Study of Potential Landing Sites on Lunar South Polar area for Chandrayaan-2 Lander

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Introduction: The prime objective of Chandrayaan-2 mission is to design, realize and deploy a Lunar Lander-Rover capable of soft landing on a specified lunar site and deploy a Rover to carry out in-situ analysis [1]. Lander is to be de-orbited from 100 km circular orbit and has to descent to the moon surface at the identified site using the liquid engines for braking. Landing site plays a key role in the success of soft landing for the Chandrayaan-2 Lander. The Lander poses some constraints (local slope, Sun illumination during mission life, Radio communication with earth, Global Slope towards equator, Crater density, Boulder size and distribution) because of its engineering design for the selection of the landing site and on the other hand the landing site / region imparts some constraint on the Lander.

The landing sites currently envisaged for the mission have been identified based on the engineering design constrain (power generation and ground communication) of the Lander. This paper provides a thorough characterization of the south polar area (85°-90° S Latitude) of moon based on technical criteria for identification of potential landing sites. The study is based on datasets from Chandrayaan-1, Clementine and Lunar Reconnaissance Orbiter Camera (LROC-NAC, LROC-WAC and LOLA) missions.

Characterization of the Hazards distribution: The major hazards of importance are Slopes, Boulders / craters and shadows [2]. Slope has been derived from Lunar Orbiter Laser Altimeter (LOLA) Digital Elevation Model (DEM), whereas Boulders and craters have been extracted from LROC-NAC and Chandrayaan-1 images through image processing techniques. The criteria considered for selection of suitable sites are:

- Slope < =15° towards equator
- Avg. Elevation > 2000 m
- Illumination (Not Permanently shadowed)
- South Polar area; 85-90 Lat.; Near Side of Moon
- Landing ellipse (16 km along track x 10 km across track)
- Minimum Hazard free Grid area (300 m x 900 m)
- Distance from approach side of landing side = 12 km
- Distance exceeding the landing site = 4 km

Using the site selection criteria, a hazard distribution map for entire 85-90 degree latitude south polar area were generated . The GIS layers with corresponding hazard map used for identification of landing sites are shown in figure-1(a).

Characterization of the Illumination Conditions: There are fundamental differences between Earth and Lunar illumination conditions. Illumination on Earth is from the Sun, lunar albedo, or artificial illuminations and cast shadows which are softened due to atmospheric diffusion. On the moon, illumination is caused by the Sun, Earth albedo and negligibly by starlight and cast shadows result in completely darkened areas [2]. In the lunar Polar Regions, elevated areas cast shadows that can span tens of kilometres.

llumination (Shadow) assessment is currently based on the analysis of LROC WAC images taken at times at which the illumination conditions (Sun azimuth and elevation angles) are equivalent to those expected at the estimated landing date and time. LRO's 50-km polar orbit enables images of each pole to be acquired every ~2 hours during normal spacecraft and instrument operations (average time between WAC observations is 2.3 hours including spacecraft and instrument disturbances). The WAC 90° field of view (monochrome mode) allows for a 104- km region within 2° degrees of the pole to be acquired at a resolution of 100 m/pixel. This repeat coverage enables the creation of illumination maps that has been used to delimit permanently shadowed regions and permanently (or near permanently) illuminated regions and allows us to visualize the way lighting conditions at each pole change over a calendar year. The percentage illumination map over the year (2010-2011) has been shown in figure- 1(b)

Results: On the basis of characterisation of south polar area of moon and the Landing ellipse, four landing sites are identified as suitable landing sites as shown in Figure-2 (a). The topographic details of one of the sites (Liebnitz B Plateau South) have been provided in figure-2(b) and 2(c). The details of all the sites are tabulated in table -1. The study and analysis carried out in this work are considered significantly representative of the real conditions at the lunar surface on poles; however the effects of certain limitations including the resolution of LOLADEM used may still be significant for the results.

Future Work: All the four selected sites will be further characterized for local slopes and the horizon.

References::

[1] Landing Site for Ch-2 mission-A study; ISRO-isac-Ch2-PR-2434. [2] Diego De Rosa et. al. “Characterisation of potential landing sites for the ESA Lunar Lander project” in Planetary and space science, 74(2012) 234-246.

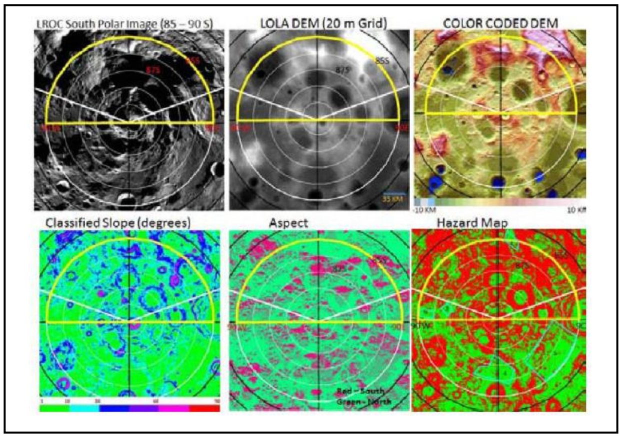

Figure-1(a) GIS Layers used for LS identification

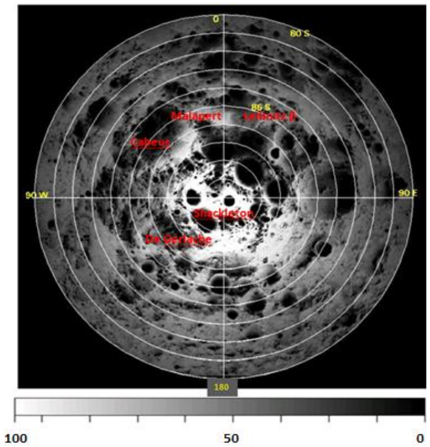

Figure-1(b) Accumulated Illumination map over the year (Feb'2010 to Feb'2011)

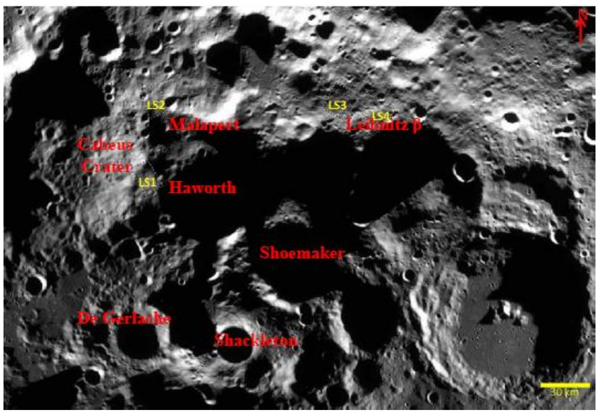

Figure-2(a)Overview of Identified Landing Sites (LS)

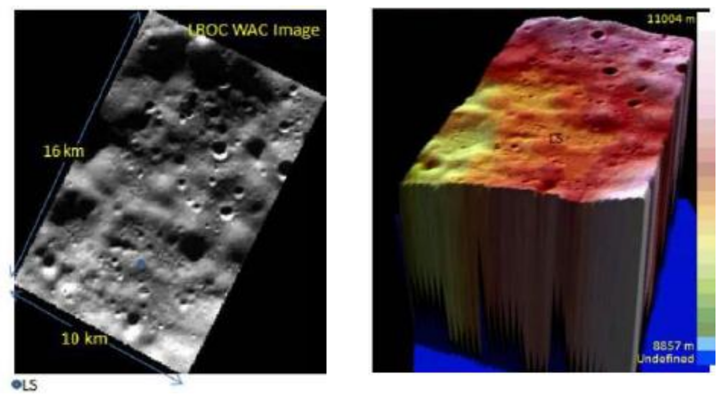

Figure-2(b) Topographical Details of Landing Site Leibnitz Plateau South(LS-3)

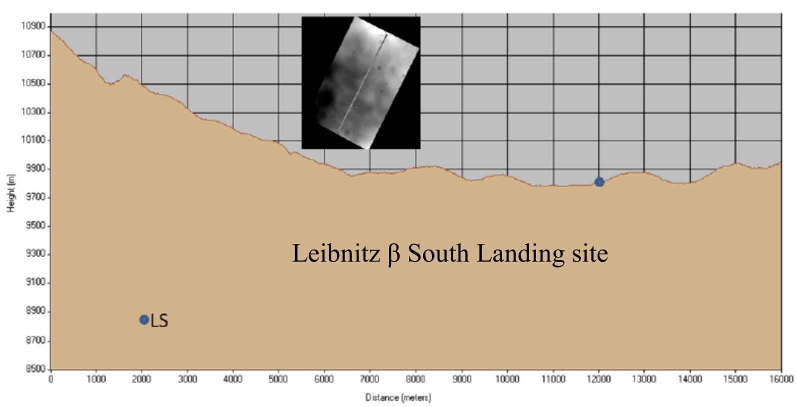

Figure-2(c): Height Profile along the line (to equator)

Table-1: Details of Potential Landing Site (16 km x 10 km landing ellipse)

L.S.	Name	Lat.	Long.	Area (Sq. km)	Hmin (m)	Hmax (m)	Havg (m)	Crater Density (> 4m)
1	Cabeus Crater Rim	-86.793	-25.805	16 X 10	62	5685	2685	502
2	Malapert West	-85.480	-16.098	16 X 10	-624	4683	2243	434
3	Leibnitz β Plateau South	-85.090	26.505	16 X 10	8857	11004	10031	354
4	Leibnitz β Plateau North	-84.918	35.924	16 X 10	9392	13792	12408	300