OVERVIEW OF NASA PAYLOADS FLYING ON CLPS TASK ORDER 19D TO MARE CRISIUM. M. E. Banks[1], C. Barney[2], C. Buhler[3], C.I. Calle[3], M. Carter[4], M. Collier[1], D. Currie[5], J. Davis[2], M. DuPuis[3], A. Goode[4], R.E. Grimm[6], Z. Hull[2], D. Klumpar[2], B.J. LaMeres[2], R. W. Maddock[7], C.M. Major[2], M. Mehta[8], M. M. Munk[7], S. Nagihara[9], C. P. Nguyen[7], J. J. K. Parker[1], J. Sample[2], L. Springer[2], D.E. Stillman[6], O. Tyrrell[7], B. M. Walsh[10], R. N. Watkins[11,12], K. Zacny[13]. [1]NASA Goddard Space Flight Center, maria.e.banks@nasa.gov, [2]Montana State University, [3]NASA Kennedy Space Center, [4]Aegis Aerospace, Inc., [5]University of Maryland, [6]Southwest Research Institute, [7]NASA Langley Research Center, [8]NASA Marshall Space Flight Center, [9]Texas Tech University, [10]Center for Space Physics, Boston University, [11]Arctic Slope Regional Corporation Federal, [12]NASA Headquarters, [13]Honeybee Robotics.

Introduction: As part of NASA's Commercial Lunar Payload Services (CLPS) initiative, Task Order (TO) 19D includes ten NASA science instruments and technology demonstrations. The payloads will fly on the Firefly Aerospace Blue Ghost lander propelled into space by a SpaceX Falcon 9 rocket. These payloads will operate on the lunar surface for one lunar day and are scheduled to land in Mare Crisium (~18.560°N, 61.807°E) [1] in the third quarter of 2023. TO 19D will contribute science investigations, test technologies, and demonstrate capabilities that will help NASA explore the Moon and prepare for human missions under the Artemis program.

NASA TO 19D Payloads: Here we summarize details for the TO 19D NPLP (NASA Provided Lunar Payload) and LSITP (Lunar Surface Instrument and Technology Payload program) payloads. Among many key NASA personnel supporting TO 19D are Dr. Maria Banks (Project Scientist), Dr. Ryan Watkins (Program Scientist), Mark Dillard (Payload Integration Manager), and Greg Barnett and Dennis Harris (Mission Managers).

Electrodynamic Dust Shield (EDS). The EDS, which can lift, transport and remove particles from surfaces with no moving parts, will be demonstrated for the first time on the lunar surface (Fig. 1a). This technology, developed in the Electrostatics and Surface Physics Laboratory at NASA Kennedy Space Center, will show the feasibility of self-cleaning glass and thermal radiator surfaces [2]. In addition to dust removal, the EDS will apply lunar dust to these surfaces using the new reduster technology which will lift and transport dust from the lunar surface and transport it to the desired location without moving parts or gasses. The EDS will be released from a fifth leg of the lander and positioned directly onto the lunar surface to maximize dust contact. High resolution images will determine the dust removal efficiency of the EDS on the lunar surface.

Lunar Environment heliophysics X-ray Imager (LEXI) will image Earth's magnetosheath and magnetopause to study how energy is coupled from the solar wind into Earth's magnetosphere to drive geomagnetic disturbances and storms (Fig. 1b). From the lunar surface, LEXI will look back at Earth to measure magnetopause motion to understand the physics driving this process. The soft X-ray (0.1 - 2 keV) imager will measure photons emitted from charge-exchange between high charge state solar wind ions and neutrals in Earth's exosphere.

Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity (LISTER) will measure the flow of heat originating from the interior of the Moon (Fig. 1c). It is designed to penetrate 2- to 3-m depth into the regolith and determine the heat flow as a product of two separate measurements of thermal gradient and thermal conductivity of the depth interval penetrated.

Lunar Magnetotelluric Sounder (LMS) measures natural time-varying electric and magnetic fields from the solar wind and the Earth's magnetosphere in order to determine the electrical conductivity profile of the Moon's interior (Fig. 1d). This will constrain the temperature structure and thermal evolution of the Moon, as well as distinguish the anomalous Procellarum KREEP Terrane (PKT) from the lunar background. The LMS and LISTER investigations are both enhanced by their complementary data.

Lunar PlanetVac (LPV). LPV is a pneumatic based sample acquisition and delivery system [3] (Fig. 1e). It consists of three subsystems: Sampling Head, Transfer Tube, and Sample Container. Pressurized gas such as N2, is jetted towards the surface within the Sampling Head, stirring up the regolith into a cloud of dust. A secondary set of jets pointed up the Transfer Tube carry this regolith directly into a Sample Container. The sampling operation takes a few seconds and does not require human in the loop. Captured regolith, up to 1 cm in size, will be sieved and photographed inside the Sample Container. This technology is applicable for any mission or instrument that requires a surface (or subsurface) sample.

Regolith Adherence Characterization (RAC) will determine how lunar regolith sticks to a range of materials exposed to the Moon's environment throughout the lunar day (Fig. 1f). Thirty samples, including a dust collection disk, thermal control paint, Kapton, and titanium, have been provided by NASA and industry. Those samples constitute two identical sets of 15 coupons that are contained in two sample wheels which rotate into view of cameras every 24 hours for imaging. One wheel is covered until post-landing commissioning is complete and acts as a control for transit effects on the other wheel, which is exposed for the entire mission. RAC will collect IR, UV, and temperature data to augment science return of the 5.1 MP images. Operations are autonomous with some ground commanding access for recovery and contingency. RAC is being developed by Aegis Aerospace, Inc., in Houston, TX and relies on heritage technology from Aegis Aerospace's MISSE facility, an ISS-based orbital testing platform.

Radiation Tolerant Computer (RadPC) is a technology demonstration of a radiation tolerant computer system (Fig. 1g). RadPC implements a set of fault mitigation strategies to recover from single event effects (SEEs) caused by ionizing radiation. The recovery procedures are implemented on a commercial Field Programmable Gate Array (FPGA), allowing an acceptable level of total ionizing dose (TID) to be achieved inherently while simultaneously taking advantage of the performance and power efficiency of commercial parts. The RadPC payload contains the computer technology running a comprehensive test program along with instrumentation on its state-of-health. Three dosimeters tuned to different sensitivity levels are included in the payload to provide further environmental information for correlation to RadPC's performance and to provide detailed radiation information about the landing site.

Stereo Cameras for Lunar Plume Surface Studies (SCALPSS) 1.1 will capture video and still image data of the lunar surface prior to, during and after the lander's descent engine plumes interact with the lunar surface (Fig. 1h). This is a slightly enhanced version of the SCALPSS payload scheduled to fly on the CLPS Intuitive Machines IM-1 mission. By collecting topography data through stereo photogrammetry both prior to and after Plume-Surface Interactions (PSI), an accurate measurement of the total erosion and crater volume can be made. Transient data collected while PSI is occurring will add information regarding the rate at which the surface morphology changes. This data will then be used to validate computational models of PSI effects which are critical in the design and risk evaluation of future large lunar landers. The SCALPSS 1.1 payload is being developed at NASA's Langley Research Center, and is based off of the EDLCam descent camera system used by the Mars 2020 rover.

The *Lunar GNSS Receiver Experiment (LuGRE)* will demonstrate Global Navigation Satellite System (GNSS)-based spacecraft navigation in transit to the Moon and on the lunar surface for the first time [4] (Fig. 1i). This will open the door to operational use of existing Earth-based GNSS signals for real-time onboard positioning, navigation, and timing (PNT) around the Moon, increasing mission capability while reducing reliance on ground networks for PNT. The LuGRE payload is a collaboration between NASA and the Italian Space Agency (ASI) and consists of an ASI-provided weak-signal GNSS receiver that tracks GPS L1 C/A and L5, and Galileo E1 and E5a signals; a 14dBi high-gain GNSS antenna; and a low-noise amplifier. The payload will achieve three primary objectives: a) to receive GNSS signals at the Moon and characterize the signal environment, b) to demonstrate navigation and time estimation using GNSS data collected at the Moon, and c) utilize the collected data to support development of GNSS receivers specific to lunar use.

Next Generation Lunar Retroreflector (NGLR) will support the Lunar Laser Ranging Program for a long term investigation of lunar physics, Astrophysics and Cosmology (Fig. 1j). The NGLR will reflect very short laser pulses from Earth-based Lunar Laser Ranging Observatories.

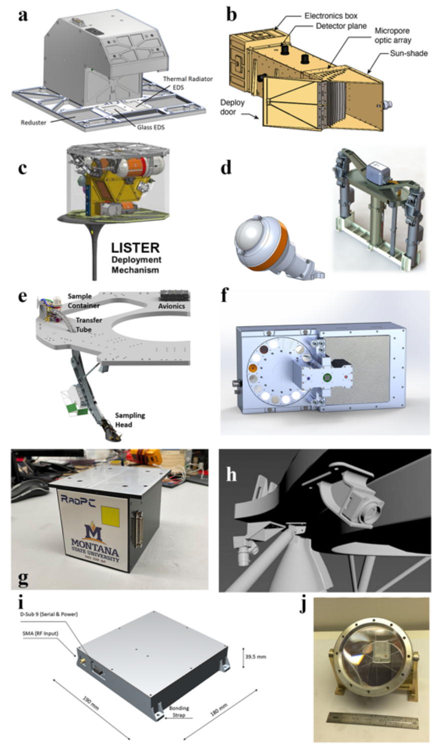

Figure 1: NASA payloads of CLPS Task Order 19D to be delivered to Mare Crisium. a) EDS. b) LEXI. c) LISTER. d) LMS electrode launcher (left, 1 of 4), magnetometer and mast stowed (right). Not to scale. Electronics box not shown. e) Lunar PlanetVac. f) RAC. g) RadPC. h) Illustration of SCALPSS 1.1 cameras (3 of 6). i) LuGRE. j) NGLR.

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