary Science Division

NAC HEOC/SC Joint Mtg - Jan. 14 2021


NEW HORIZONS
MOON
LUNAR TRAILBLAZER
LUNA H-MAP
LUNAR RECONAISSANCE ORBITER
VIPER
CLPS (X3)
MARS
MARS EXPRESS (ESA)
MRO
MAVEN
TRACE GAS ORBITER (ESA)
MMX (JAXA)
MARS ODYSSEY
INSIGHT
CURIOSITY
PERSEVERANCE
ROSALIND FRANKLIN (ESA)
JANUS
OSIRIS-REx
DART
BEPICOLOMBO (ESA)
Q-PACE
NEOWISE
LUCY
EUROPA CLIPPER
JUICE (ESA)
PSYCHE
JUNO
DRAGONFLY
FORMULATION
IMPLEMENTATION
PRIMARY OPS
EXTENDED OPS
PLANETARY FLEET



# PSD and the Moon

- **Continuing a strong lunar research program**
  - SSERVI
  - Participating Scientist programs
  - Other ROSES elements
- **Leading the development of lunar missions**
  - Volatiles Investigating Polar Exploration Rover (VIPER)
  - Lunar Trailblazer
  - LunaH Map
- **Working closely with ESSIO and across the agency to maximize the science from CLPS and Artemis**
  - Curation
  - Tools
  - Astronaut geology training
  - Landing site selection process
- **Engaging with the community**
  - Lunar Surface Science Workshops
  - Artemis Science Definition Team report

# The Solar System Exploration Research Virtual Institute (SSERVI)

Jointly funded by SMD and HEOMD

Supports 12 domestic teams (4 rolling off soon) and 11 international partners

Major activities in 2020 include:

- SSERVI-managed Regolith Testbed supported VIPER lighting studies for rover navigation
- The European Lunar Symposium, co-organized by SSERVI and its European partners (5/20). Annual meeting held in partner countries since 2012, focusing on European lunar science and missions with major U.S. and European participation, particularly since inception of Artemis
- The NASA Exploration Science Forum (NESF), SSERVI's premiere annual event (7/20) focusing on the science of human exploration. Included HQ Artemis panel, address by Administrator Bridenstine and other NASA leaders, numerous scientific talks and an innovative, interactive virtual poster session.
- Provided leadership and expertise with virtual meeting production to a wide variety of planetary science and human exploration meetings during the pandemic, including the ongoing Lunar Surface Science Workshop series, the LEAG annual meeting and many others.

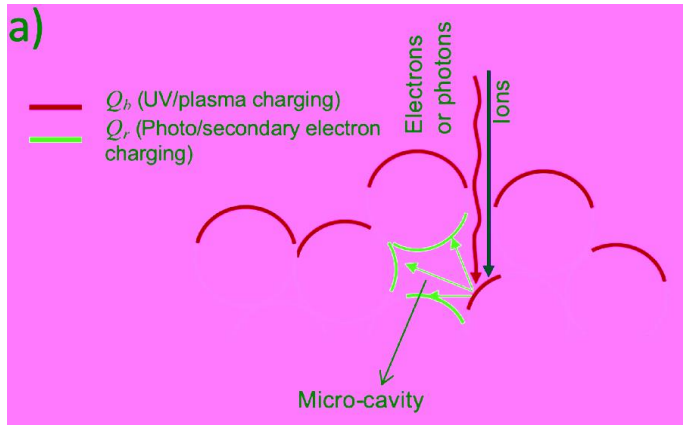
Solar System Treks Project major milestones in 2020 include:

- Release of two new SSTP portals – Bennu Trek and Ryugu Trek. Continued improvements in Moon Trek with an emphasis on utility for Artemis and other missions
- Supporting VIPER and subsequent lunar missions through collaboration with the MIT-RESOURCE team on rapid, collaborative science decision support tools.

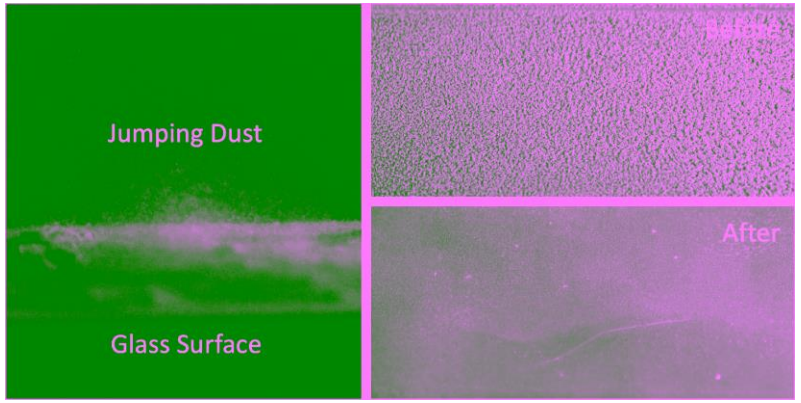
# Science Highlight – New Dust Mitigation Technology

## Project Summary:

- Dust hazards are considered a technical challenge for future lunar exploration as mobilized dust on the lunar surface can readily stick to spacesuits, optical devices, and mechanical components.
- Research led by SSERVI's IMPACT team (PI Horanyi) in collaboration with JPL and Univ. of Iowa demonstrated an electron beam can charge fine-sized dust particles and shed them off of surfaces as a result of electrostatic forces. Emission and absorption of photoelectrons inside microcavities between dust particles causes them to release as a result of large inter-particle repulsive forces.
- Surfaces covered by JSC-1A lunar simulant particles (<25 μm in diameter) were tested using an electron beam with different surface materials and thicknesses of the initial dust layer.
- It was found that the overall cleanliness for a medium to thin dust layer (40–65% initial) can reach 75–85% on a timescale of ~100 s.
- The maximum resulting cleanliness was found to be similar between a spacesuit sample and a glass surface.
- Future work will focus on removing the last monolayer of dust particles with short wavelength UV light.




*Patched charge model for a dusty surface. In the microcavities between dust particles, the blue surface patch exposed to electron beam or UV emits secondary electrons or photoelectrons, which then deposit on the red surface patches of the surrounding particles.*



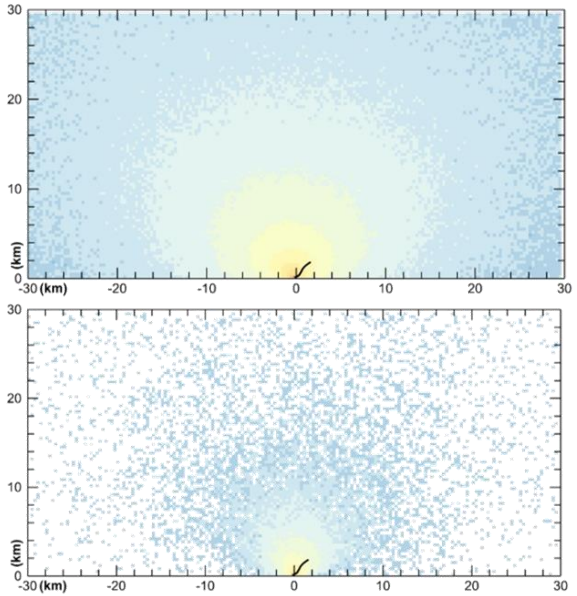

*Left: Dust jumping off a glass surface due to exposure to an electron beam (230 eV, 1.5 μA/cm²); Right: Images of the glass surface before and after the beam exposure.*

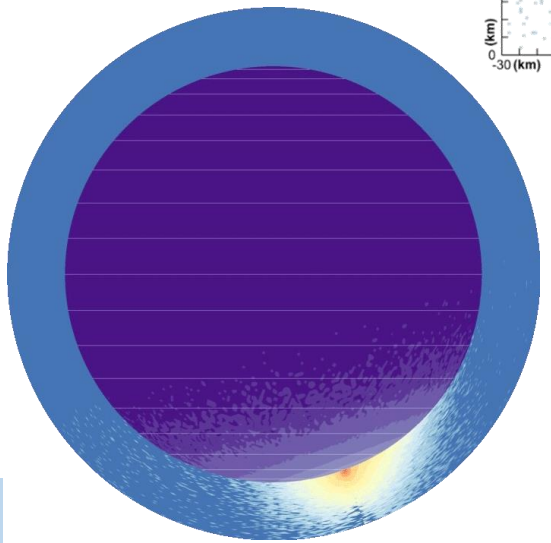
*Ref: Farr et al. 2020. "Dust Mitigation Technology for Lunar Exploration Utilizing an Electron Beam." https://doi.org/10.1016/j.actaastro.2020.08.003*

# Science Highlight - Simulating Artificial Lunar Atmospheres

- PI Killen's LEADER team has determined that almost any lunar landing will involve the release of spacecraft exhaust gases into the lunar environment, creating a thin, temporary lunar atmosphere.
- Spacecraft exhaust gases can persist in the lunar environment (primarily adsorbed to the surface) for longer than two lunar days.
- Exospheric density and surface deposition in the initial 24 hours after a landing may be diagnostic of desorption activation energy.
- In a modeled high-latitude landing scenario, ~20% of exhaust water vapor is delivered to both north and south polar cold traps
- Computer simulations can predict how these gases behave. Comparing simulation results to observations of the lunar exosphere during future lunar landings can address important questions, such as:
  - How do spacecraft systems alter their environments?
  - Specific science questions are:
    - How far should a rover travel to reach an area uncontaminated by exhaust gases?
    - How fast does water (a common exhaust gas) migrate to permanently shadowed regions near the lunar poles?

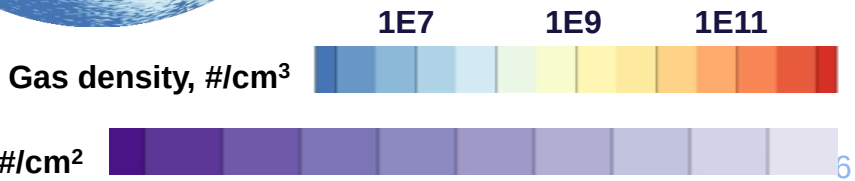
Views showing the $H_2O$ gas density at 155 s after thruster firing commences. The descent trajectory is marked in black. Possible outcomes depend on how strongly water adsorbs to the surface.



<u>Animation:</u> Exospheric $H_2O$ transport over 24 hours after a 70° S landing, assuming a desorption activation energy of 0.7 eV.

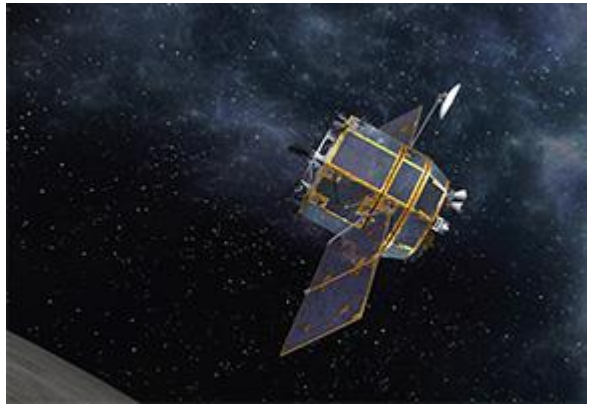
Monitoring the lunar atmosphere during and after lunar landings can help in planning missions and can address outstanding science questions.



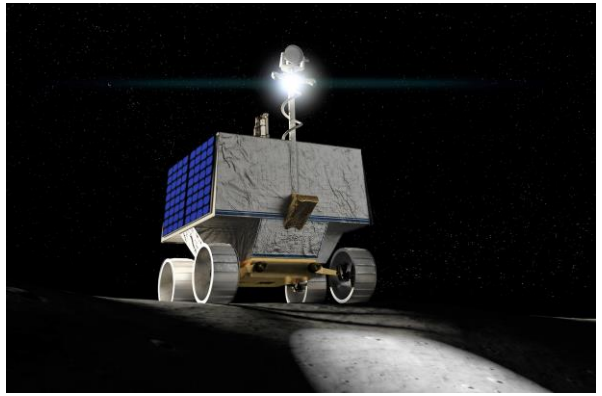

*P. Prem, D.M. Hurley, D.B. Goldstein, P.L. Varghese (2020), The Evolution of a Spacecraft-Generated Lunar Exosphere. JGR Planets (https://doi.org/10.1029/2020JE006464).*

# Participating Scientist Programs

- Korean Polar Lunar Orbiter (KPLO)
  - 9 KPLO selections announced, they will join the team this year
  - Launch is scheduled for summer of 2022, with ~11 month nominal mission.



- Volatiles Investigating Polar Exploration Rover (VIPER)
  - developing call now, expect it to be released late winter/early spring



# Continuing a strong lunar research program

- Healthy lunar selections across ROSES elements
  - Lunar Data Analysis Program (LDAP)
  - Other ROSES elements (SSW/EW/PDART/etc)
  - Apollo Next Generation Sample Return (ANGSA)
  - Development and Advancement of Lunar Instruments (DALI) - Mid-TRL development program

Funded by ESSIO/ managed by PSD

# Apollo Next Generation Sample Analysis Initiative

## *Preparing for Artemis*

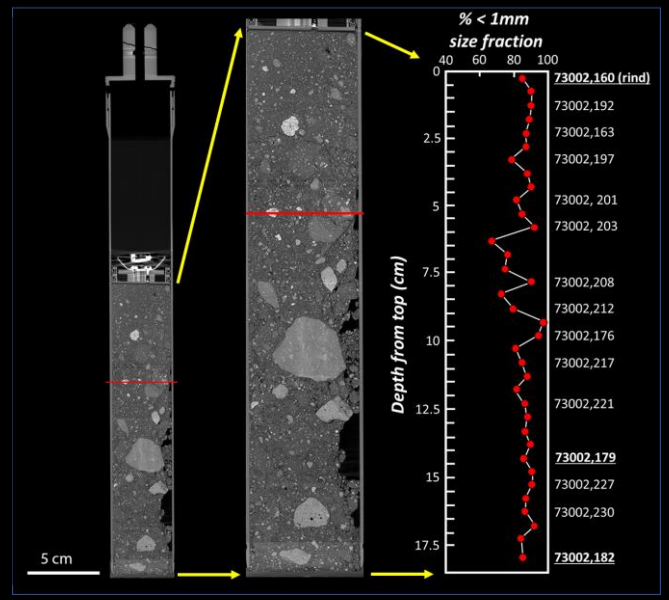
*linking generations of lunar explorers from Apollo to Artemis*

- Special samples collected by  Apollo are the target of this initiative.
- Several of the samples have never been opened and are unique with regards to containment and geological environment.
- ANGSA Consortium consists of 9 original teams and over 60 scientists and engineers.
- The ANGSA was designed as a new lunar sample return mission.
- Processing, PE, and analyses were designed to utilize new and improved technologies and recent mission observations.
- The ANGSA Initiative links the first generation of lunar explorers (Apollo) with  future explorers of the Moon (Artemis ) through multi-generational science and preliminary sample examination.

***Station 3 Apollo 17 Mission***
***With ANGSA Team Member Harrison Schmitt***

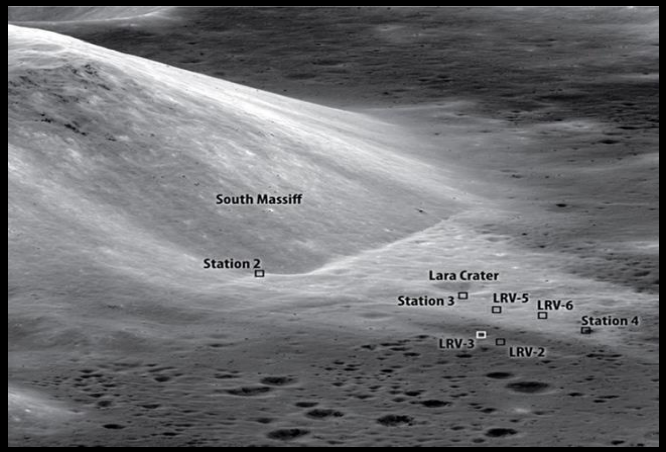
# Sample processing and allocation to science teams

- Upper double drive tube 73002 (430g) extruded into a N atmosphere glovebox.
- Multi-generational preliminary examination team carried out. Prepares a new generation for samples return by Artemis.
- New tools that feeds forward to Artemis were developed for examination of 73002
  - Micro-XCT scanning.
  - Multi-spectral scanning.
  - Transportation tools for keeping sample pristine.
  - Cold curation lab developed for frozen samples
- First samples were sent off for analysis just prior to COVID-19 closing of curation and labs. (organics, stable isotopes D/H, O, Cl).
- Due to COVID-19 there was a delay in getting material out to labs. Starting in November 2020 material started reaching labs.
- In a collaboration between ANGSA team members in the USA and ESA a gas extraction tool has been developed for opening Core Sample Vacuum Container (CSVC) 73001. Tool will be used in summer of 2021 to capture and analyze lunar gases.



# Science Highlights

Held special session on first results at AGU, will also be a special session at LPSC



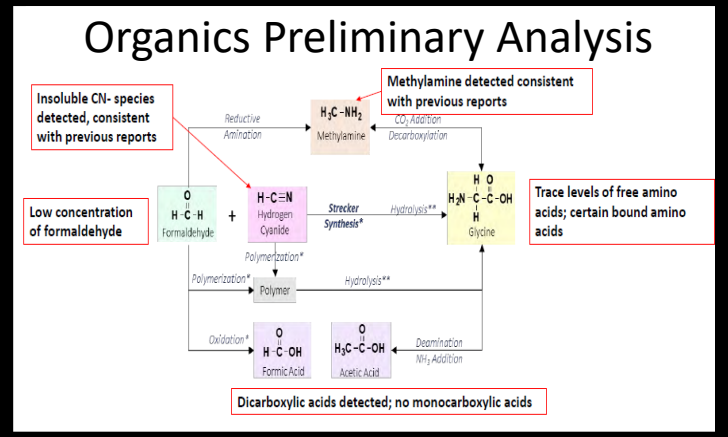

## Looking into a landslide deposit by linking 73001/2 core and orbital data.

## Lunar landslides are initiated by movement along scarps (Lee-Lincoln).

- Multiple landslide deposits of distinct ages.
- Confirmation of this concept will be investigated by reconstructing stratigraphic column and dating horizons within core.

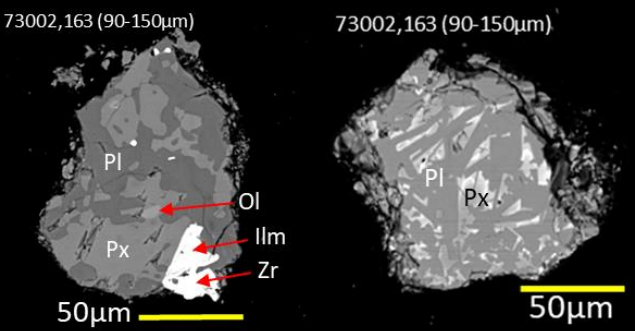
## Transport of material during a lunar landslide event are enhanced by fluidizing volatiles.

- The landslide core compared to other Apollo cores is distinctly friable and compressible.
- This may indicate the escape of fluidizing volatiles responsible for transport of fine material in the landslide column.
- Confirmation of this concept may be established by reconstructing stratigraphic column, dynamical modeling of events, and stable isotope measurements of H and non-traditional stable isotope systems.




## Organic compounds in lunar samples.

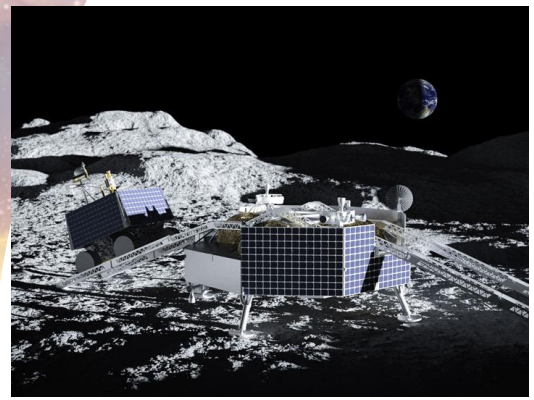
- Defining and monitoring sources of organics with witness plates in curation facility.
- Identified organic compounds not previously recognized on the Moon (e.g., Dicarboxylic acids). Confirmed several previous unique and unverified occurrences.




## New Ancient volcanism-magmatism in the Taurus-Littrow Valley.

- New rock types from South Massif identified in landslide deposit.

# Volatiles Investigating Polar Exploration Rover (VIPER)



Astrobotic's Griffin Lander

Rover testing at JSC Rockyard

**Science Objectives:**

- Characterize distribution and physical state of lunar polar water and other volatiles in lunar cold traps and regolith to understand their origin
- Provide data and resource maps necessary for NASA to evaluate the potential return of ISRU from lunar polar regions

**Key Mission Info:**

- CLPS (Commercial Lunar Payload Services) delivery by end of 2023 on Astrobotic's Griffin lander
- ~100 Earth-day mission
- Instruments:  Neutron, Near-IR, and Mass spectrometers; and a 1m drill

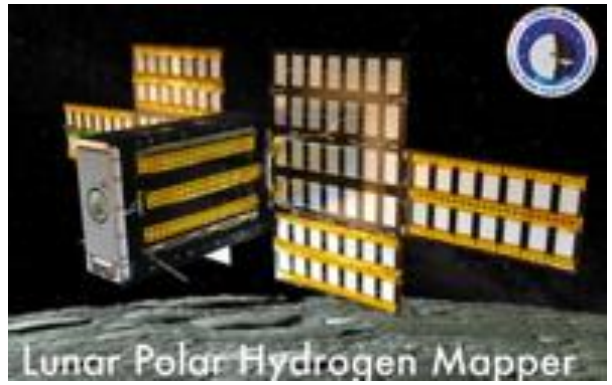
**Project Status:**

- Preliminary Design Review (PDR) successfully completed in late August

# Lunar SIMPLEx missions

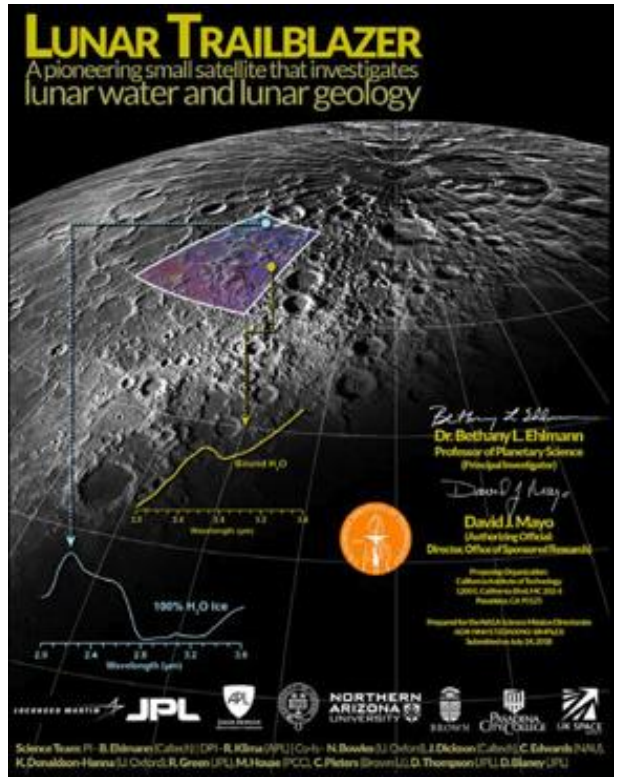
**LunaH-Map:**

- Will map hydrogen enrichments within permanently shadowed regions of the lunar south pole using a compact neutron spectrometer
- Will launch on Artemis-1, NLT November 2021
- Delivery required January 2021




**Lunar Trailblazer (IMAP rideshare):**

- Will addresses major scientific questions about the Moon and water cycles on airless bodies using:
  1) High-resolution Volatiles and Minerals Moon Mapper ($HVM^3$): a JPL-built imaging spectrometer (0.6-3.6 μm)
  2) Lunar Thermal Mapper (LTM): University of Oxford-built multispectral thermal camera (7-100 μm) to determine the form, abundance, and distribution of water on the Moon.
- Passed KDP-C on November 24



# Lunar Surface Science Workshops

- Series of ~monthly 1-day workshops to get community input on our highest priority questions.
- Was originally scoped as a 3-day in-person workshop scheduled for last April, canceled due to Covid.
- Jointly organized by PSD/ESSIO/HEO/OCS with support from SSERVI and the LPI
- Many of the early sessions relied on abstracts submitted to the original workshop, but for certain topics we have had additional abstract calls
- Getting ~200-300 participants per session. Strong participation from both inside and outside NASA
- Talks are recorded, and discussion notes organized into deliverable products:

https://lunarscience.arc.nasa.gov/lssw

# Lunar Surface Science Workshops

Previous sessions:

- Overview and Background (May)
- Tools and Instruments (May)
- Volatiles (July)
- Samples (July)
- Dust and Regolith (August)
- Planetary Protection (September)
- The Value of Mobility (October)
- Foundational Data Products (November)

Upcoming Sessions:

- January 20th-21st
  - Space Biology – joint with BPS
- February 24th-25th
  - Structuring Real-Time Science Support of Artemis Crewed Operations
- April TBD

https://lunarscience.arc.nasa.gov/lssw

# Artemis III SDT report released

- Science Definition Team (SDT) report to define the detailed science objectives of the Artemis III mission was released in December
- Thank you to the team for their hard work under challenging circumstances, and the lunar community who submitted white papers and commented on the draft report
- Report available at [www.nasa.gov/reports](www.nasa.gov/reports)