# Plume Surface Interaction: Scale-Up Study

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## Objective

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.

## Goals

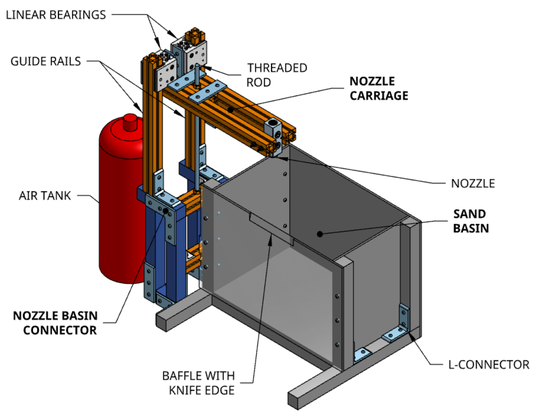
- Design Testing Apparatus
- Measure the effect of the nozzle diameter on the crater geometry
- Analyze the data to find a correlation between scaling and crater geometry

## Background

Plume Surface Interaction (PSI) is a field of study focused on the effects of rocket plumes on extraterrestrial surfaces. NASA and members of the Human Lander System (HLS) have already characterized many different facets of PSI, but how crater formation is affected by nozzle size has not yet been studied. Team 518's project focuses on studying the effects of variable nozzle sizes on crater formation to aid in the refinement of advanced PSI numerical models.

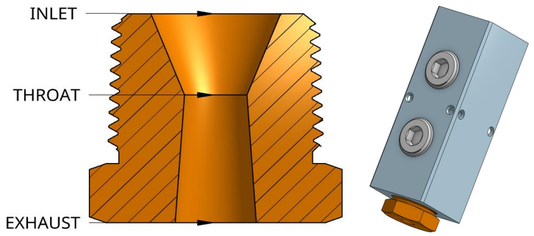
## Experimental Rig

The team designed an apparatus with a clear knife-edge baffle to split the jet flow. The nozzle carriage includes a threaded rod and linear bearings for height adjustment. Images of the resulting half-crater will be used to measure depth and width. Below is the CAD model of the rig used for testing.



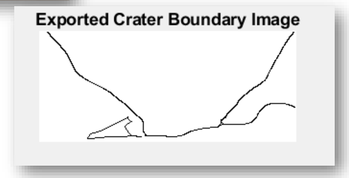

## Nozzles

A Converging-Diverging nozzle is required for supersonic flow. The team designed nozzles with exit diameters of 0.5, 0.78, and 1 cm. Initial trials will ensure constant mass flow rate and the nozzle's throat-exhaust area ratio ensures constant exit speed. Below is the CAD of the nozzle and the nozzle installed in the manifold.




## Data Processing

During the experiment, the camera captures a slow-motion video to obtain the images of the crater. After testing and observing a valid crater profile, these images are processed through the image edge detector functions on MATLAB to determine a crater profile for each new nozzle, including measurements of the profile's depth and diameter. The team will establish scaling laws for how nozzle size impact craters along with an analysis of their results.




## Camera

The device used for the experiment is an iPhone 12 Pro that has a frame rate of 240 frames per second and will be mounted securely to minimize vibrations. A calibration board will be used to ensure accurate extraction of position data.

## Results and Future Work

Through our image processing, Team 518 was able to extract crater profiles and the time evolution of the craters. It was found that the width and depth of the craters grew as the nozzle size increased, but it was not a linear relation. More processing of the data and a few more experiments are required to quantify the effect that scaling the nozzle has. In the future, more tests would be run at larger and smaller nozzle sizes to expand this initial data set, as well as some tweaks to the rig to make it more consistent and robust.