LANDING SITE SELECTED FOR THE BLUE GHOST MISSION TO MARE CRISIUM. S. Nagihara[1], M. E. Banks[2], R. E. Grimm[3], D. E. Stillman[3], R. N. Watkins[4,5] and R. R. Ghent[6], [1]Department of Geosciences, Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), [2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, [3]Southwest Research Institute, Boulder, CO 80302, [4]Arctic Slope Regional Corporation Federal, Beltsville, MD 20705, [5]Exploration Science Strategy and Integration Office, NASA Headquarters, Washington, DC 20546, [6]Planetary Science Institute, Tucson, AZ 85719.

Introduction: In September 2023, ten NASA-supported science instruments and technology demonstrations are scheduled to be delivered to Mare Crisium on the Blue Ghost lander of Firefly Aerospace [1]. This delivery is being carried out under NASA's Commercial Lunar Payload Services (CLPS) initiative. The payloads were selected prior to selection of the landing destination. Some payloads were location-agnostic, while others required landing in specific regions and/or geologic settings to meet their science objectives. Mare Crisium was chosen, principally as a nearside mare away from the anomalous Procellarum KREEP Terrane (PKT), to meet the shared objectives of two payloads: the Lunar Instrumentation for Subsurface Thermal Exploration with Rapidity (LISTER) [2] and the Lunar Magnetotelluric Sounder (LMS) [3]. The present authors were tasked with proposing a landing site within the mare that met various requirements of the payloads and the lander. Here we summarize the consideration that led to the selection.

Landing Site Requirements and Down Selection Process: Payload-specific requirements were the main driver in prioritizing potential landing areas within the mare. For example, Mare Crisium has bullseye magnetic anomalies on its northern and southern rims [4], which LMS seeks to avoid for optimum sensitivity to time-varying magnetic fields. In addition, the landing site crust must be of relatively uniform thickness for LMS and LISTER data interpretation. These criteria first led us to the central E-W corridor of the basin where the magnetic anomaly is lowest (Fig. 1). The Lunar Environment heliophysics X-ray Imager (LEXI), also on the lander [1], preferred an eastern site for X-ray imaging of the interaction between the solar wind and Earth's magnetosphere. Therefore, we focused on the east-central part of the basin in the vicinity of an old volcanic vent, which has recently been named *Mons Latreille* (Fig. 2). This feature will serve as a good landmark for the terrain relative navigation capabilities of the spacecraft.

LISTER uses a pneumatic drill and deploys its probe to 2- to 3-meter depth into regolith [2]. This requires the regolith be devoid of large, buried rocks that would impede drilling. There is no sure way of identifying such areas based solely on remote observations, but certain types of data, such as the rock abundance estimates from the Diviner thermal infrared radiometer of the Lunar Reconnaissance Orbiter (LRO), can guide us to areas that have less likelihood of encountering large rocks than others [5]. The thermal infrared wave is sensitive to regolith properties down to only a few-centimeters deep, however. The P- and S-band radars of the Arecibo Observatory can probe properties of regolith down to ~1-m and ~7-m depths, respectively. Regolith with low rock concentration in these depth ranges may be recognized as areas with low circular polarization ratio (CPR) [6]. Using overlay analysis, we identified ~30 areas where the Diviner rock abundance and Arecibo P-band and S-band CPR values are low in our area of interest (Fig. 2).

For further down selection, we conducted a series of topographic analyses to locate a 50-m radius landing area (Fig. 3), using Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) images with high incidence angles (>50 degrees), and a LROC NAC stereo-derived digital terrain model (DTM) (Fig. 4).

Additional CLPS and lander requirements include slopes ≤10°, low risk of obstacles (rocks and craters) >2 m in diameter, no topographic obstructions to the west in the direction of the setting sun, and that the lander be illuminated at the time of landing (not in shadows). The selected landing ellipse is centered at 18.560° N, 61.807° E (Fig. 3). This ellipse contains the lowest density of craters >~2 m in diameter, all of which appear at least moderately degraded (shallower depths, lower slopes on crater walls, low likelihood of associated boulders). No boulders at the ~1-2-meter scale could be identified, consistent with Diviner results. Slopes within the ellipse are <~5°. Terrain ruggedness index (TRI) values (using values derived for Apollo and other lunar landing sites as a reference [8]) within the ellipse are <0.4 m. Finally, based on the projected dates and times, we simulated and assessed illumination conditions at landing and sunset using the DTM (Fig. 4).

Conclusions: Based largely on the remote observations of LRO and the Arecibo radar, we believe that we have selected a site that meets the scientific and safety requirements of all payload instruments, CLPS and the lander, while maximizing the chance of success and the scientific return of this mission.

Acknowledgments: The maps generated for the present study used the following datasets obtained from the Planetary Data System (PDS): LROC WAC 100 mpp global mosaic, LROC NAC images and DTMs, and Arecibo P- and S-band images. We also used the SELENE magnetic anomaly grid from the archive of JAXA. We thank the LROC Team for their timely acquisition and processing of NAC stereo images and DTMs and E. T. Wright at NASA Goddard Space Flight Center for the illumination simulations. The work presented here is supported by the Lunar Surface Instrument and Technology Payload (LSITP) program of NASA.

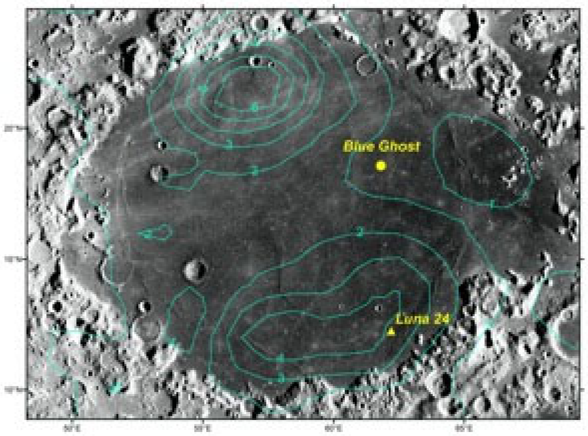

Figure 1. LROC Wide Angle Camera (WAC) mosaic of Mare Crisium. The yellow dot indicates the landing site selected for Blue Ghost. Magnetic anomaly contours (1 nT intervals) at 30-km altitude [7] are also shown.

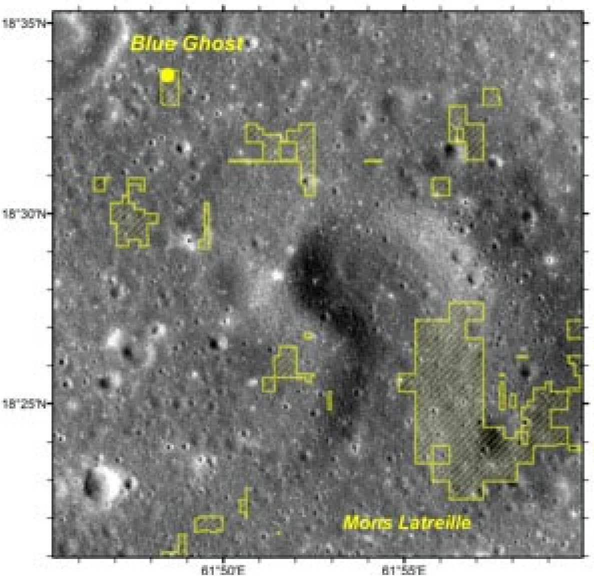

Figure 2. LROC WAC mosaic of the vicinity of the selected landing site (yellow dot). Yellow polygons delineate the areas of low rock concentrations based on an overlay analysis of Diviner rock abundance and Arecibo P- and S-band radar CPR images.

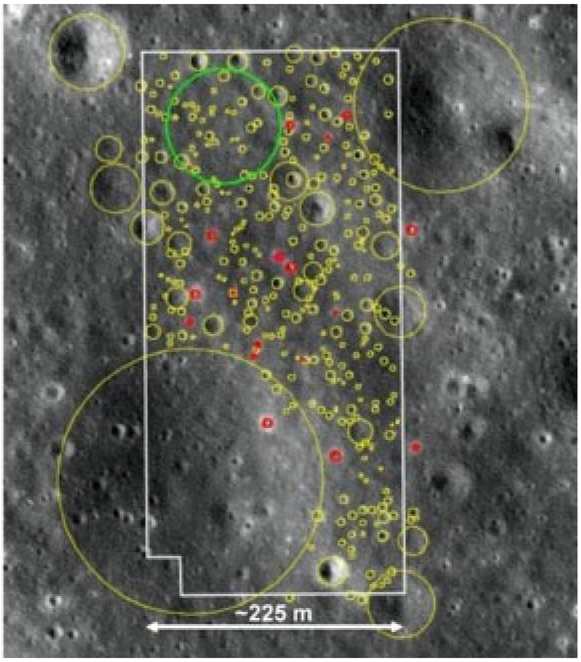

Figure 3. LROC NAC mosaic (M1356089436L/R and M1356103508L/R) of the selected landing area showing the landing ellipse with a 50-m radius (green circle). The white rectangle shows the area of lowest rock concentrations expected. The yellow circles show the craters identified within the rectangle. The red circles indicate fresh (optically bright) craters.

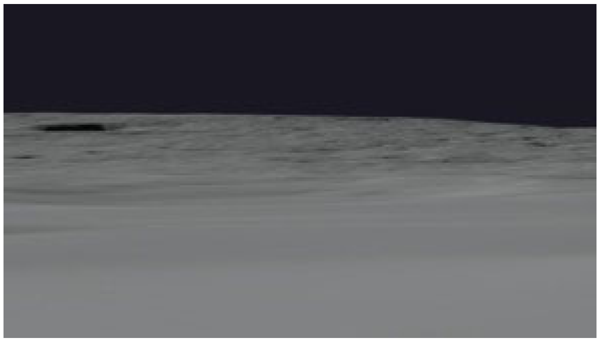

Figure 4. Perspective view rendered from a LROC NAC DTM (Product ID: NAC_DTM_CRISHORSE01). View is looking southeast at distant *Mons Latreille*, from 2-m height at roughly the center of the ellipse (Fig. 3) at ~20 hours after sunrise.

References: [1] Banks M. E. et al. (2022) *this conference*. [2] Nagihara S. et al. (2020) *LPSC LI,* Abstract #1432. [3] Grimm R. E. (2020) *LPSC LI,* Abstract #1568. [4] Baek S.-M. (2019) *JGR 124,* 223-242. [5] Bandfield J. L. et al. (2011) *JGR 116*, E00H02. [6] Ghent R. R. (2016) *Icarus 273*, 182-195. [7] Tsunakawa H. et al. (2014) *Icarus 228*, 35-53. [8] Lawrence et al (2020), *LPSC LI*, Abstract #2579.