PROCESS FOR SELECTING LUNAR LANDING ELLIPSE FOR A SMALL ROVER. B. DesRochers1,2, N. Jackson1, C-E Morisset1 and J. Burley1,3, 1Canadian Space Agency, Saint-Hubert, Qc, Canada, 2Université de Sherbrooke, Sherbrooke, Qc, Canada, 3Western University, London, On, Canada.

Introduction: Determining the landing site and specific landing ellipse within it for a small rover mission has major repercussions on potential scientific results and safety. In the specific case of the lunar South Pole, solar illumination and direct Earth communications can be of particular concern, as these are varying vastly depending on topography and time of year. We have therefore developed a process that accounts for a combination of factors like illumination modeling and terrain analysis to identify favorable landing ellipses within a site.

Previous work: Prior to selecting the ellipses themselves, work was done to identify 25 km² areas in the lunar South Pole that were suitable for rover operations [1]. At 60m resolution, average slopes and average Sun and Earth access were evaluated alongside with the proximity of scientific areas of interest for the entire South Pole.

Methods: Once potential landing areas at the South Pole were identified, a method to select specific landing points and their corresponding ellipses was developed. This method focuses on the characterization of the terrain within the ellipse and the expected operations duration based on modeled illumination and Earth visibility at 20 meters resolution provided by Mazarico et al [2]. The slope threshold that the lander can tolerate was set at 5°. The first step consisted in classifying the slopes at a resolution of 5 meters per pixel based on Lunar Orbiter Laser Altimeter (LOLA) Digital Elevation Models (DEM) [3]. The classification consisted of 3 classes being (1) everything below or equal to 5°, (2) everything between 5° and 7° and (3) everything above 7°. An ellipse with a radius of 100 meters was then computed from the center of every pixel in the first class. For every ellipse, we ensure that no slopes from the third class is present in the radius, it is otherwise discarded. Remaining ellipses are then evaluated once again to determine the percentage of the area occupied by slopes from the second class. As a risk acceptance measure to expand landing options, up to 10% of the pixels in the ellipse can have a slope between 5° and 7°. All the ellipses that do not respect this constraint are also discarded. Depending on the topography of the sites, hundreds or even several thousands potential ellipses per 25 km² area are identified at this step.

In order to assess which of these ellipses per 25 km² area are best suited to maximize rover operation we used a number of other metrics. Since Solar illumination and direct Earth communications are dependent on time, it was necessary to identify specific periods for operations. To do so, the illumination data for each 25 km² areas were combined into lunar days. Here, a day is defined as the time interval between when the first dark pixel of the area becomes illuminated and when the last illuminated pixel becomes dark. The Earth visibility for the same time period is also computed. By combining these two layers, the best three lunar days in terms of maximum lander and rover operations duration are kept.

Once days were selected, we extracted the 10th percentile for lander operations duration of all the pixels within the ellipses. The 10th percentile was used instead of the minimum value to exclude outliers within the ellipse for point-to-point comparison. A manual threshold was then determined depending on the distribution of ellipse’s operations duration values within each 25 km² area to only keep the highest values in the sites. Using a Geographic Information System (GIS) to visualize the data, the team then overlaid the remaining ellipses with rover operations duration and lander visibility to isolate areas of potential landing ellipses. The lander visibility was computed using a viewshed tool, which shows which pixels are visible to an observer based on the terrain.

A score was calculated for each ellipse in the selected areas to rank them based on lander visibility, lander operations duration, rover operations duration and the percentage of slopes between 5° and 7°. The 2 or 4 ellipses with the highest score were kept as potential landing ellipses. These were used as starting points for a traverse planning exercise [4].

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References: