SIMULATING LUNAR LANDING SITE ILLUMINATION WITH SYNTHETHIC DEMs. J. A. McGovern[1], David T. Blewett[1] , G. Wesley Patterson[1], and N. R. Lopez[1], [1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD 20723 USA (andy.mcgovern@jhuapl.edu).

Introduction: As part of the Autonomous Landing and Hazard Avoidance Technology (ALHAT) project, the Applied Physics Laboratory was tasked with developing realistic lunar navigation, descent and landing simulations. A strong science rationale exists for landing near the poles, where it may be possible to exploit permanently shadowed craters containing resources helpful for long term habitation [1]. Obviously illumination near the poles will be drastically different from mid-latitude Apollo-era missions and may pose significant challenges for a piloted or automated landing. The primary goal of these simulations is to understand what sensors or pilots would see as they approach and land near the lunar South Pole along a given trajectory. Each simulation consists of three important components: a digital elevation model (DEM), a known illumination geometry, and an appropriate photometric function.

Surface Modeling: Surface modeling is accomplished by APL-developed tools that generate high-resolution synthetic digital elevation models (DEMs) for the Moon; detailed application of the tools is provided in reference[2]. The software can start with existing data, such as the Goldstone Radar DEM, and fill gaps with purely synthetic terrain, and realistic random terrain, that conforms to established size-frequency distributions for craters and rocks. Beyond providing an important component for simulating illuminated surfaces, these DEMs are also useful in characterizing landing hazards [2,3].

Illumination Geometry: The second component of the simulations is calculation of the illumination geometry. ALHAT trajectories are the primary input for illumination determination; these trajectories are essentially a listing of spacecraft states for the navigation and landing phases. Each state includes a time-stamp, and the spacecraft position and attitude in a Lunar body-fixed frame. Using the trajectory information, along with the latest NAIF ephemeris, illumination and viewing geometry can be calculated for each facet at each time step; and ray tracing is used to identify regions of terrain shadowing.

Photometric Function: The Lambert model is a convenient photometric model that works surprisingly well in many cases; in this model incidence angle is the only illumination variable. The Lambert model uses the cosine of the incidence angle which results in a value of 1 at the sub-solar point and zero at the terminator. A quick look at the Moon reveals that this model is insufficient as the brightness of the surface decreases only slightly from the sub-solar point out to the limb. A more appropriate photometric function is the Lunar-Lambert function [4]. The Lunar-Lambert function was developed empirically with the recognition that limb-darkening on planetary bodies with no atmosphere is remarkably insensitive to different surface albedo units. The function incorporates the full photometric geometry of incidence, emission, and phase angles to model limb-darkening as well as backward and forward scattering. Lookup tables of model parameters have been formulated from the Clementine Ultraviolet/Visible (UVVIS) camera basemap.

Simulation and Future Work: The Lunar-Lambert function is relatively simple to understand and use but has the drawback that each trajectory step within the simulation must be rendered anew since the viewing geometry is different for each step and each surface facet. This drawback can be mitigated by using a programmable graphics processing unit (GPU) to evaluate the photometric function for surface facets in parallel. Figure 1 shows some results from illumination and ray tracing of a synthetic DEM.

Future work will incorporate data from the Lunar Reconnaissance Orbiter (LRO) and simulate second-order illumination effects such as Earthshine and multipath reflections.

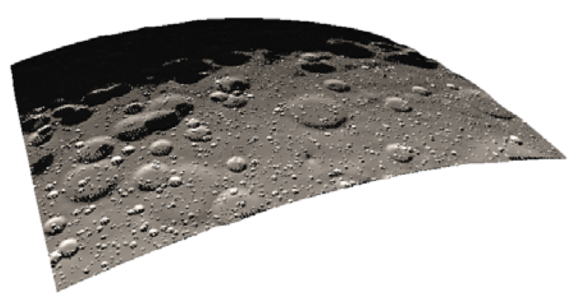

Fig.1. Illuminated and ray-traced synthetic lunar South Pole in early August of 2011.

References:

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