Innovative Features of NASA's Celestial Mapping System to Support Exploration in the Lunar South Pole.

P. Agrawal[1], M. E. Peterson [1,2], G. M. Del-Castillo[1,2] , I. Lopez-Francos [1,3], G. Mackintosh[1,4] , A. Zuniga[1], [1]NASA Ames Research Center, Moffett Field, CA 94035-1000, parul.agrawal-1@nasa.gov, [2] USRA, [3]WYLE Labs, [4]BAERI.

Introduction: NASA's Celestial Mapping System (CMS) [1,2] is developed to address the need for 3D tools for planetary science investigations, mission planning, in-situ operations, in a 3D-first design constructed around a unified view of a planetary globe. At present CMS provides many critical functionalities that include: 1) equipment planning and optimized placement on Lunar surface 2) line-of-sight (LOS) analysis 3) powerful measurement tools based on 3D terrain with realistic 3D models to represent rovers, astronauts and equipment 4) visualization of derived mapping products (e.g. resource maps), and 5) a data engine for hosting new observations that are not available in other contemporary lunar data tools [1, 3]. CMS is founded on the robust NASA WorldWind globe engines [4]. In near future, users will be able deploy CMS across multiple hardware configurations and platforms, including Windows, Linux, iOS and, Android. Users will also be able to update to the latest imagery and terrain datasets as they are being acquired (in real time) before and/or during the exploration mission. CMS can also consume and analyze data from locally hosted and external sources. It is compatible with Open Geospatial Consortium (OGC) data and file standards and currently integrates datasets from the Astrogeology Science Center of USGS. This includes global and local data acquired from NASA (LRO, Clementine, Lunar Orbiter) and JAXA (SELENE/Kaguya), with capability of integrating more datasets. CMS, with expertise in both the end-user application and planetary engine development can readily adapt to emerging Lunar cartography standards as they develop and become recognized by international geospatial panels.

Overcoming Polar Distortions: 3D geospatial applications traditionally exhibit significant distortions in polar imagery due to several reasons: 1) distortions in the source imagery, 2) incompatible tessellation algorithms at the poles, and 3) map projections. In the lunar context, especially focusing on the South pole, such distortions are unacceptable. The CMS team is exploring solutions to address polar imagery distortion, leveraging new tessellation algorithms and reprojecting data using projections that are better suited for polar scenarios. Fig 1 shows the potential error introduced by different tessellation methods, represented by the red and green circles for Shoemaker crater. There is ~2 Km difference in the placement of the crater.

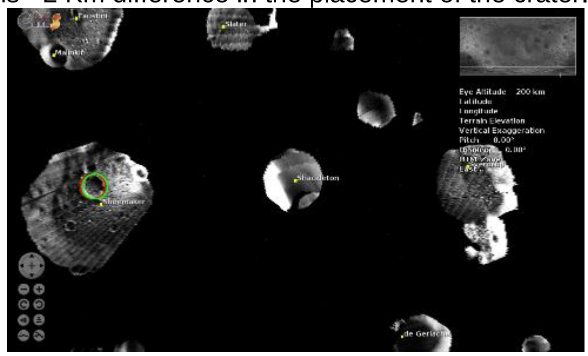

Fig 1: Distortion at Shoemaker crater. Source CMS.

LOS Analysis and Traverse Planning: We've integrated a LOS tool into CMS which analyzes terrain profiles and obstructions to determine visibility for remote observers. Fig 2 shows the viewshed analysis on a permanently shadowed region (PSR) in the lunar South Pole's Nobile region, the site of the upcoming NASA VIPER mission. The PSR layer was generated using images generated by HORUS denoising tool [5]. The yellow pin shows the observer location outside the PSR, with the yellow region representing the visible portion of the PSR. Areas obstructed and not visible for the observer are shown in red. We expanded this analysis to account for varying observer heights and subsequently conducted the viewshed analysis. Combining the different visibility profiles can help designing improved traverses within the PSR.

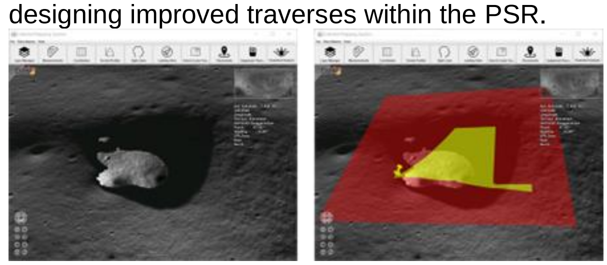

Fig 2: Line of sight analysis within a PSR. Source: CMS

References: [1] https://celestial.arc.nasa.gov [2] Agrawal et. al. “Celestial Mapping System for Lunar Surface Mapping and Analytics”, Lunar Surface Innovation Consortium, 2021 [3] Agrawal et. al., “Science Investigations and Exploration in Celestial Mapping System LSSW 17, June 2022 [4] https://worldwind.arc.nasa.gov/ [5] Bickel V. et al. (2021) Nat Commun 12, 5607