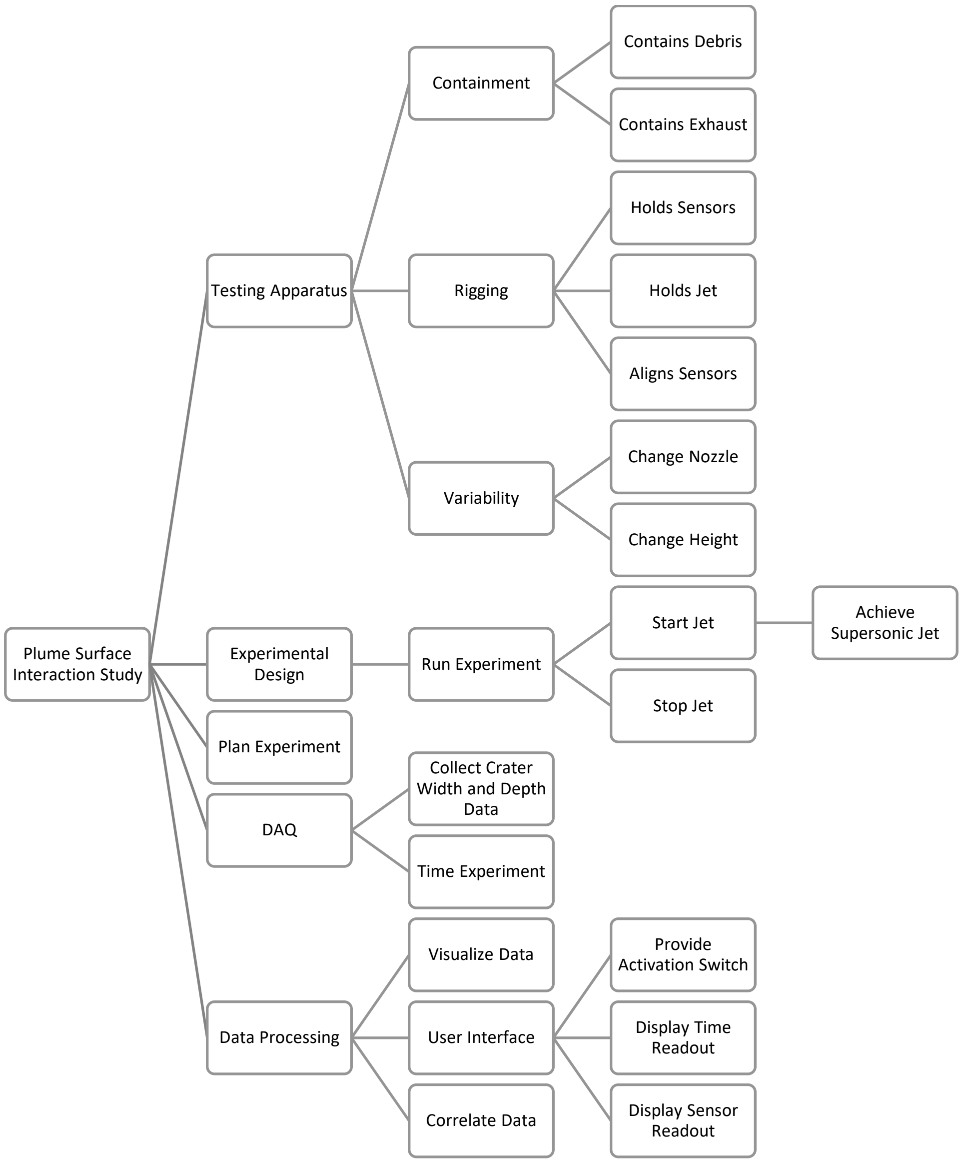
1.3 Functional Decomposition

Functional decomposition is a systems engineering approach to breaking down complex problems into systems and subsystems that can be then ordered and tackled more efficiently by design teams.

Although the deliverables of Team 518 differ slightly from the typical engineering design goals, the process of breaking down project needs into functional objectives remains mostly the same. The functions shown below were formed through discussions with the project sponsor and represent the main goals which need to be achieved for the project to be successful.

1.3.1 Functional Decomposition of PSI Study



The major functions and features of the study are the testing apparatus, the experimental design, and the data processing. These were determined by considering which aspects of the test would be necessary to ensure substantive results that upheld both the team's standard and the requests of the project sponsor. The subfunctions are a further breakdown of what is needed for the major functions to succeed. For the testing apparatus to perform, it must be able to maintain plenum conditions by containing debris and reducing the effect of exhaust on pressure. It also must be able to hold both the sensors and jet in a stable and repeatable position to ensure precise data. It also must be able to be adjustable to allow the dependent variable of jet size to be changed; in addition, the height must be adjustable to create the impingement characteristics requested by the sponsor. For the experimental design, it must be able to start and stop the tests reliably, to eliminate downtime and procedural error. The team must also plan the tests to gather enough data to see a statistically reliable trend. It must also feature a robust data acquisition system, which must be able to collect both the width and depth information from the crater, as well be able to time the test accurately. Finally, the study must involve data processing to be able to produce usable and understandable results. The test will feature a user interface which will include an accurate start/stop button, a sensor readout display, and a time display. These will allow for better control of the tests and a reduction in bad data. The team will also play a part in the data processing, by correlating the data and then visualizing it. This will turn the data into a usable and understandable form that will be presentable to the sponsor. All the functions and subfunctions are what will allow the PSI study to be successful.

1.3.2 Major Subsystems and Functions Cross-Reference Table

	Testing Apparatus	**Experimental Design**	**Data Processing**
Contains debris	x	x	
Achieve supersonic jet	x	x	
Holds sensors fixed	x	x	x
Holds jet fixed	x	x	x
Change nozzle	x	x	
Change height	x	x	
Start jet	x	x	x
Shut off jet	x	x	x
Plan experiment	x	x	x

Measure crater width and depth	x	x	x
Time the experiment	x	x	x
Visualize data			x
Correlate data			x
Provide activation switch	x	x	x
Display time readout		x	x
Display sensor readout		x	x

The above cross-reference table shows the relationships between functions and systems. Every function, except for visualizing data, affects the experimental design, as the experimental planning and acquisition of data are dependent on the other subsystems. The testing apparatus directly impacts the experimental design; similarly, the resulting data and user interface are also crucial for our experimental design. Focusing on the sensing part of the project: the testing apparatus and sensor placement are a component; experimental design and the method of collecting sensor data is another component; and the data processing of the sensor data is the final component. Many parts of this project will need to be done in tandem and require multiple functions to be completed before a wholistic view of a subsystem can be realized.

1.3.3 Smart Integration

As discussed above, the integration of each system and function is very important to be able to collect accurate and reliable data. The table below ranks each function based on its potential for interconnectivity between subsystems, also referred to as smart integration. The functions are ranked from 1 to 10, with 10 being the most potential for smart integration and 1 being the least.

Function	**Ranking (out of 10)**		**Function**	**Ranking (out of 10)**
Contains debris	6		Plan experiment	10
Achieve supersonic jet	10		Measure crater width and depth	10
Holds sensors fixed	9		Time the experiment	6
Holds jet fixed	9		Visualize data	1

Change nozzle	7		Correlate data	1
Change height	6		Provide activation switch	7
Start jet	8		Display time readout	6
Shut off jet	8		Display sensor readout	5

The functions that are rated 10 are the ones that are critical to the testing apparatus, experimental design, and data processing. The functions rated 9 are required for the most important functions to properly operate, and so on. The functions that are rated lower than a 5 are less important to multiple subsystems, but still important to the objective of the project. While "visualize data" is the least important in terms of smart integration, it is crucial to convey the findings of the project; without it, the collected data would have little meaning to someone unfamiliar with the experiment and important results would not be known.

1.3.4 Action and Outcome

To measure PSI the sponsor indicated to experiment varying the nozzle diameter of the plume and measure its crater formation. To achieve this, the experiment would take place in an impingement jet facility, specifically the Short Take-Off and Vertical Landing Jet Facility (STOVL) from Florida Center of Advanced Aero-Propulsion laboratory. The setup consists of the actions described in the next paragraph.

The jet nozzle will be placed vertically above regolith with a constant Height from the platform/Nozzle Diameter ratio, where both height and diameter are recorded with values specific to the trial but a constant ratio for each trial. The jet exhaust would start and impact the surface forming a crater. At this point, the data is being recorded by measuring crater depth and width using distinct apparatuses. Subsequently, another trial would run with different values for the same ratio.

The outcome of the experiment is to know the impact of the plume on crater formation. This information will later be used by the sponsors for space travel in future lunar missions. This analysis obtained from the data will allow NASA to design the appropriate plume for the most optimal landing.

1.3.5 Connection to Systems

The project has three major systems, the testing apparatus, the experimental design, and the data processing. The major systems will determine the success of the project. Each system will be ranked on a scale of 1-10 based on priority. A ranking of 10 means that the system is critical for the project’s success and a ranking of 1 means that the system is not critical for the project's success.

The testing apparatus system is necessary to properly simulate PSI and control variables, so results are useful. This is possible through the system's basic functions which contain debris, hold the jet and sensors, and control the variability of the experiment such as the nozzle and jet height. The stability of the testing apparatus, particularly the parts that acquire data, and control over testing variables are important for maintaining the purity of the experiment. This system receives a priority ranking of 10 because without this system, the results would be useless which is critical for project success.

The experimental design system is necessary to acquire data and run the experiment itself. This is possible through the system’s basic functions which are to start and stop the jet, time the experiment, and collect data on crater width and depth. This system and its functions are important to control the experiment which is necessary for obtaining results. This system receives a priority ranking of 10 because without the system, starting the experiment would not be possible and neither would obtaining results.

The data processing system is necessary to provide data for interpretation. This is possible through the system’s basic functions including providing an activation switch and displaying time and sensor output. Providing sensor output is important because it allows those running the experiment to view and interpret results. This system receives a priority ranking of 8 because it is critical for interpreting data but not as important as obtaining the data itself.

Considering these system rankings, a ranking for each function was made from an overall objective perspective, with weighting applied (10 => 1, 1 = > 0.1) to get a more accurate representation of the importance of each function. The first number represents the function rating within the system, and the second number is the weighting from the system rating.

Function	Ranking (out of 10)	Function	Ranking (out of 10)
Contains debris	4*1= **4**	Plan experiment	10*1= **10**
Achieve supersonic jet	10*1= **10**	Measure crater width and depth	10*1= **10**
Holds sensors fixed	9*1= **9**	Time the experiment	10*1= **10**
Holds jet fixed	9*1= **9**	Visualize data	10*0.8= **8**
Change nozzle	8*1= **8**	Correlate data	10*0.8= **8**
Change height	7*1= **7**	Provide activation switch	5*0.8= **4**
Start jet	7*1= **7**	Display time readout	3*0.8= **2.4**
Shut off jet	7*1= **7**	Display sensor readout	3*0.8= **2.4**

The major systems testing apparatus and experimental design received priority rankings of 10 and will therefore be the systems with the most time and resources allocated. The data processing system will be cared for but only after the other major systems based on priority ranking; it is recognized, however, that without data processing, the results would not be understandable. This will require more importance being shifted to the data processing once the testing apparatus and experimental design are in a good state.