SUITABILITY OF LOLA DEMS FOR PROCESSING TMC IMAGES OF CHANDRAYAAN-1.**P.V.** Radhadevi, D. Sudheer Reddy, J. Saibaba and Geeta Varadan. Advanced Data Processing Research Institute, Department of Space, Manovikasnagar P.O., Secunderabad 500 009, India, e-mail: drpvr@adrin.res.in.

Introduction: The Terrain Mapping Camera (TMC) of Chandrayaan-1 has three CCD arrays acquiring stereo triplet of the target scene in the Fore (F), Nadir (N) and Aft (A) views with a resolution of 5m [1]. One of the challenges for the photogrammetric processing of these strips is the identification of distributed Lunar Control Points (LCP) from coarser reference images. The Lunar Orbiter Laser Altimeter (LOLA), a payload on the Lunar Reconnaissance Orbiter (LRO) provide a precise global geodetic grid on the Moon. Details of LOLA's imaging, sampling strategy and mission operations are given in [2]. The LOLA GDRs are raster Digital Elevation Models (LDEM) of the lunar surface with respect to a spherical datum about the centre of mass with radius 1737.4 km, and are generated at multiple resolutions (Table 1). Global products use the equi-rectangular map projection, while the higher-resolution products generated from dense polar coverage use the Polar Stereographic projection In this paper, we study the impact of height error in combination with view angle of the cameras on planimetric accuracy by extracting height from different resolution LDEMs to decide which LDEM is suitable for TMC data processing.

Method: Each TMC strip has a length of about 1600km. To process the full strip, distributed LCPS are required. We use Chandrayaan-1 TMC images with vertical controls derived from LOLA DEM which is the highest resolution global models of topography of the lunar surface and Planimetric control points are derived from Clementine UVVIS ortho mosaic which has a resolution of about 100m. As it is shown in Table 1, high resolution LDEM sizes are huge and therefore, they are aggregated in subsets (tiles) of global coverage.One strip of TMC image many fall in multiple tiles. Thus, even though LOLA DEM with 1024 PPD is having the best accuracy, it is difficult to handle multiple tiles in operational scenario. Mosaicing of tiff files for which sizes are more than 4GB is very difficult in COTS packages because many of them don't support Big Tiff. . In this paper, we do a comparison between different LOLA DEMS by analyzing the impact of height error on planimetric accuracy by using LCP s and Check points from each source while processing Mono images .Using an Automatic LCP identification tool, a set of conjugate points from TMC images and the corresponding planimetric coordinates from Clementine mosaic are identified. Heights are extracted from LDEM-16, 64, 256 and 1024 for the same set of points. The geometric correction algorithm include different steps like Initial fitting of the orbit trajectory and orientation of the sensor with given ancillary data, Modeling of the viewing geometry and Attitude data refinement using Lunar control points. Details are given in [3]. After this, Lunar referencing at the check points using refined exterior orientation parameters is done in which the rays are traced down to intersect with the surface of moon.

Table 1 LOLA equi-rectangular Map-projected Digital Elevation Models

Product	Product Size	Pixel size (m in lat)	No./size of tile	Bits per pixel
LDEM_16	64 MB	1895	Global, 0-360	32
LDEM_64	1 GB	473.8	Global, 0-360	32
LDEM_256	4x2GB	118.45	4 tiles, Grid: Lon 180° bands Lat: 90° bands	16
LDEM_1024	64x2GB	29.612	64 tiles, Grid: Lon 45° bands Lat 22.5° bands	16

Results and Discussion: Around 1500 Check points whose latitudes are ranging from -50^0 to +70 ^{0} are identified automatically from 17 strips of TMC. For these points, the heights are extracted from LDEM-16 and LDEM-256 and the corresponding difference in heights is shown in Fig.1a. The minimum and maximum difference is about -600m and +400m respectively. For a particular orbit no 1174 having a shift in this range is analyzed further and compared with heights extracted from LDEM-16, 64, 256 and 1024 as shown in figure 1b. The difference between heights from LDEM-16 and 256 are of the order of -600m to 400m and the corresponding difference between LDEM-256 and 1024 is less than ± 60m.

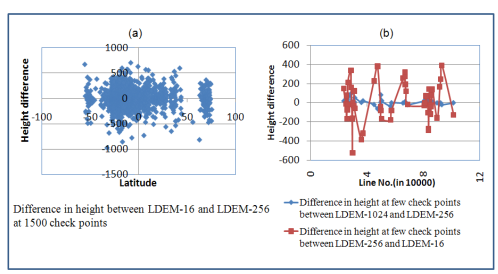

Fig.(1) (a) Difference in heights between LDEM-16 and LDEM-256 at 1500 points, (b) a case of orbit no. 1174.

Now, we analyze the planimetric error caused due to the combined effect of height error and view angle in the processing of mono images. Figure 2 clearly demonstrates this effect. θ is the incident angle, which will be in the neighbourhood of view angle.

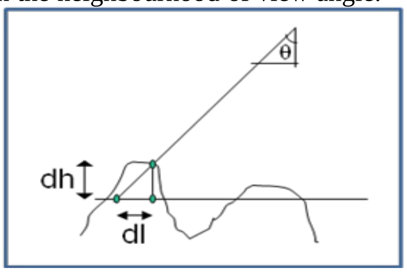

Fig.2. Planimetric error in mono configuration of image due to the error in the input height ($dl=dh \cdot \tan\theta$).

Thus, theoretically, a maximum of 290m error can occur in planimetry for Fore and Aft images due to an error of 600 m shift in height as it is observed between LDEM-16 and LDEM-256. Figures 3a, 3b and 3c shows the actual errors observed in mono adjustment of TMC cameras. 10 points are used as LCPs and orbit / attitude correction is done for all the three cameras. Errors are evaluated at 40 check points.

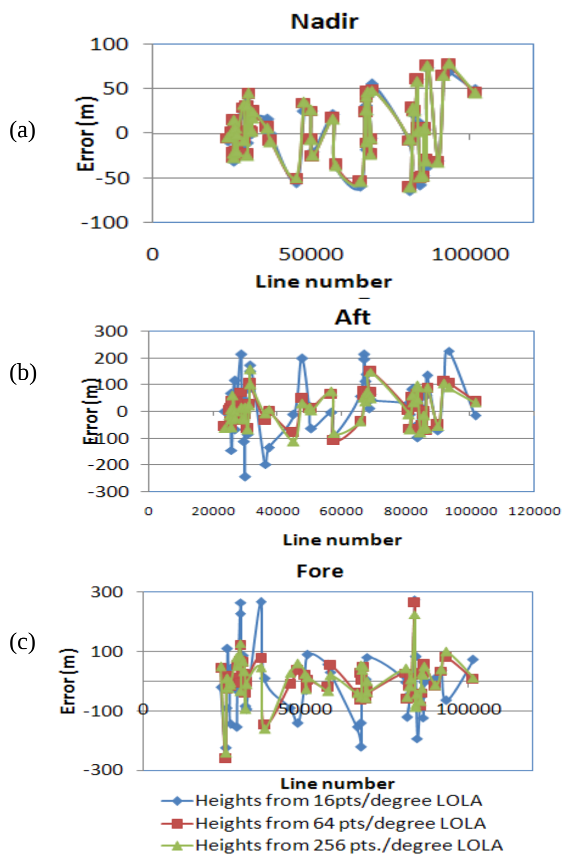

Fig.(3) Planimetric error for (a) Nadir, (b) Aft, (c) Fore in mono adjustment with heights taken from 3 LDEMs.

Geometric correction and mono adjustment evaluation is repeated 3 times with heights of points extracted from LDEM-16, LDEM-64 and LDEM-256. For Nadir camera (θ=0°) there is no effect of height variations between LDEMs, where as in case of Fore and Aft cameras a variation in error along latitude direction is observed. The magnitudes of errors for Nadir image are of the order of ±60m where as in case of Fore and Aft images they are of order of ±250m. Figure (4) shows the effect opposite view angles (±26°) of Fore and Aft camera on planimetric accuracies which causes a mirroring effect when heights used from LDEM-16. A similar effect is not seen when LDEM-256 is used indicating that accuracy of LDEM-256 is sufficient for processing of TMC images.

As planimetric controls for processing TMC images are derived from UVVIS-Clementine ortho which is of 100m resolution, it is better to use 118m(close to100m) resolution LDEM-256 as height control. From our study we observe that height errors in LDEM-256 is minimum compared to LDEM-16 and LDEM-64. Usage of LDEM-256 overcomes the difficulties of handling multiple tiles, huge data sizes and mosaicking issues when LDEM-1024 is used.

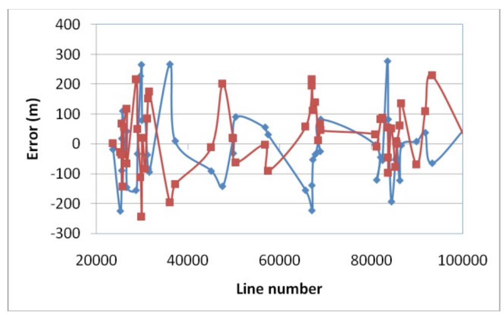

Fig. (4) Effect of opposite view angles (±26°) on planimetric accuracy.

References: [1] Kiran Kumar, A.S. et.al. (2009), Current Science, Vol.96, NO.4,25,492-495.

[2] Smith et.al, Initial observations from the Lunar Orbiter Laser Altimeter (LOLA), Geophysical Research Letters, VOL. 37, L18204, 2010.

[3]P.V.Radhadevi, V. Nagasubramanian, S.S.-Solanki, Krishna Sumanth T, J. Saibaba and Geeta Varadan, Rigorous Photogrammetric processing of Chandrayaan-1 Terrain Mapping Camera (TMC) images for Lunar Topographic Mapping. 42nd LPSC Conference, P.No. 1384, 2011.