SCALPSS Development Status

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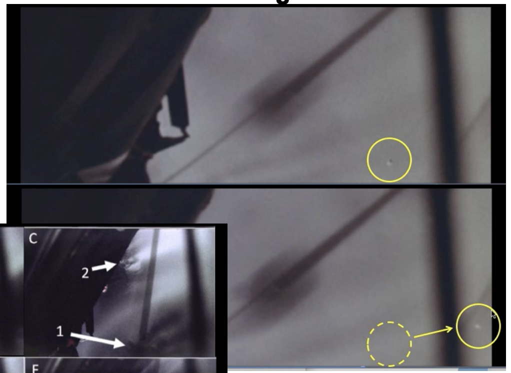
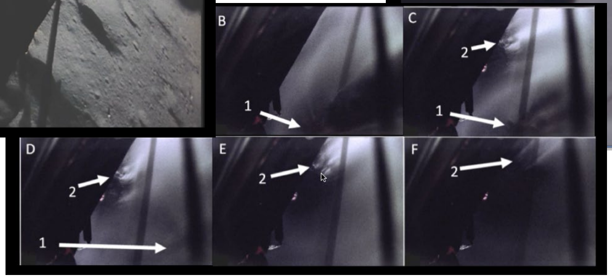
Plume Surface Interactions – Why are they important?

- Lunar dust is a significant obstacle to achieving a sustainable human presence on the Moon, and lunar landers will be a major source of dust transport across the lunar surface.
- There is currently a lack of lunar flight data from plume-surface interaction (PSI) effects during descent and landing which leads to one of the greatest source of risks during the landing phase.
- Safety and operational risks due to lander-induced dust/erosion are significant drivers of dust mitigation and PSI flight validation data will help anchor computational and engineering tools, to enable design of future landers, surface elements and surface operations.
- As NASA and commercial companies prepare to land larger and larger payloads on the Moon (and eventually Mars), it will be important to assess the effect of the lander engine plume(s) on:
  - the size and shape of the crater(s) formed at landing
  - the landing vehicle itself
  - nearby assets (including those in orbit)
  - the science and operations achievable at that site

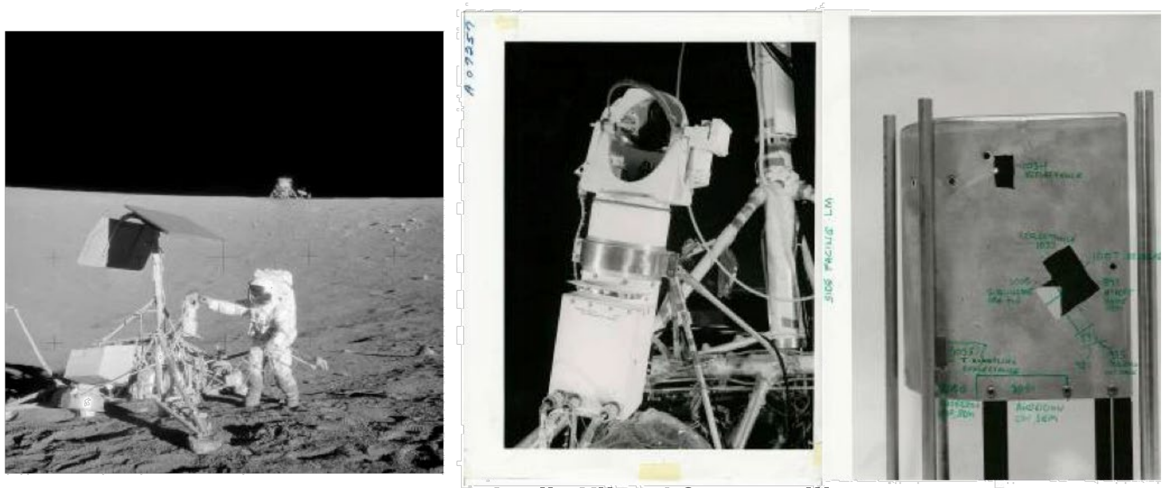
Dust

Blowing Rocks





Terrain Modification

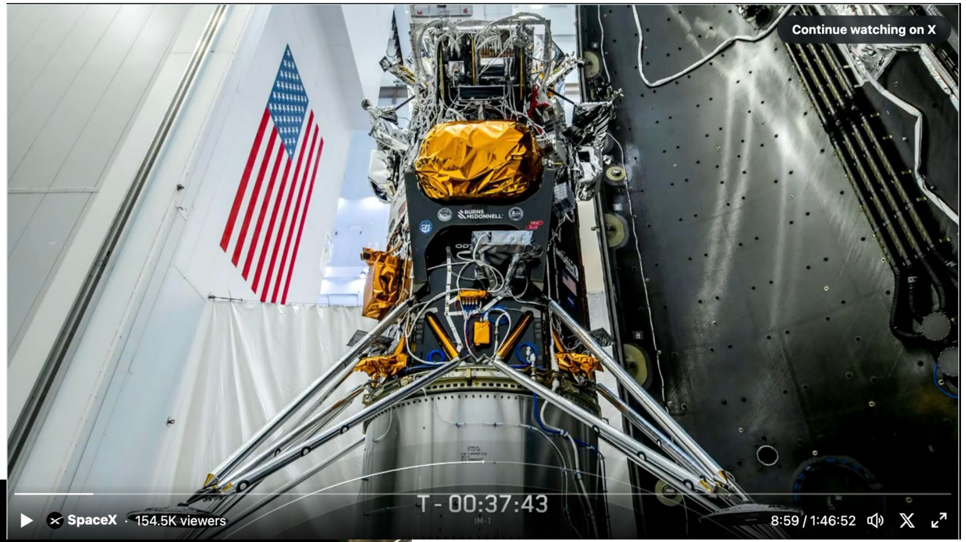


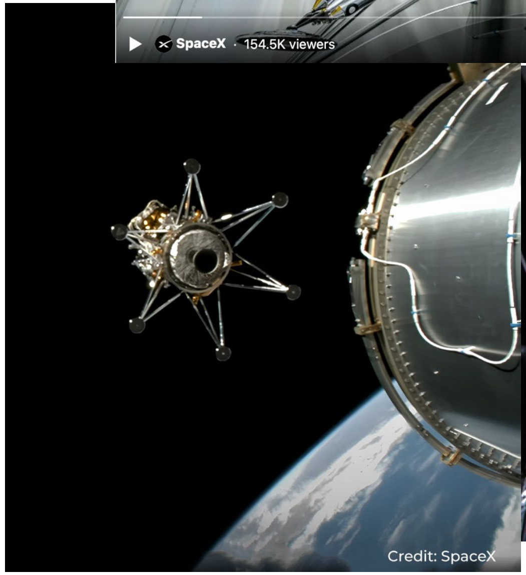
Apollo XII and Surveyor III

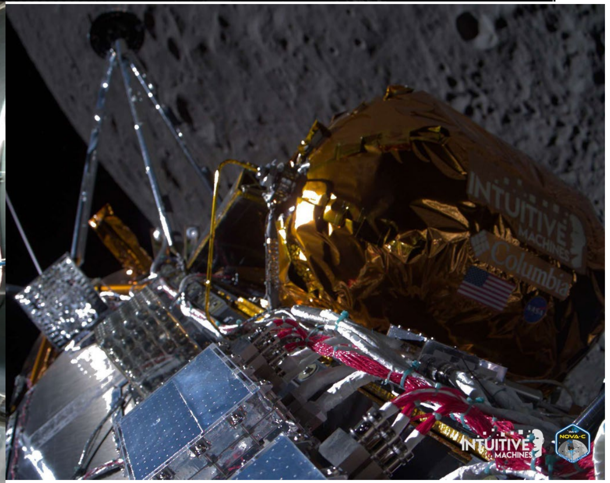
SCALPSS 1.0 (CLPS / Intuitive Machines)

Funded by SMD/NPLP

- Primary Objective: Collect stereo images of the disturbed lunar surface post landing.
- Secondary Objectives: Collect stereo images during descent (possibly beginning prior to the onset of PSI)
- Configuration: 4 ea. 3.2 MP cameras (3.37mm focal length) on individual camera mounts, Data Storage Unit, USB Hub *(Mars2020 EDLCam heritage)*
- Payload Delivery: October 2020
- Payload Integration to Lander: August 2023
- Launch: 15 February 2024
- Lunar Orbit Insertion / Landing : 22 February 2024

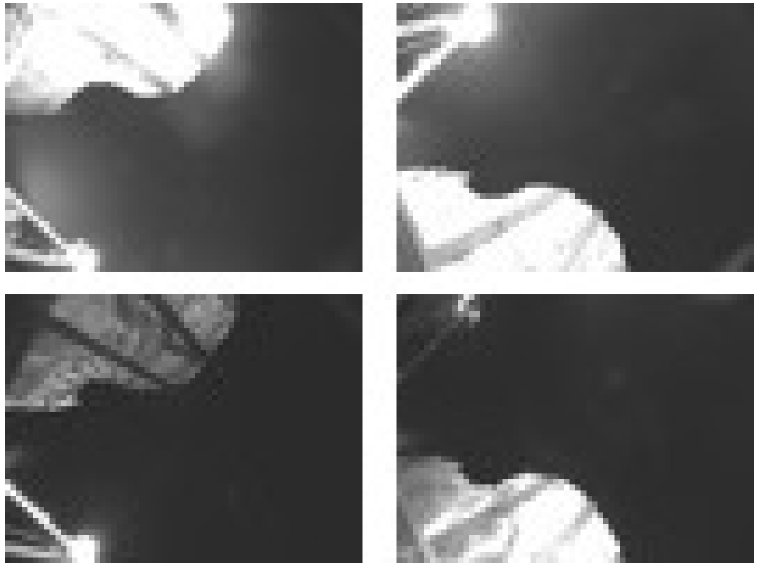


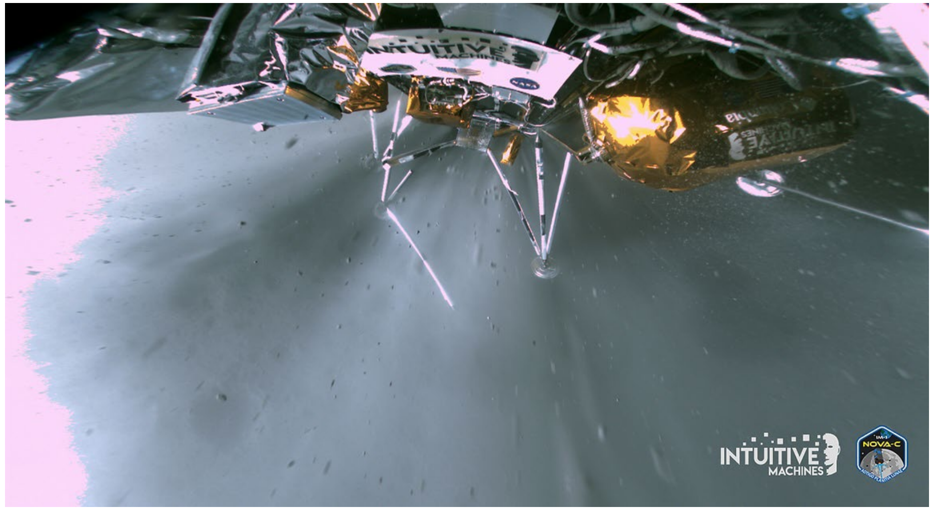




SCALPSS 1.0 Payload Performance

- The SCALPSS 1.0 payload did survive launch and was able to perform a nominal transit checkout.
- The lunar orbit checkout was canceled due to troubleshooting being done on the lander.
- During descent, the payload was not powered on as expected due to erroneous altitude data on the lander resulting in a faster than expected descent and ”hard/skip” landing.
  - evidence seems to indicate that the payload was powered on at the correct “time”, however, the lander was already on the ground at that point
- Due to these and other lander faults as well as the final lander orientation (on its side), no PSI data was collected.
- Late in the surface mission (day 5 of 6 day surface mission), **the payload was able to operate successfully on the lunar surface** in both “checkout” and “manual” modes.
  - one camera was inoperable due to high temperatures (predicted)
  - lander FSW was updated to utilize redundant command channel
  - due to the lander orientation and sun position, images taken were oversaturated
  - the payload team was not given the opportunity to correct for this and collect additional imaging data

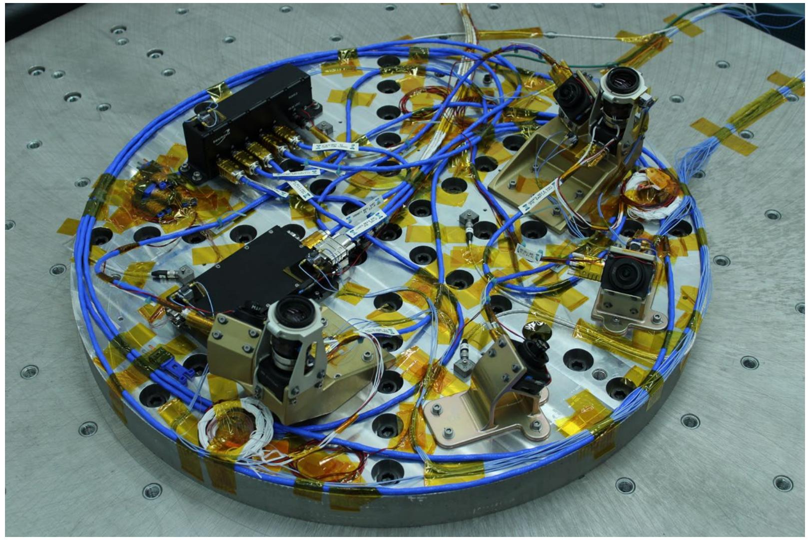




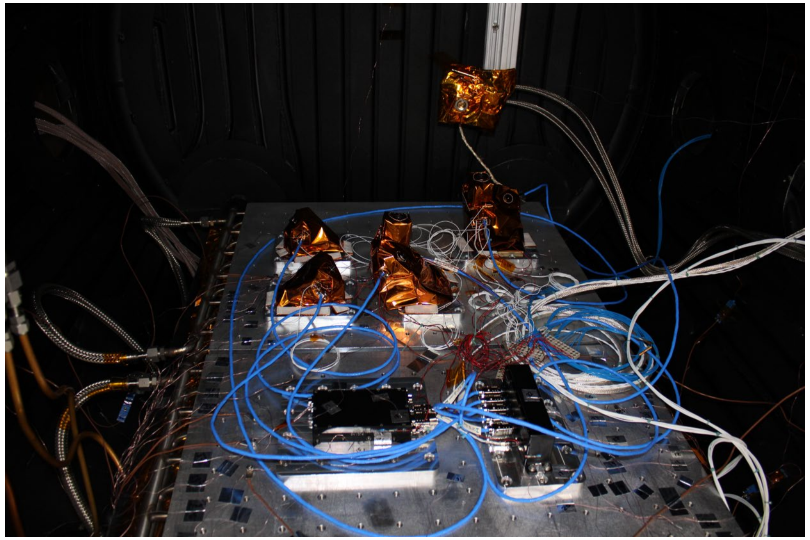
SCALPSS 1.1 (CLPS / Firefly Aerospace)

Funded by STMD/GCD

- Primary Objectives: Collect stereo images of the lunar surface prior to being disturbed (pre-PSI), during descent (transient), **and** post landing; also determine when PSI onset occurred.
- Secondary Objectives: Detect and measure ground obscuration due to PSI ejecta.
- Configuration: 6 ea. 3.2 MP cameras (2 @ 3.37mm, 2 @ 5.4mm, and 2 @ 50mm focal lengths) on 4 camera assemblies, Data Storage Unit, USB Hub (*SCALPSS 1.0 heritage*)
  - utilizes full data handling capabilities of DSU design
- Payload Delivery: October 2022
- Payload Integration to Lander: April 2024
- Launch: “late 2024”
- Lunar Orbit Insertion / Landing : “early 2025”
  - ~30 day lunar transit
  - ~15 days in lunar orbit



SCALPSS 1.1 Vibration Testing

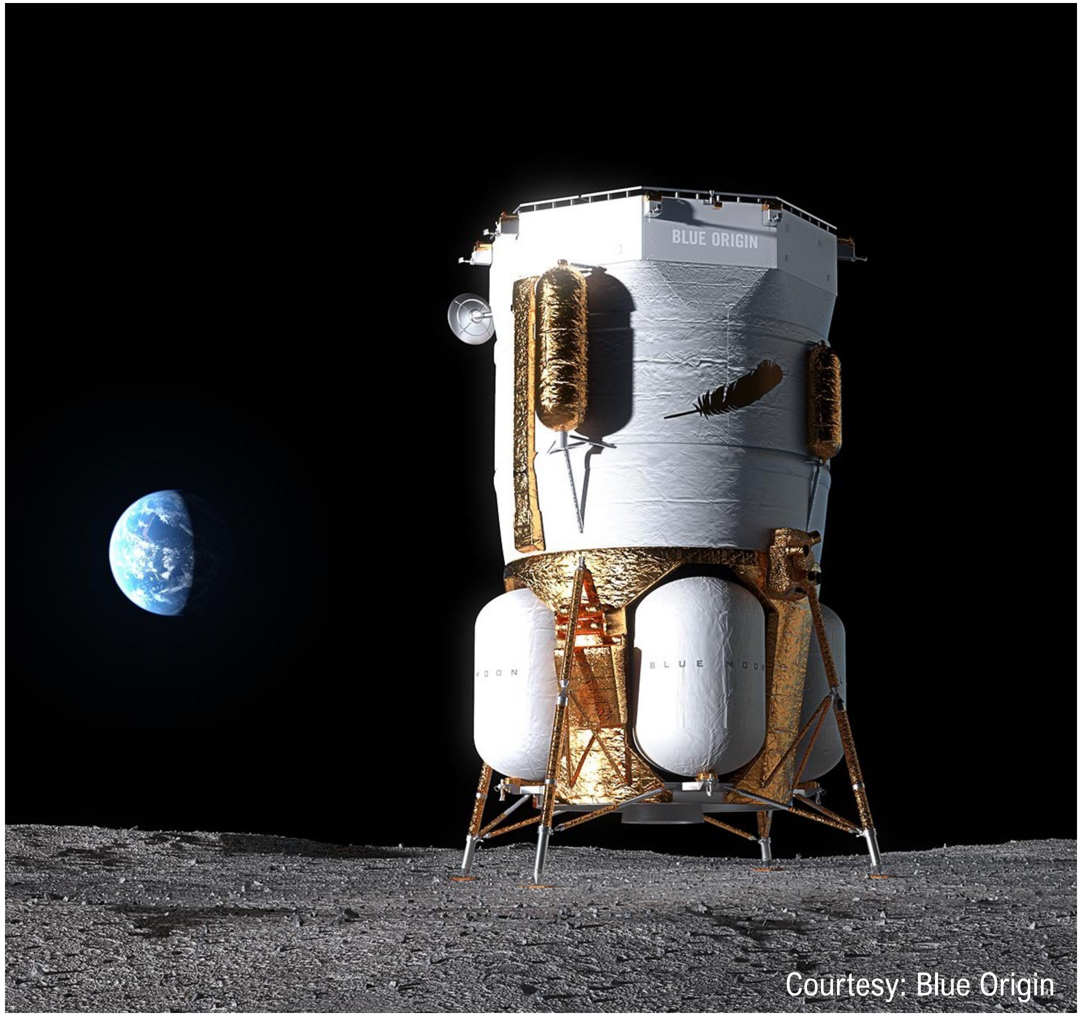


SCALPSS 1.1 TVAC Testing

SCALPSS 1.x (Blue Origin Mk1-SN001)

Funded by STMD/GCD and SMD as part of the SCALPSS 1.1 Project utilizing spare SCALPSS 1.1 hardware

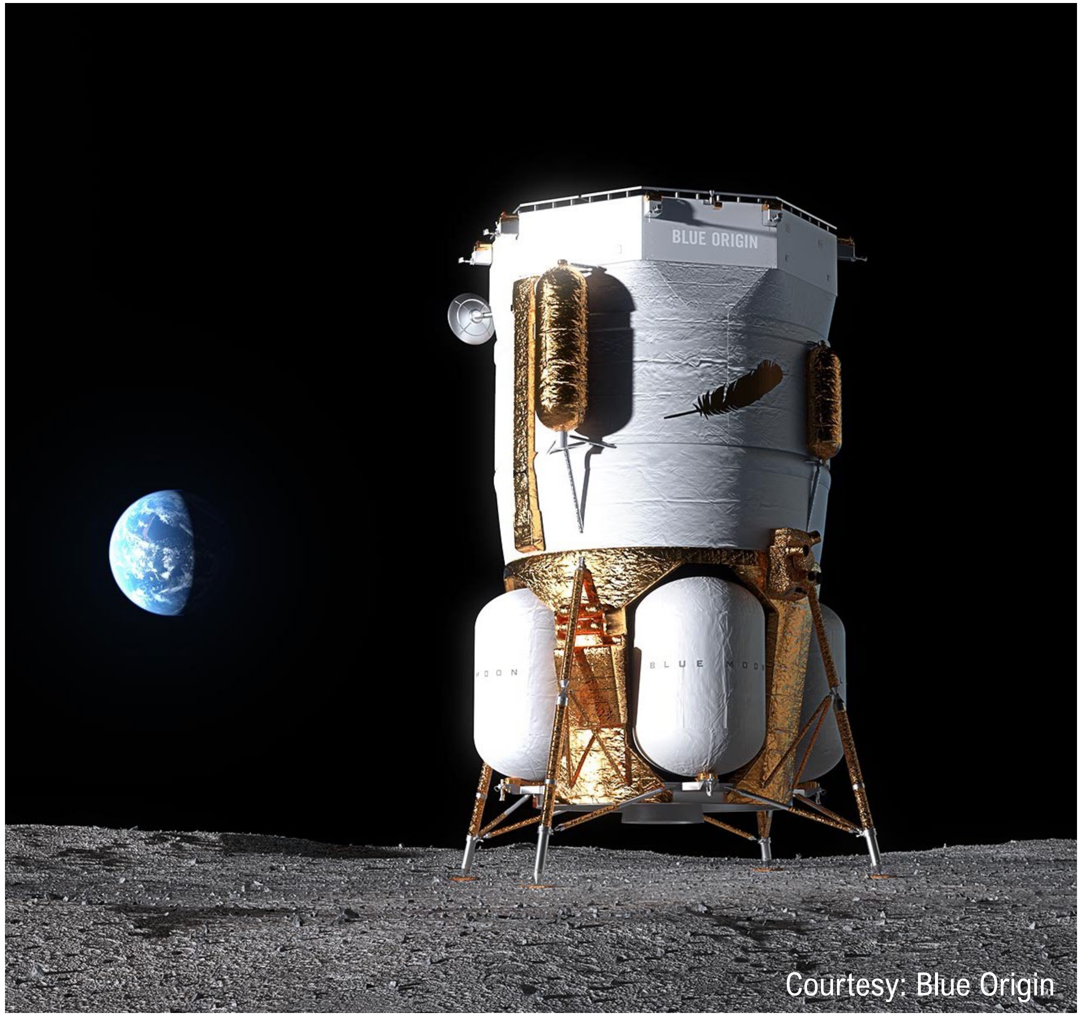
- Primary Objectives: Collect stereo images of the lunar surface prior to being disturbed (pre-PSI), during descent (transient), **and** post landing; also determine when PSI onset occurred.
- Secondary Objectives: Detect and measure ground obscuration due to PSI ejecta.
- Configuration: 6 ea. 3.2 MP cameras (3.37 - 50 mm focal lengths) Data Storage Unit, USB Hub *(SCALPSS 1.1 heritage*)
  - utilizing new single and combo camera mounts for Mk1 lander
- Payload Delivery: May 2025 (TBR)
- Payload Integration to Lander: June-Sep 2025 (TBR)
- Launch: “mid-to-late 2025” (TBR)
- Lunar Orbit Insertion / Landing : TBD



SCALPSS 2.0 (Blue Origin Mk1-SN002)

Funded by STMD/GCD as part of the PSI Instrumentation Project

- Primary Objectives: Same objectives as SCALPSS 1.1 *with improved coverage and/or resolution*, and the addition of measurements of the ejecta sheet structure (ejecta angles, sheet morphology, etc.)
- Secondary Objectives: Measure ejecta particle size and velocity.
- Configuration: 6 ea. **12.3 MP** cameras (3.37 - 50mm focal lengths), Mini-Suite Electronics (MSE-lite), and laser dot grid projector
    - will also test a passive reflector for generating dot grid
- Payload Delivery: December 2025 (TBR)
- Payload Integration to Lander: March 2026 (TBR)
- Launch: “mid 2026” (TBR)
- Lunar Orbit Insertion / Landing : TBD



Courtesy: Blue Origin

PSI Mini-Suite

- As early as FY25, the PSII Project hopes to restart development of the PSI Mini-Suite Payload
  - Formerly known as CLPS PSI Mini-Suite (or PLUMES) Project in FY23
  - This will significantly expand the types of flight data available for PSI model development and verification
  - Intended to be compatible with CLPS, HLS, and/or Artemis
- Mini-Suite Electronics (currently in development as part of PSI Instrumentation Project)
  - An expanded version of MSE-lite used for SCALPSS 2.0
  - Improved data interface(s) to lander (100+ Mbps capability)
  - Improved data handling capabilities
  - Capable up to 2 GBbs write speed to memory
  - Designed to be modular, flexible, and expandable to accommodate additional sensors with various data interfaces (e.g., serial, USB, LAN, LVDS, Spacewire, etc.)
  - Smart power management / switching capability for sensors
- Will accommodate SCALPSS 2.0 along with other PSI sensors in development, ***for example***:
  - Lunar Lander Base Instrumentation (LLBI): Measure the environment induced (temperature, heating, and pressure) below the lander base by landing thruster(s) and PSI. (LaRC)
  - Particle Impact Event (PIE) Sensor: Measure velocity/energy of regolith particles from PSI. (GRC)
  - Dust Ejecta Radar Technology (DERT): millimeter-wave doppler radar measurement of particle velocity and direction of particles resulting from PSI. (KSC)

Summary

- PSI creates significant safety and operational risks to lunar landers, surface assets in the vicinity of the lander, and the landing site itself.
- As a first of its kind, SCALPSS will provide the much-needed flight data to validate the design tools to be used for designing the next generation of lunar exploration.
- Although unable to collect PSI data, the SCALPSS 1.0 payload was able to verify that the hardware could successfully operate in the lunar environment.
- The SCALPSS 1.1 payload, with its flight planned for late this year, is ready to provide a wealth of data and information regarding the PSI erosion for CLPS scale landers.
- The SCALPSS 1.x payload on the Blue Origin Mk1 test flight will add to this information by providing data at much larger lander thrust level (close to HLS-scale).
- The next generation SCALPSS instrument, SCALPSS 2.0, will build upon the capabilities and successes of the SCALPSS 1.0/1/x payloads by improving the quality of the erosion data, while also attempting to collect the first direct measurements of the ejecta environments.
- The capabilities of the MSE under development should enable the flight of a full PSI suite of sensors, to collect data in all areas of interest (erosion, ejecta, induced environments) in preparation for a sustained human presence on the lunar surface.