FAMU-FSU College of Engineering

Plume Surface Interaction Scale Up Study

Team 518

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Sponsors

NASA

Jacobs
Space Exploration Group

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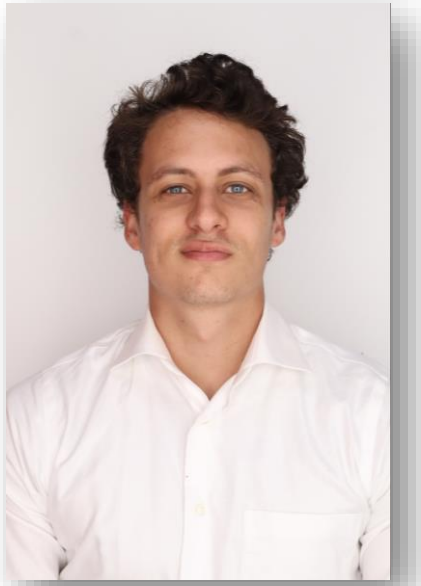
Team Members



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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.

VDR 1

Project Brief

- PSI Scale Up Study
- Crater Formation

Key Goals

- Testing Parameters
- Given Information by Sponsors

Costumer Needs

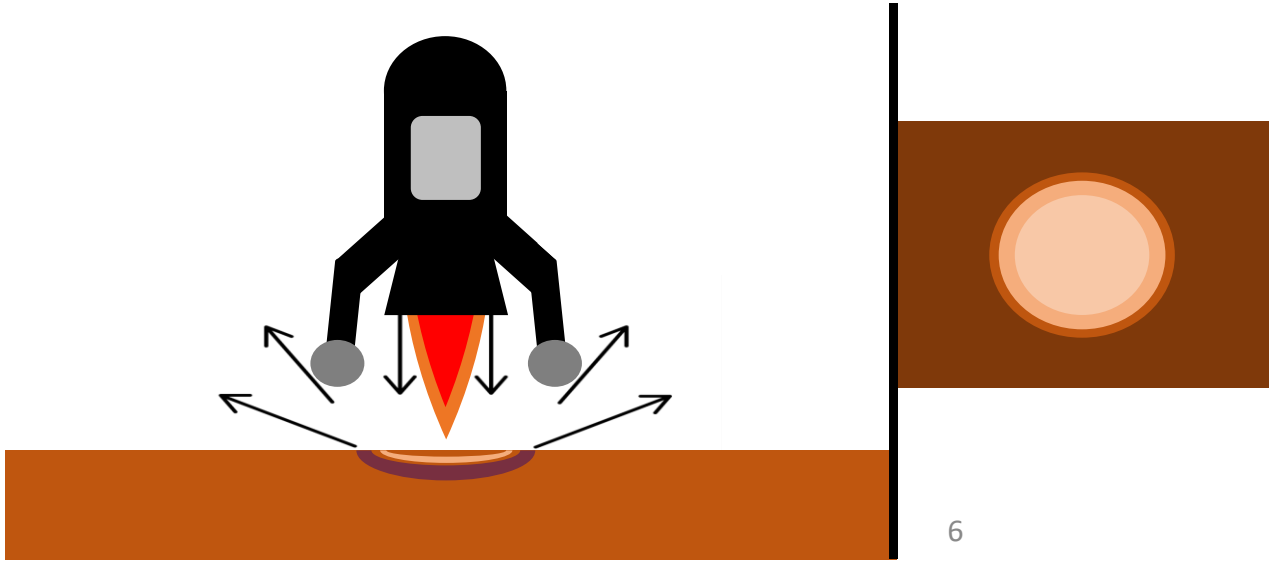
- Design of Supersonic Nozzle
- Data delivery of PSI

Markets

- Space Industries
- Academia

Functions

- Testing Apparatus
- Data Processing
- Experimental Design



Potential Experiment Locations

Outdoors

- Extended Space for Experiment
- Little to no Need for Accomodation
- Experiment Sensitive to Outdoor Conditions

Senior Design Lab

- Good Availabilty in Accomodation
- May provide limited space for experiment

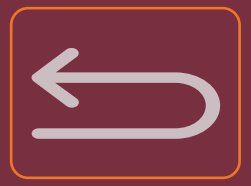
Room at AME/CoE

- Nearby Faculty
- Need Accomodation

Targets and Metrics

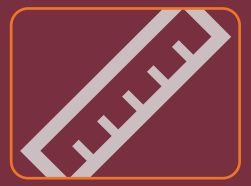
Exit Jet Speed

- Must reach Mach 2



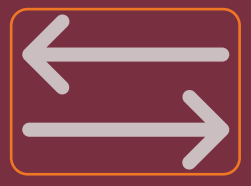
Enclosure Effect

- Minimize back pressure to 0 psi



Measure Crater width and depth

- Within 0.5% of total measurement



Correlate Data

- Create scaling laws that are accurate to 5%

Concept Generation

100 Concepts

Medium Fidelity

High Fidelity

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Medium Fidelity

Steel nozzle, steel frame, PIV DAQ, air tank provides gas, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

Steel nozzle, steel frame, Schlieren based DAQ, a can of compressed air provides gas, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

Aluminum nozzle, aluminum frame, Schlieren based DAQ, air tank provides gas, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

PLA nozzle, plexiglass frame, PIV based DAQ, a compressor provides gas, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

Construct the enclosure out of wood and baseboard. Set up the jet testing with interchangeable 3D printed nozzles. Track the measurements with stereophotography.

High Fidelity

PLA nozzle, aluminum frame, PIV based DAQ, a compressor provides gas, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

PLA nozzle, wood frame, Lidar based DAQ, a compressor provides air, a vacuum removes excess regolith, Matlab is used to analyze the data, and air is the type of gas used.

Use clear baffles with a knife edge to separate the flow from the jet. Take images of the half-crater formed at a fixed distance to obtain crater depth and width measurements. The rest of the data can be extrapolated in some software.

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Concept Selection Tools

- Binary Pairwise Comparison
- House of Quality
- Pugh Charts
- Analytical Hierarchy Process

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Binary Pairwise Comparison

Customer Need	Score
Sand between 70 and 100 microns	1
Maintains atmospheric properties	1
Multiple Nozzle Sizes	4
Depth, area, and profile measurements of crater	6
Data Analysis	4
Nozzle must achieve supersonic speeds	7
Sturdy Structure	1
Under-expanded Jet	4

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House of Quality

1. Velocity of Gas at Exit
2. Precision of Nozzle
3. Adjustable Nozzle Height
4. Holds Jet Steady
5. Pressure of Gass Supplied

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Pugh Charts

- Datum: Auburn Experimental Set-Up

Engineering Characteristics
Pressure of Gas Supplied
Holds Jet Steady
Velocity of Gas ant Nozzle Exit
Adjustable of Nozzle Height
Precision of Nozzle

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Analytical Hierarchy Process

Engineering Characteristics
Pressure of Gas Supplied
Holds Jet Steady
Velocity of Gas ant Nozzle Exit
Adjustable of Nozzle Height
Precision of Nozzle

Weighted Sum Vector {Ws}=[C]{W}	Criteria Weights {W}	Consistency Vector {Cons}={Ws}./{W}
0.337	0.066	5.10
1.751	0.335	5.23
0.308	0.061	5.07
1.386	0.272	5.10
1.375	0.266	5.17

Average Consistency	Consistency Index	Consistency Ratio
5.13	0.033	0.029

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Final Selection

Concept #51

- **Use clear baffles with a knife edge to separate the flow from the jet. Take images of the half-crater formed at a fixed distance to obtain crater depth and width measurements. The rest of the data can be extrapolated in some**

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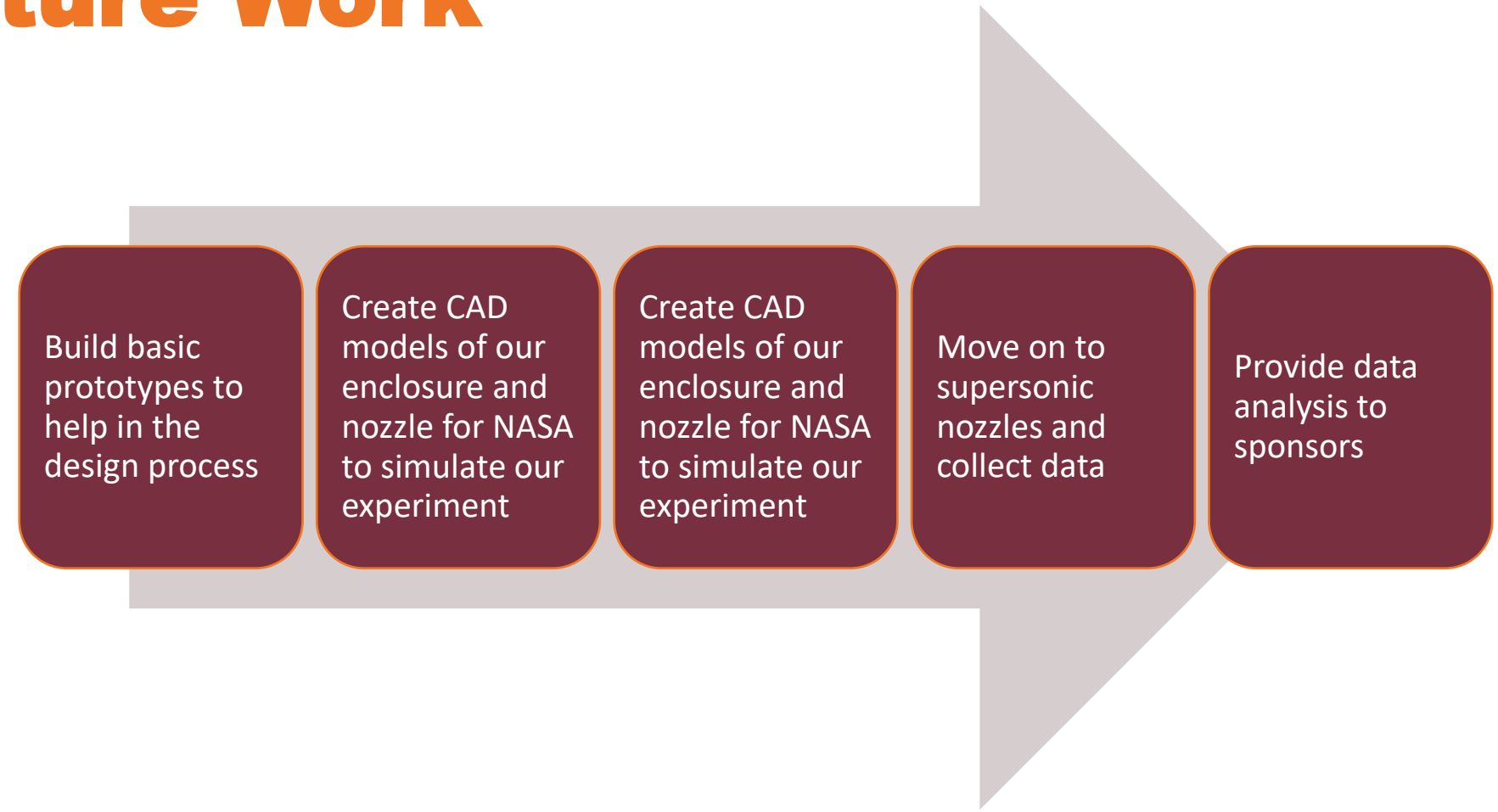
Future Work



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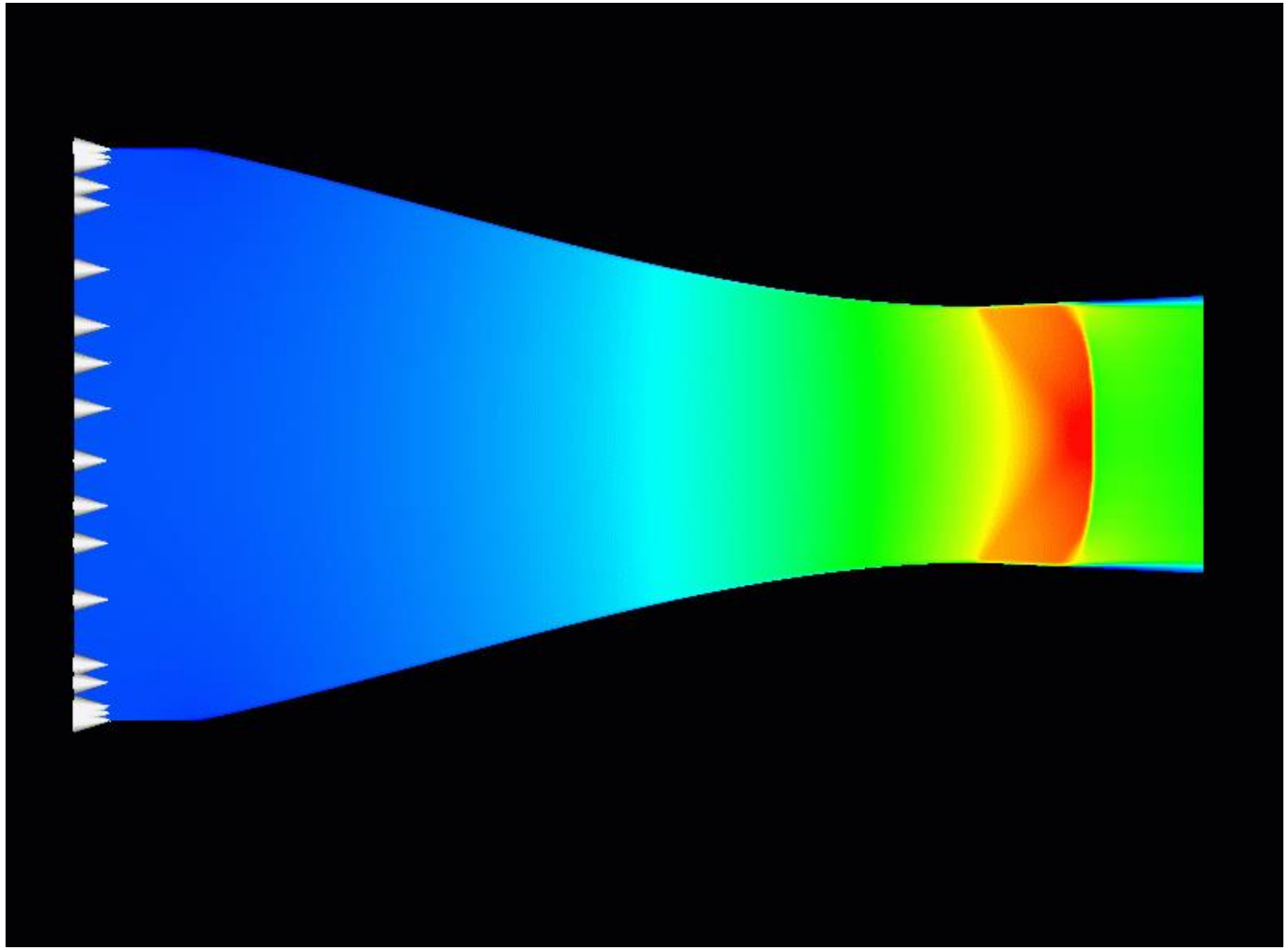
Thank You!



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