Detecting the effect of Chandrayaan-3 Lander Engine Plume on Lunar Surface dust using Lander Imager, OHRC and NavCam images

Amitabh, K Suresh, Kannan V Iyer, Ajay K Prashar, Shweta Verma and Abdullah Suhail A Z
Signal and Image Processing Area, Space Applications Centre (ISRO), Ahmedabad-380015 (India);
amitabh@sac.isro.gov.in

Introduction: Chandryaan-3 Lander Vikram landed on lunar southern hemisphere at Shiv Shakti point (Lat.:69.373 S, Long.: 31.319 E) between Manzinus-U and Boguslawsky-M craters on 23rd August 2023. Lunar dust is one of the important indicator about the environment of lunar surface. Lander Imager (LI) on board Vikram lander was operated during the entire period of landing from Power descent phase to touch down and total 835 images was captured and transmitted to earth in near real time mode during the entire trajectory [1]. During the landing, all the 04 engines of Chandrayaan-3 was started firing at an altitude of nearly 30km for deceleration and worked till first hovering of Lander at 800m altitude. From 800m only 02 diagonal engines were kept on and these engines worked till touchdown to the surface. Once one of the four sensors situated in lander footpad indicated the touchdown in combination with accelerometer reading as zero, the engines were shut down within 30ms.

As per the literature available from different global heritage lunar missions, the plume interacted with the lunar surface and dust reaches at various heights depending on the lander weight, engine thruster's power and the soil type of the area. The height of dust interacted with plume in previous missions are provided in table-1 [2].

Table-1: Initial height of Dust interacted with plume in different missions

Missions	A11	A12	A14	A 15	A 16	A17	CE 3
Height (m)	24	33	30	52	18.4 - 23.4	18	60

A* Apollo, CE (ChangE)

This paper describes the interaction between the engine plume and the lunar surface as well as movement and distribution of lunar dust on the basis of analysis of Chandrayaan-3 descent Lander Imager (LI) images and Chandrayaan-2 OHRC images of Landing site acquired before and after the landing.

Methodology and Results: Hot plume has been fired from the engine throughout the trajectory for deceleration process. All the lander imager images were analyzed for the plume dust interaction and it was found that the plume after reflecting from moon's surface seen first in frame number-834 which is partially covered while Frame-835 was nearly fully covered by plume. Figure-1 shows the image frames of LI camera used for finding the plume.

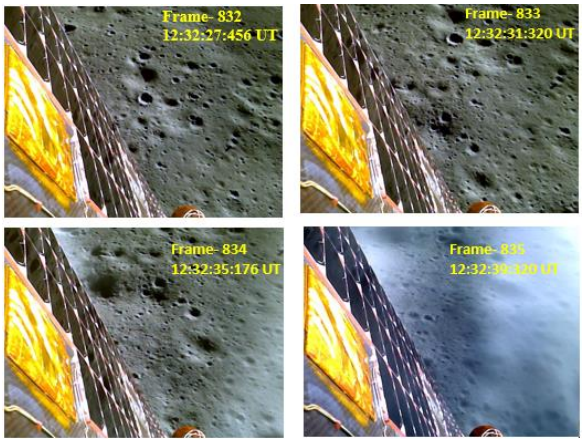

Figure-1: Details of LI Images used for Plume-Dust interaction analysis

Table-2: Observed Plume Status in LI Images

Frame No.	Time (UTC)	Altitude (m)	Plume Status
832	12:32:27:456	**17.9**	Absent
833	12:32:31:320	**12.9**	Absent
834	12:32:35:176	**8.7**	Present
835	12:32:39:320	**4.6**	Present

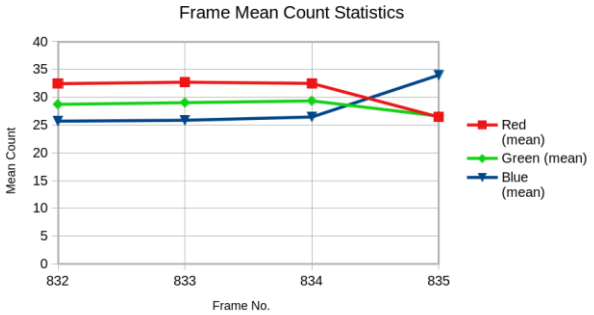

Figure-2: Plot of Mean count in different bands over solar panel

From Table-2 it was observed that the Plume appeared first in the LI Frame no. 834 which is acquired from an altitude of 8.7m from the lunar surface. The LI images are multispectral Bayer patter images and all the channels (Red, Green and Blue bands) are analysed for detection of plume and dust on the solar panels which is static in all the frames.

It was found that the mean count in Blue channel is quite high in Frame No.835 wrto other frames which suggest that the plume has reached to the solar panels as shown in figure-2.

Degree and Extent of plume: In order to study the degree and extent of the plume's effect on objects on the lunar surface, we analyze images captured before and after the landing from the series of images taken by Lander Imager in conjunction with OHRC images. The OHRC images were obtained before landing on 23rd Aug. 2023 (8:58:36.29 UTC) and after landing (14:50:47.58 UTC) on the same day. OHRC camera of Chandrayaan-2 obtained very high resolution images at 26cm (Figure-2). The time interval between the images is nearly 6 Hrs. The sun angle and elevation variation between the two images are very less or nearly similar and this can be seen by the contrast, brightness and shadows in the two images. The lander location is clearly seen in post landing Image (figure-2). The Image (brightness) difference shown in figure-3 and 4 clearly illustrate the change in texture around the Lander. Figure-5 shows the 3D (anaglyph) generated from Rover Nav Camera of the landing area with lander.

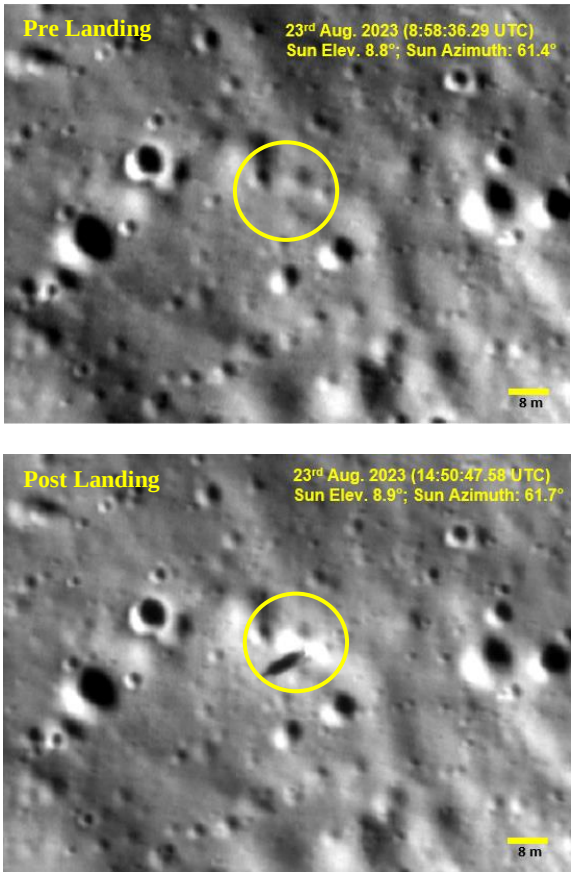

Figure-2 OHRC Images acquired before (Pre) and After (post) Landing on 23 Aug.2023

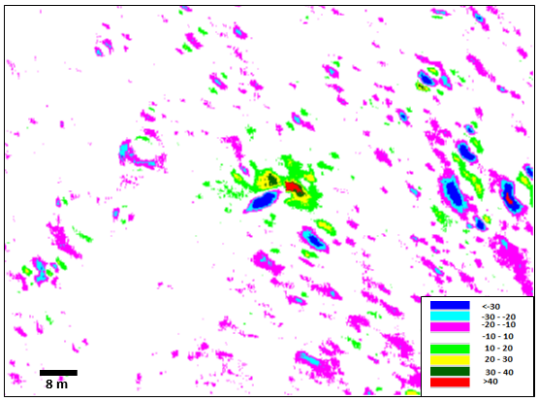

Figure-3: Difference Color Image (Post Landing – Pre Landing Image)

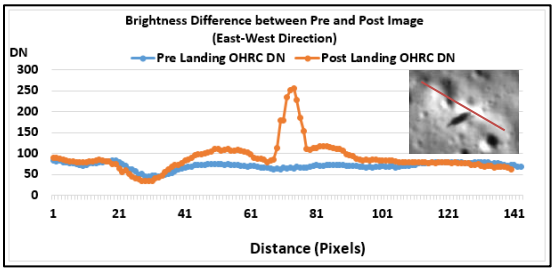

Figure-4: Pre and Post Brightness Profile of area near Landing Point

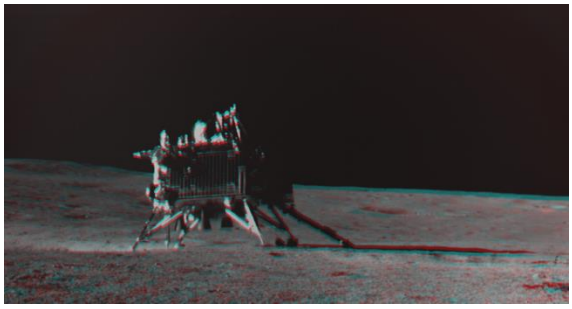

Figure-5: Anaglyph (3D) generated from NavCam

Conclusions: After analysis it has been observed that the plume interacted with lunar surface and reaches to the lander between a height of 8.7 to12m maximum which is the least reported by any other mission. The comparison of pre and post landing images show that the lunar dust blown by engine plume of Chandrayaan-3 lander is lesser than reported by earlier landing missions as 17m in west-east direction and 14m in north south direction with an effective area of 145 sq. meters. 3D measurements from NavCam Images onboard Rover also confirms the area affected by plume-dust interaction with an indicaton that the dust spread after landing was far lesser than the Apollo and ChangE-3 missions.

Acknowledgements: Authors express their sincere gratitude to Director-SAC, DD-SIPA/SAC and GD-PMPG/SAC for their guidance and support.

References: (1) Technical Note - Chandrayaan-3/DP/SAC/SIPA/PMPG/TN-01/October 2023 (2) Chun-Lai Li et.al, RAA 2014 Vol. 14 No. 12, 1514–1529 doi: 10.1088/1674–4527/14/12/002