APPLICATION OF EARTH-ANALOG SITES FOR LUNAR SIMULATED DIGITAL ELEVATION MODELS. S. P. Scheidt[1,2,3], J. A. Richardson[2,3,4], M. K. Barker[2], N. E. Petro[2], C. I. Restrepo[5], E. Mazarico[2], L. Kerber[6], S. X. Hudziak[7]. [1]Howard University, Washington, DC 20059 (stephen.scheidt@howard.edu), [2]NASA Goddard Space Flight Center, Greenbelt, MD. [3]CREEST, Greenbelt, MD 20771. [4]University of Maryland, College Park, MD. [5]NASA Johnson Space Center, Houston, TX. [6]Jet Propulsion Laboratory, Pasadena, CA. [7]University of Iowa, Iowa City, IA.

Introduction: Knowledge of surface features such as craters, boulder distribution, and other surface characteristics help to strategize hazard avoidance during human and robotic space exploration of rocky planetary bodies. Recent successes were demonstrated by the use of optical terrain relative navigation (TRN) for the recent landing of NASA's Perseverance rover on Mars [1] and sample collection from the asteroid Bennu by the OSIRIS-REx mission [2,3]. Future missions to the Moon and other target bodies will use these technologies, including LiDAR [4]. As they improve, scientists and engineers will explore new features on the Moon that are more challenging to explore, with ever rougher surfaces, higher rock abundance, and steeper slopes.

Lunar Exploration: Geologists, data scientists, and navigation engineers are working together to overcome challenges to landing on unknown terrain by utilizing synthetic and real Digital Elevation Models (DEMs) to understand surface properties and simulate scenarios for entry, descent, landing and navigation (EDLN). The data are also important for determining targets of interest. Our ability to identify hazards and achieve navigation solutions for lunar exploration is dependent on image and DEM data resolution and quality, as well as the realism of synthetic DEMs, which are used in simulation scenarios. In general, the resolution of DEMs produced for the Moon are between 1 – 4 m/pixel [5,6], whereas the scale of relevant hazards is < 0.1 m. High-resolution DEM data is needed to validate EDLN strategies and workflows for both robotic and crewed missions to planetary surfaces.

Lunar-Like Analog Data: Earth has been an ideal testbed for creating analog digital terrains for rocky planetary bodies where similar surface processes occur [7]. The application of small Uncrewed Aerial Systems (sUAS) and stereophotogrammetry are heavily utilized in the science community to produce DEMs with centimeter-scale resolution and accuracy.

We are bridging a critical gap by building a library of lunar-like DEMs of surfaces at Earth analog and Apollo Training sites. For example, the Potrillo Volcanic Field, NM has pits that resemble lunar pits (Figure 1) and shape data of these features can help test ingress/egress concepts for relevant lunar missions [8,9], and Central Iceland has abundant volcanic plains with lunar-like rock distributions (Figure 2). We have several DEMs in hand, and future DEM additions to the library will have large areas from small uncrewed aerial systems with spatial resolution as low as 0.01 m/pixel. Ground-based techniques produce sub-cm data where needed. We can combine terrestrial, lunar and synthetic DEM data to produce state-of-the-art fusion products. These can be made available for analysis, EDLN simulations, illumination analysis, visualization, and advanced planning/simulation/training for EVA surface ops. Advantages of these data are the realism to natural surfaces, shape, and scale. DEM production was supported by NASA RISE2 and GIFT projects [10].

References: [1] Maki, J. N. et al. (2020). *Space Sci. Reviews*, *216*(8), 1-48. [2] Berry K. et al. (2013). *36th Annual AAS Guidance & Control Conference* (pp. 13-095). Breckenridge, CO. [3] Lauretta, D. S. et al. *LPSC*, No. 2097. [4] Restrepo C. I. et al. (2019). *2nd RPI Space Imaging Workshop* (pp. 2-3). [5] Alexandrov, O. and Beyer, R. A. (2018). *Earth & Space Sci.*, 5(10), 652-666. [6] Scholten F.et al. (2012). *JGR: Planets*, *117*(E12). [7] Shepard, M. et al. (2001). *JGR*, 106, E12, p. 32777-32796. [8] Nesnas et al. (2019) 2019 *IEEE Aerospace Conference* (pp. 1-23). [9] Kerber, L. et al. (2019). *LPSC,* No. 2132, p. 1163. [10] Young, K. E. et al. (2018). *Earth & Space Sci. 5*(11), 697-720.

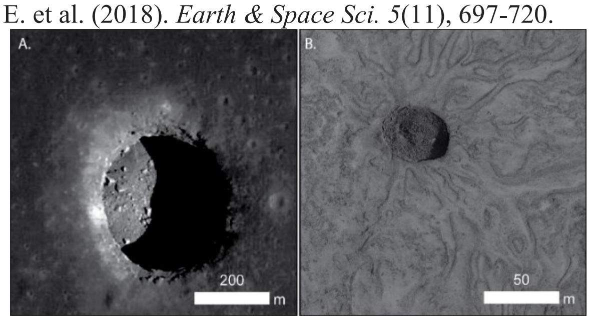

Figure 1. A) Mare Tranquillitatis pit (LROC NAC image M126710873R). B) sUAS image of lava tube skylight near the Portrillo Volcanic Field, NM.

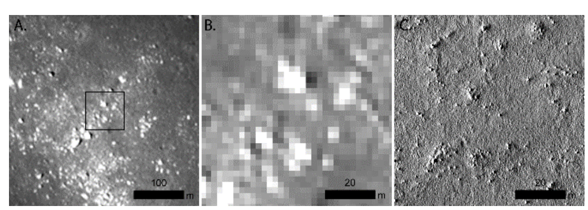

Figure 2. a) Impact crater ejecta (LROC NAC image M126710873R). b) Inset view of ejecta. c) Boulder field on a sand sheet in northern Iceland near the Askja and Holuhraun eruptions. Hillshade of 5 cm/pixel resolution sUAS-generated DEM the same scale.