1.1 Project Scope

1.1.1 Project Description

The objective of this project is to design and implement a testing apparatus to study the effects of scaling on crater formation due to Plume Surface Interaction. While Stubbs et al. 2022 collected data on crater formation with a changing relative elevation, the effects of scaling the rocket nozzle on crater formation have not been studied extensively. With NASA and other private companies looking to conduct lunar missions in the future, understanding all the effects of a plume surface interaction (PSI) is vital to ensuring safe landings.

1.1.2 Key Goals

For this project to be considered successful, Team 518 should create a scalable and predictive experiment that shows the behavior of the PSI regarding crater formation. This project is focused on the research aspect of the issue, as studies have not collected data on the effect of scaling rocket nozzles on crater formation. Stubbs et al. 2022 provides a good starting point for the experiment, but the independent variable will be changed to collect new data. The data we collect will be related to the size of the craters and how they are affected by the change in nozzle size; with that data, scaling laws can be verified, and future experimental accuracy can be improved.

1.1.3 Assumptions

To be able to realistically achieve our goal of collecting relevant PSI data, several assumptions are made. First, it is assumed that a single nozzle will be tested at one time. While many landers have multiple rockets to assist with landing, Team 518 will focus on a baseline study to determine the effects of scaling on a single rocket. Second, it is assumed that using a knife edge to split the jet will be sufficient to model the cratering effects of the jet. This will

allow Team 518 to collect crater depth and width data as a function of time without the need for complicated and somewhat restricted stereo-photogrammetry or LIDAR techniques. . Third, Team 518 assumes that the testing will be conducted at room temperature and atmospheric pressure. Although PSI effects at lower pressures are relevant, they are unrealistic to achieve within the laboratories that the FSU-FAMU College of Engineering has. Fourth, it is assumed that an air jet will be an accurate model of the physics of crater formation. The exhausts from actual landers are at much higher temperatures due to the propulsion systems they use, but similar velocities can be obtained with air jets without compromising the validity of the experiment.

1.1.4 Stakeholders

As Team 518 begins to work on developing our project, the project stakeholders, consisting of NASA-MSFC & Jacobs Space Exploration Group, Dr. McConomy, Dr. Nair, Dr. Kumar and experimental principal investigators (PIs), the members of Team 518, and members of the Human Lander System (HLS) will be kept in mind. The project sponsors (NASA-MSFC & Jacobs Space Exploration Group) are interested in the data that our study will produce and its effects on future research into PSI. Dr. McConomy and Dr. Nair are serving as the team's mentors and help to guide the team. Dr. Kumar and the other experimental PIs will be assisting the team with experimental logistics in the laboratory. The members of Team 518 are controlling the direction of the project and will design and execute the study. Members of the HLS (Human Lander System) will also be interested in the resulting data, as a greater understanding of PSI increases the success of extraterrestrial landings.

1.1.5 Markets

Along with the stakeholders, this project's primary market is NASA, the project sponsor, as the research that will be carried out over the next two semesters will help to further NASA's goals of designing better landers by considering the effects of crater formation due to PSI. Secondary markets include private companies who have the goal of landing on other celestial bodies with little to no atmosphere, possibly including SpaceX, ispace, Blue Origin, and Boeing Space, Defense & Security, who would benefit from having this preliminary data to guide future studies.

Sources:

Stubbs, D. "Three-Dimensional Measurement of the Crater Formation During Plume–Surface Interactions Using Stereo-Photogrammetry," *AIAA Journal*, Vol. 60, No. 3, March 2022. https://doi.org/10.2514/1.J060835