RESULTS FROM THE NASA INSTRUMENTS ONBOARD BLUE GHOST MISSION 1. M. E. Banks[1], K. Acosta[2], H. Austin[3], C. Barney[3], C. Buhler[2], C. I. Calle[2], K. Carrington[4], M. Carter[5], W. A. Chambers[6], D. Currie[7], J. Davis[3], P. M. Danehy[8], F. Dovis[9], M. DuPuis[2], T. W. Fahringer[8], S. Fantinato[10], Z. Fitzgerald[4], A. Goode[5], R.E. Grimm[11], Z. Hull[3], H. Jung[4], D. Klumpar[3], B.J. LaMeres[3], R. W. Maddock[8], C. M. Major[3], M. S. Manginelli[6], M. Mehta[6], R. Misra[4], M. M. Munk[8], M. Musmeci[12], S. Nagihara[13], P. Ngo[4], C. P. Nguyen[8], J. J. K. Parker[1], J. Phillips[2], J. Sample[3], L. Sanasarian[4], L. Springer[3], D.E. Stillman[11], J. Toth[2], O. Tyrrell[8], V. Vendiola[4], B. M. Walsh[14], R. N. Watkins[15], J. M. Weisberger[8], W. K. Witherow[6], K. Zacny[4]. [1]NASA Goddard Space Flight Center, maria.e.banks@nasa.gov, [2]NASA Kennedy Space Center, [3]Montana State University, [4]Honeybee Robotics, [5]Aegis Aerospace, Inc., [6]NASA Marshall Space Flight Center, [7]University of Maryland, [8]NASA Langley Research Center, [9]Politecnico di Torino, [10]Qascom Srl, [11]Southwest Research Institute, [12]Agenzia Spaziale Italiana, [13]Texas Tech University, [14]Center for Space Physics, Boston University, [15]NASA Headquarters.

Introduction: Blue Ghost Mission 1 (BGM1), or NASA CLPS (Commercial Lunar Payload Services) Task Order (TO) 19D, launched on Jan 15, 2025, to deliver ten NASA science and technology instruments to Mare Crisium on the near side of the Moon [1] as part of NASA's CLPS initiative and Artemis campaign. During the mission, cameras on Firefly's Blue Ghost lunar lander captured images and videos, including imaging a total solar eclipse and a sunset from the surface of the Moon. After a successful landing on March 2, 2025 (18.5623°N, 61.8103°E), the surface mission extended through one lunar day and multiple hours into the lunar night before concluding on March 16, 2025, as the longest surface duration commercial mission on the Moon to date.

Preliminary Results: All ten NASA payloads (Fig. 1) successfully activated, collected data, and performed operations on the Moon; most performed first-of-their-kind science and technology demonstrations [2]:

LuGRE: The Lunar GNSS Receiver Experiment acquired and tracked Global Navigation Satellite System (GNSS) signals from the GPS and Galileo constellations and calculated instantaneous navigation "fixes" enroute to and on the Moon's surface for the first time. This achievement demonstrates that GNSS signals can be used to support navigation in cislunar space and at the Moon.

RadPC: The Radiation Tolerant Computer System successfully operated through Earth's Van Allen belts, in transit to and in lunar orbit, on the lunar surface including during the total solar eclipse, and into the lunar night. RadPC verified solutions to mitigate radiation effects on computers that could make future missions safer for equipment and more cost effective.

EDS: The Electrodynamic Dust Shield successfully lifted and removed lunar regolith from surfaces using electrodynamic forces (Fig. 2). This technology demonstrates a promising solution for dust mitigation on future lunar and interplanetary surface operations.

SCALPSS: The Stereo Cameras for Lunar Plume-Surface Studies instrument captured more than 9,000 images including during the spacecraft's descent to the lunar surface, providing insights into the effects engine plumes have on the surface (Figs 3-4). The payload also operated on the surface during the lunar day, at the end of the solar eclipse, during the lunar sunset, and into the lunar night.

LISTER: The Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity is now the deepest robotic planetary subsurface thermal probe (Fig. 4), drilling and acquiring thermal measurements at eight depths down to ~1-m depth [3]. LISTER provided a first-time demonstration of robotic thermal measurements at varying depths.

LMS: The Lunar Magnetotelluric Sounder determined that the subsurface electrical conductivity profile beneath the Blue Ghost lunar lander is very similar to that below the Apollo 12 site. This implies that the widespread basaltic volcanism of the western nearside was not powered by regional enhancement of heat-producing elements, but was likely a simple consequence of easier eruption through thinner crust [4].

LEXI: The Lunar Environment heliospheric X-ray Imager captured X-ray images to study the interaction of the solar wind and Earth's magnetic field to provide insights into how space weather and other cosmic forces surrounding Earth affect the planet. LEXI also observed density profiles of the lunar exosphere through solar wind charge-exchange emission.

NGLR: The Next Generation Lunar Retroreflector has already successfully reflected and returned laser light for thousands of individual range measurements from multiple Lunar Laser Ranging Observatories (LLROs) on Earth including LLROs in Grasse, France Wettzell, Germany, and Apache Point, in New Mexico (USA). Measurements utilizing NGLR will enable precise measurements of the Moon's shape and distance from Earth, expanding our understanding of the Moon's inner structure [5].

LPV: The Lunar PlanetVac was deployed on the lander's surface access arm and collected, transferred, and sorted lunar regolith particles using pressurized nitrogen gas, including acquiring regolith without physically touching lunar surface. LPV successfully demonstrated a low-cost, low-mass solution for future robotic sample collection.

<u>*RAC: The Regolith Adherence Characterization instrument*</u> examined how regolith sticks to a range of materials exposed to the lunar environment. Results can help test, improve, and protect spacecraft, spacesuits, and habitats from abrasive lunar dust.

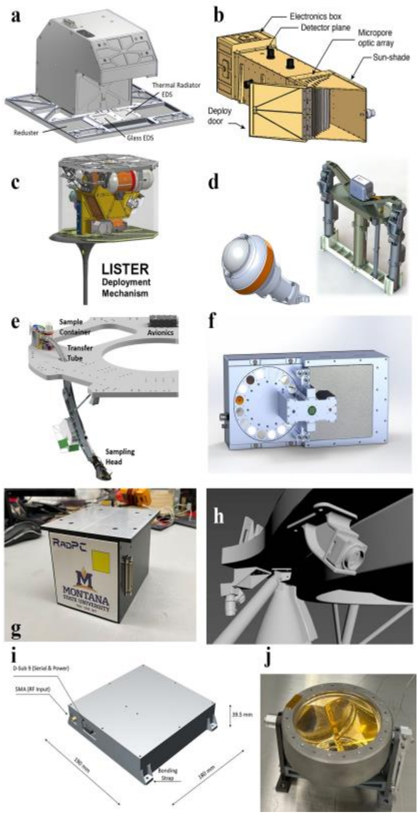

Figure 1: The NASA payloads that flew and operated on Blue Ghost Mission 1 (NASA CLPS TO 19D): a) EDS, b) LEXI, c) LISTER, d) LMS electrode launcher (left, 1 of 4); magnetometer and mast stowed (right); not to scale and electronics box not shown, e) LPV, f) RAC, g) RadPC, h) illustration of SCALPSS 1.1 cameras (3 of 6), i) LuGRE, and j) NGLR.

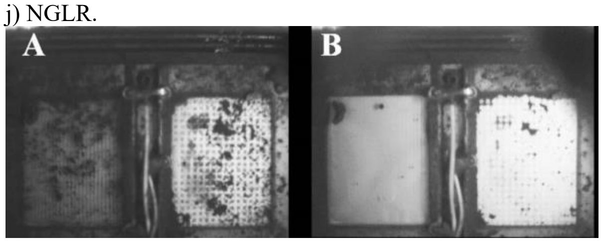

Figure 2: A) Before and B) after EDS operations on the Moon in which lunar regolith was successfully lifted and removed from thermal radiator (left) and glass (right) surfaces using electrodynamic forces [Images provided by EDS Team/ NASA KSC].

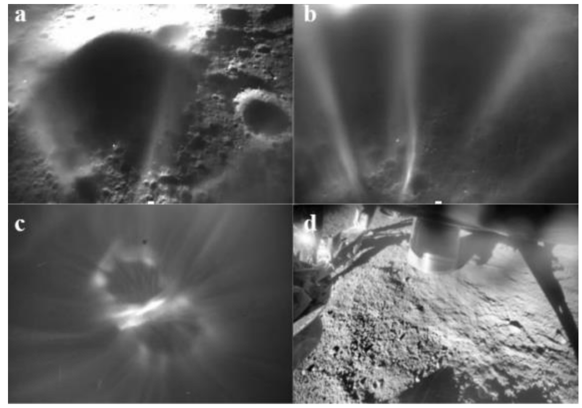

Figure 3: SCALPSS images from short focal length camera 2 (SFL2) at: a) 10 m altitude, b) ~7 m altitude, and c) just prior to landing. d) HDR composite from SFL camera 0 (SFL0) from the surface [images provided by O. Tyrrell and J. Weisberger/NASA LaRC].

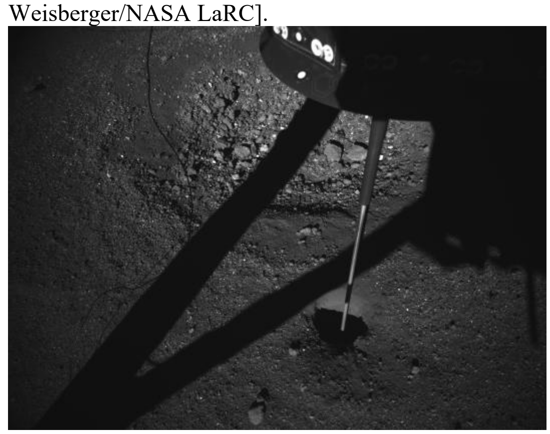

Figure 4: Image acquired from the SCALPSS short focal length camera number 3 (SFL3) showing the LISTER drill and hole (right of center), a wire connected to one of the deployed LMS electrodes (left of center), and a view of the surface rocks and regolith size distribution [image provided by C. Nguyen/NASA LaRC].

Summary. Analysis of data returned to Earth from these NASA instruments continues. The technology tested and data acquired during BGM1 will provide further insight into our understanding of the Moon, provide insights into how space weather and other cosmic forces may impact Earth, establish an improved awareness of the lunar environment ahead of future crewed missions, and will help plan for long-duration surface operations under Artemis.

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