Lunar Landing: A Numerical Perspective of its Damaging Effects on Surrounding Systems and Structures

Sanjeev Kumar Mishra[1*], K. Durga Prasad[1], Deepak Agarwal[2], Pranav Nath[2], Anil Bhardwaj[1]

1. Planetary Sciences Division, Physical Research Laboratory, Ahmedabad, India 380009

2. Liquid Propulsion System Center (ISRO), Valiamala, Thiruvananthapuram-695547

***Corresponding author:** Tel: +91 79 2631 4954 email: sanjeevm@prl.res.in

Abstract:

Soft landing on lunar surface has gained prominence in the recent past for many reasons; colonization and resource mining being one of them. Most of the future human activity on Moon, be it for development of base station, mining site or localized scientific investigations, will often require multiple landings in vicinity of one another. Since most of the modern day landers use thrusters as drivers to make soft landing, the jet plume produced by the exhaust of these thrusters creates disturbance on the lunar surface which subsequently leads to damage to the surrounding environment of the landing site. Since thrusters are going to be the means of control for most of the future landers, it is important to understand and quantify their damaging actions to the surroundings. In this work, we have used DSMC solver for analysis of plume dynamics and gaseous interactions of the plume and coupled it with the lunar regolith model consisting of particles with certain distribution of grain sizes. From the results of the DSMC solver, we have tried to quantify the ejecta profile such as eject velocity, mass flux rate etc. We have used those ejecta parameters to calculate the expected damage to a lunar outpost or hardware in its vicinity. We have calculated the total amount of damage at different stages of landing, damage profile, ejecta kinematics and overall volume of pit formed on the surface of surrounding hardware due to the high velocity ejecta particles. For most of these calculations, we take the case of India's Chandrayaan-2 lander and present a comprehensive picture of surface disturbance, ejecta profile and damage to the surrounding. The results of the study and inferences drawn based on them will be discussed.

Keywords: soil disturbance, surface modification, soft landing, hovering, jet plume, descent trajectory.