THE *LUNAR VERTEX* CAMERA ARRAY.

Brett W. Denevi[1], Heather M. Meyer[1], Giuseppe Pasqualino[2], William F. Ames[1], Scott A. Cooper[1], Ann L. Cox[1], Alexandra R. Dupont[1], Kaylee Geidel[2], James P. Mastandrea[1], Krista McCord[2], Alexandra V. Ocasio Milanes[1], Frank Morgan[1], Howard W. Taylor[1], Calley L. Tinsman[1], and David T. Blewett[1], [1]Johns Hopkins Applied Physics Laboratory, Laurel MD, USA, [2]Redwire Space, Littleton CO, USA.

Introduction: *Lunar Vertex* [1] is a suite of instruments and rover, selected through NASA's first Payloads and Research Investigations on the Surface of the Moon (PRISM) call, that will be used to explore and characterize the Reiner Gamma swirl in Oceanus Procellarum (landing site at 7.585°N, 301.275°E [2]). The *Lunar Vertex* payload includes the Vertex Camera Array (VCA), which will provide 360° imaging from the lander built and operated by Intuitive Machines.

Science Objectives: VCA objectives are focused on contributing to testing hypotheses for the origin of lunar swirls. VCA images will be used to characterize the landing site geology and to understand the physical properties of the lunar regolith in the "blast zone" affected by the impinging rocket plume, the pristine swirl surface outside of the blast zone, and within wheel tracks left by the rover as it crosses both terrains. VCA will collect a suite of images every 3.75° change in solar incidence angle (every seven hours) throughout the mission, providing a photometric data set from which the physical properties of the regolith can be assessed [e.g., 3–5]. The photometric properties of lunar swirls are distinct from those of fresh impact craters [5–9], and have been suggested to indicate swirl formation by a recent or ongoing process, such as a comet impact or unusual dust motion/sorting e.g., [6,10–12]; together with the Rover Multispectral Microscope [13], VCA will help to test this hypothesis.

Instrument Characteristics: VCA was built by Redwire Space of Littleton, Co. and consists of three clusters of three cameras (Fig. 1) fixed on the lander for 360° coverage. Each camera has a vertical field-of-view (FOV) of 40.8° and a horizontal FOV of 55.6°, leaving ~15° of overlap with each adjacent camera and a view that extends from ~5 m from the lander to the horizon. The ruggedized optics are from Edmund Optics (see Table 1 for characteristics). VCA makes use of Sony IMX214 detectors, which are backside illuminated CMOS sensors with Bayer pattern filters. Images can be read out as RAW10 or JPEG format, and are saved to camera on-board storage for compression prior to transfer to the lander for downlink. After lossless compression, the data volume of each RAW10 image (with associated meta data file) is estimated to be 9 MB.

Fig. 1. The three VCA flight units, which will be mounted on the lander for 360° panoramic coverage of the site. Each camera housing is 3.1 × 3.26 inches at its base.

Table 1. VCA characteristics

Pixel Pitch	1.12 µm
Pixels	4208 × 3120
Spectral	Bayer RGB, IR-Cutoff
Bit Depth	10-bit (RAW10), 8-bit (JPEG)
Aperture	0.89 mm
Focal Length	5 mm
F-Number	f/5.6
FOV	55.6 × 40.8° (single)
IFOV	224 µrad
Power	1.5 W (idle) 2.2 W (imaging/download) 5.5 W (boot up)
Mass	0.25 kg (per cluster)
Temperature Range	+25 to +70° (operational) –50 to +85°C (survival)

Calibration: The calibration plan for VCA is driven by the science objectives and associated requirements. Context imaging necessitates a geometric calibration to characterize alignment, magnification, and distortion such that knowledge of feature locations in detector space can be translated into relative or absolute distances. Characterizing the photometric properties of the landing site requires a radiometric calibration so that DN can be converted to radiance or reflectance regardless of the camera settings and state (exposure time, ISO setting, temperature, etc.). All calibration data have been collected at Redwire and APL.

VCA Status: VCA has now been delivered to lander integration. We are currently working to complete an image calibration and processing pipeline, including adapting APL's Small Body Mapping Tool [14] for projection, mosaicking, and analysis of VCA images.

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