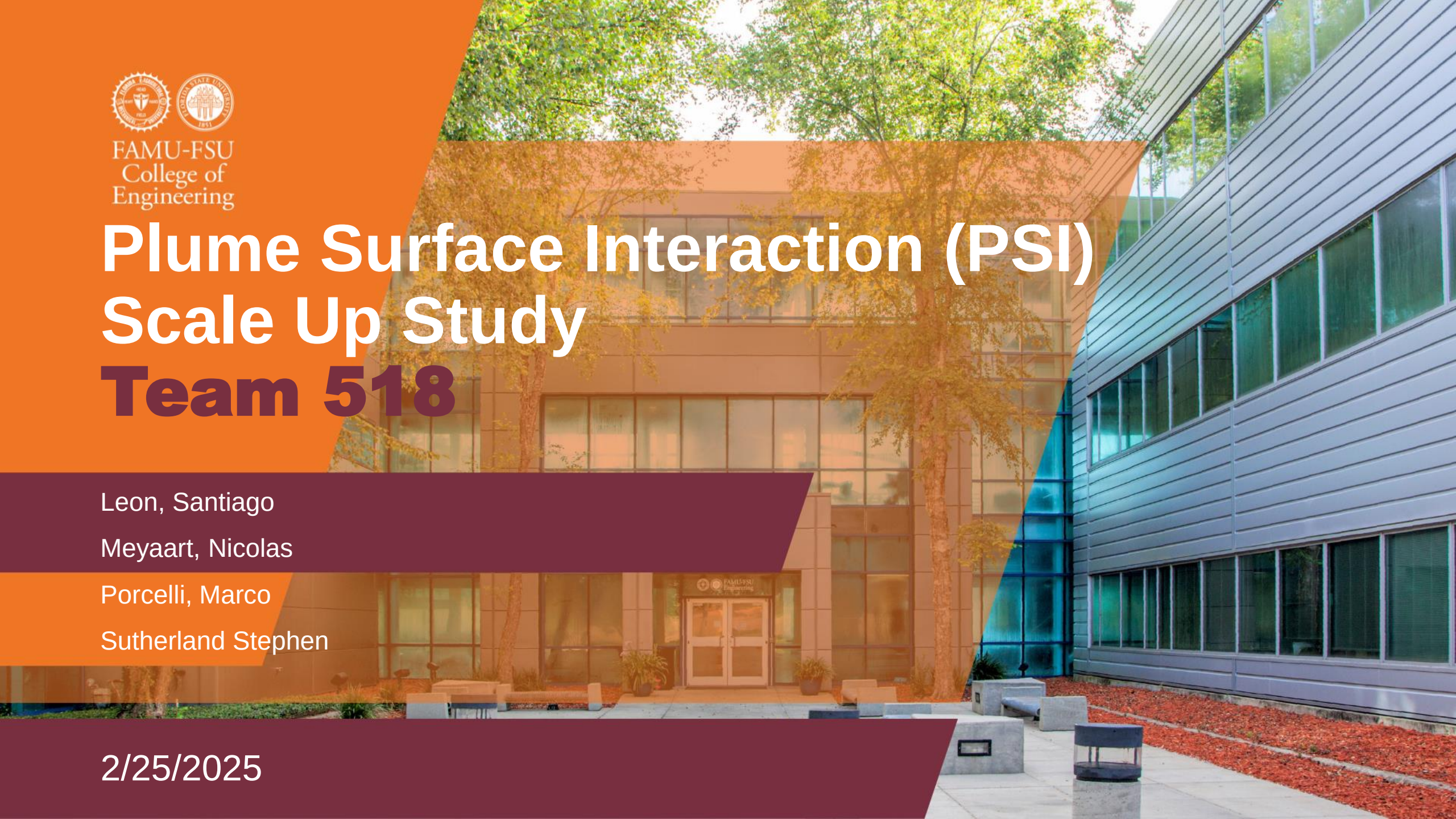

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# Plume Surface Interaction (PSI) Scale Up Study

## Team 518


Leon, Santiago

Meyaart, Nicolas

Porcelli, Marco

Sutherland Stephen


2/25/2025

# Sponsors

Marvin Barnes

Dr. Manish Mehta

Dr. Robert Adams



Stephen Sutherland

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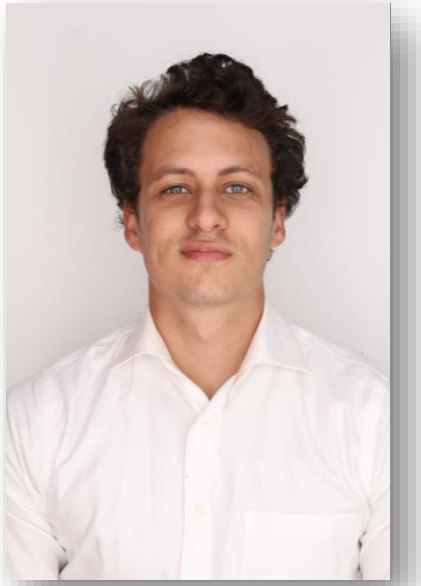
# Advisor

Dr. Unnikrishnan Nair

# Team Members



Santiago Leon

Nicolas Meyaart

Marco Porcelli

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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.



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# Project Scope

**Project Brief**

- PSI Scale Up Study
- Crater Formation

**Key Goals**

- Testing Parameters
- Verifying Scaling Laws

**Costumer Needs**

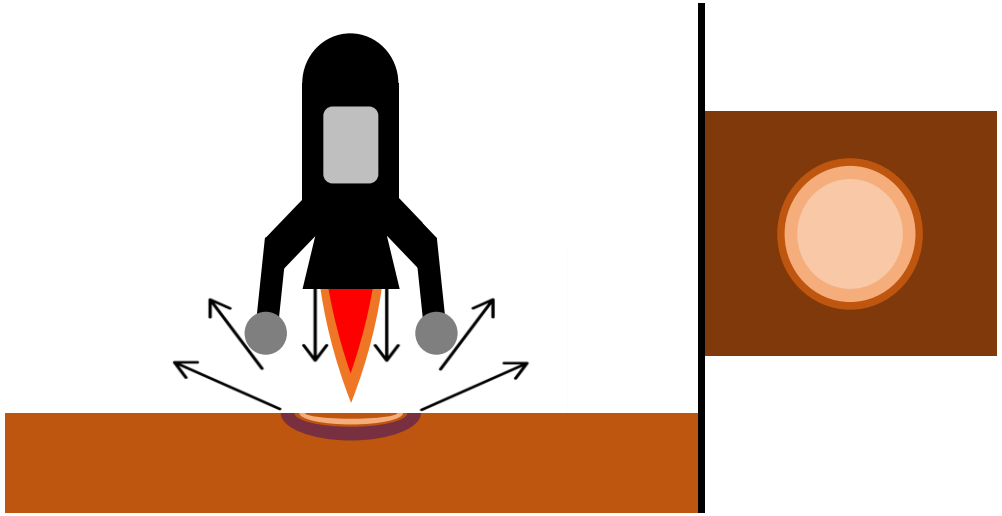
- Design of Supersonic Nozzle
- Depth and Diameter Measurements of Crater
- Constant Area Ratios
- Fixed Atmospheric Conditions
- Fixed h/d ratio

**Markets**

- Space Industries
- Academia

**Functions**

- Testing Apparatus
- Data Processing
- Experimental Design





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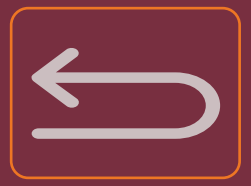
# Targets and Metrics

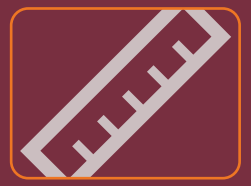
## Exit Jet Speed

- Must reach Mach 2



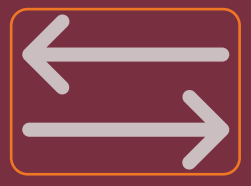
## Enclosure Effect

- 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%



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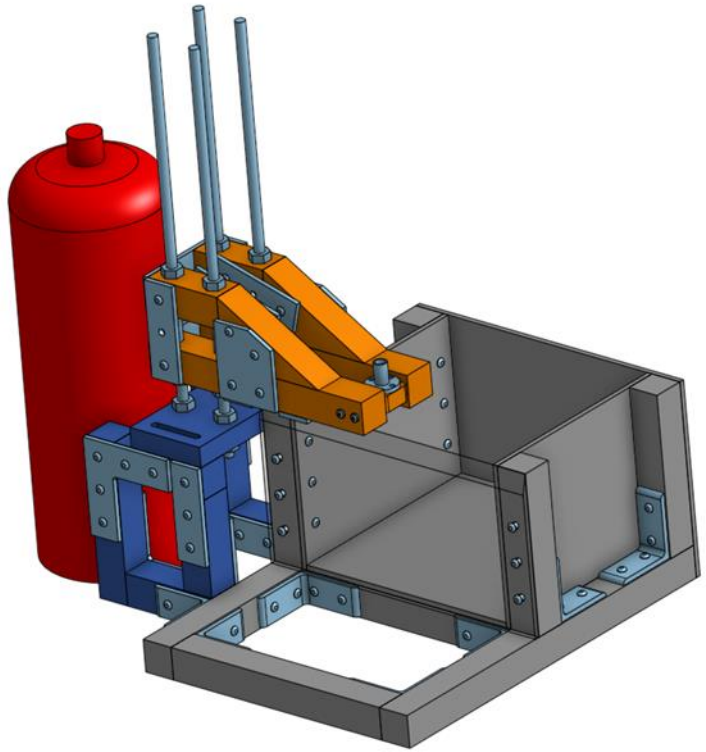
# Final Selection

## 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.**





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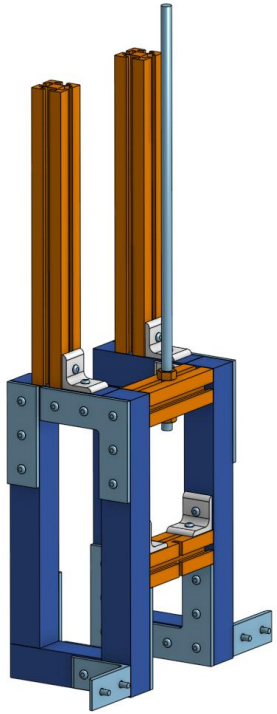
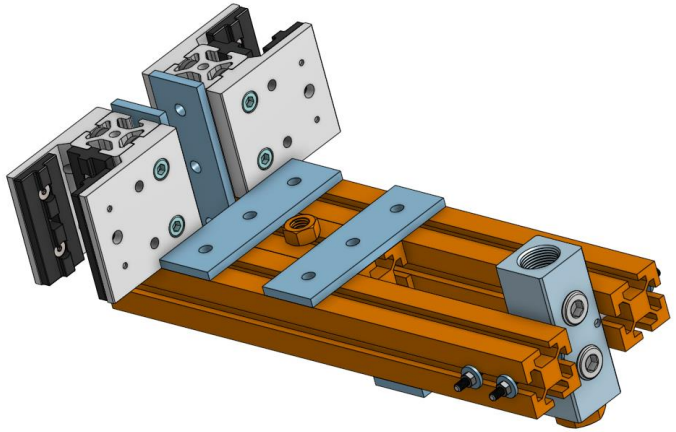
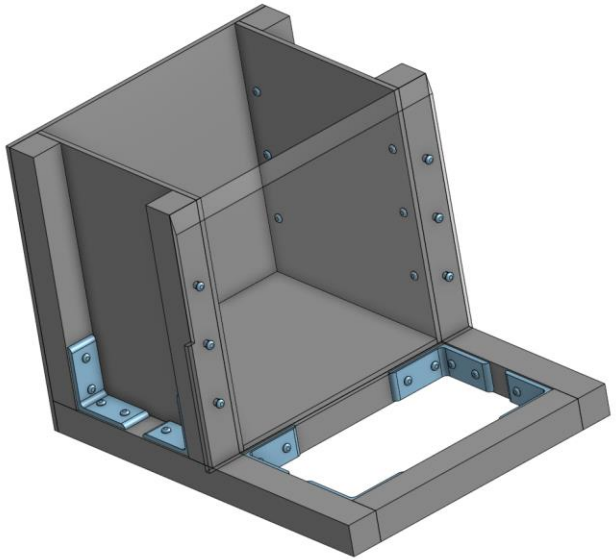
# Current CAD









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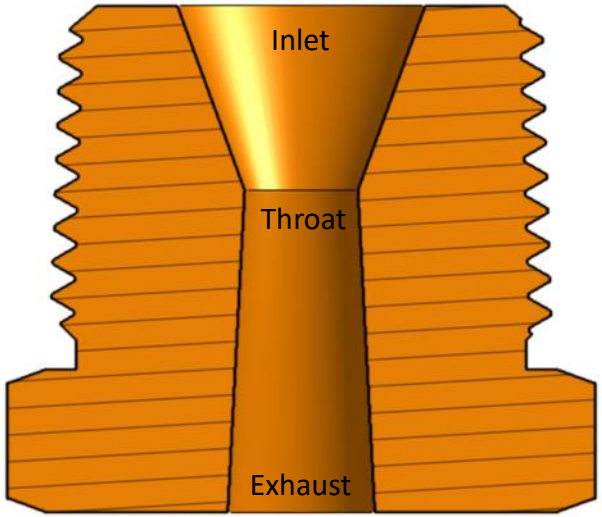
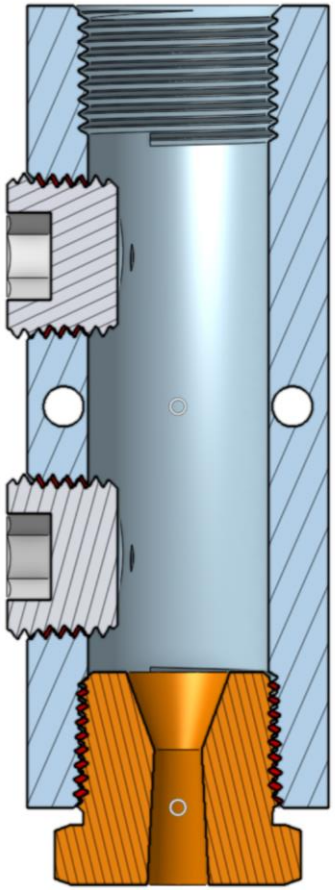
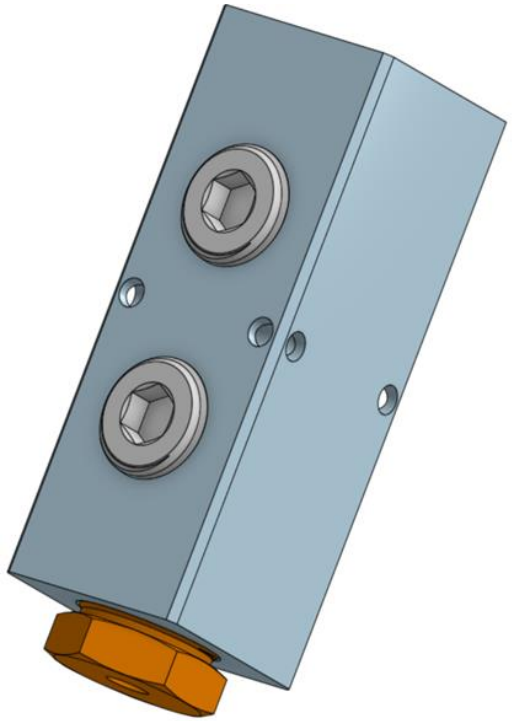
# Nozzle Design

Converging Diverging Nozzle
A/A* Ratio is 1.6875
Mach 2 Capabilities
Longer Divergence - prevents shocks

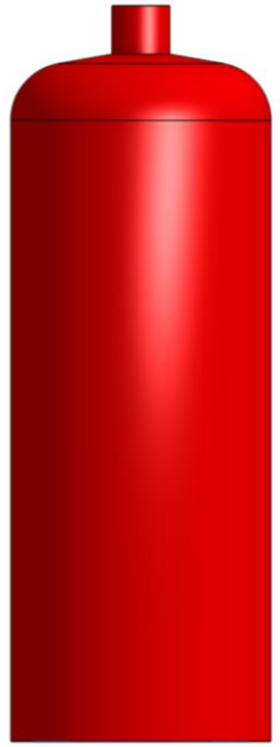




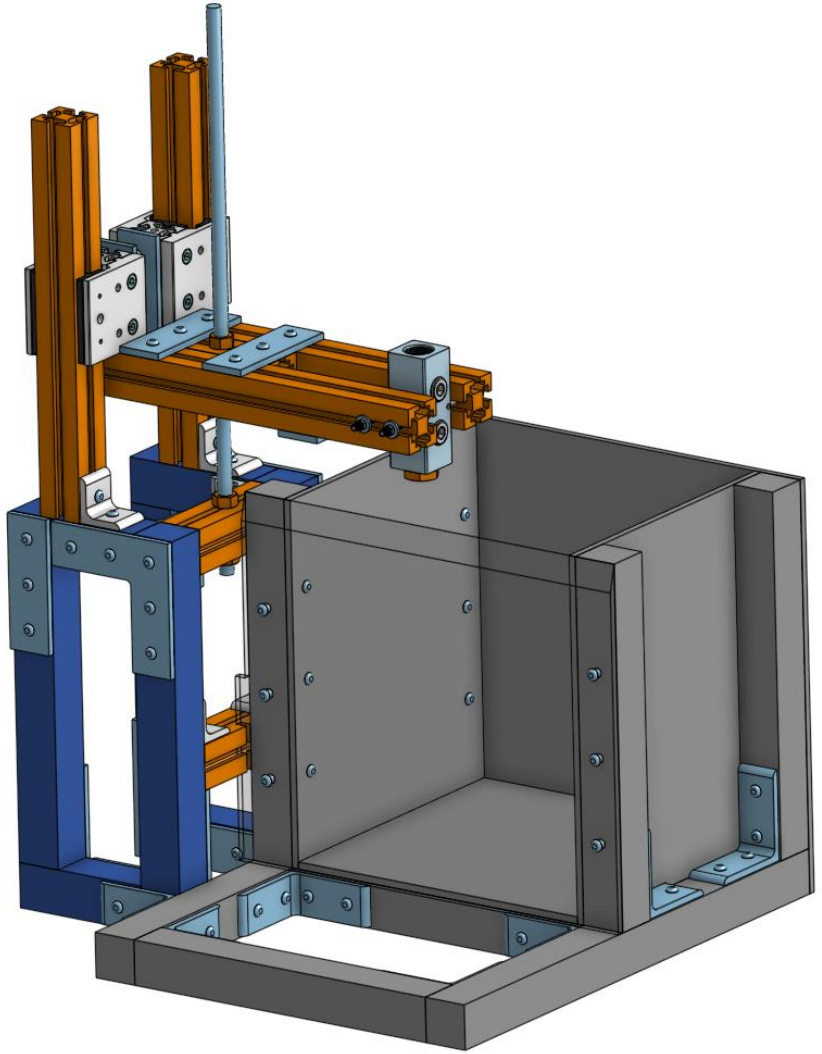
# Air Supply

- Air Supply
  - Carbon Steel 40 3AA2015
  - Holding at around 2200 psi
  - Regulator Attached set to 120 psi
- Tubing
- Pressure Guage attached to nozzle manifold to verify pressure



# Frame

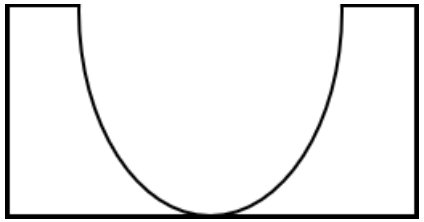
- Structure
  - 8020 Aluminum
- Walls
  - Plywood
  - Plexiglass



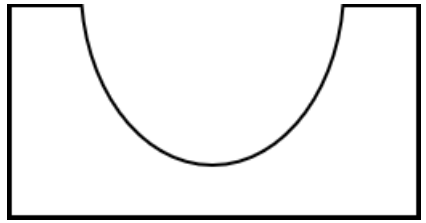
# Preliminary Testing

- Validate Targets and Metrics
- Determine sand depth
  - Test with Jonas Gustavsson in an open sand bed

Bad



Good



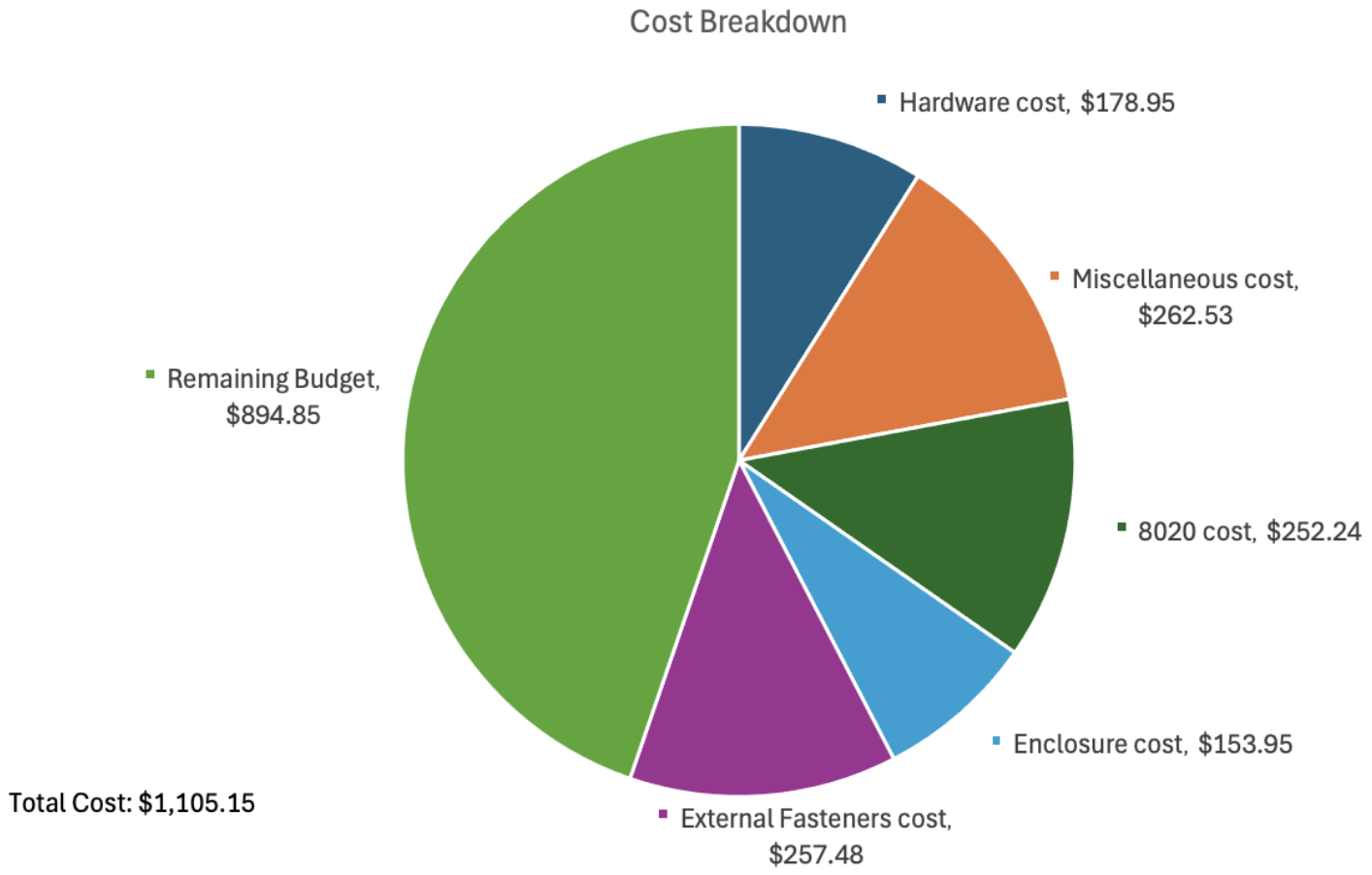
# Data Acquisition

- iPhone 12 Pro Camera
- Gimble to hold still
- Use MATLAB image processing to determine crater profile

# Bill of Materials

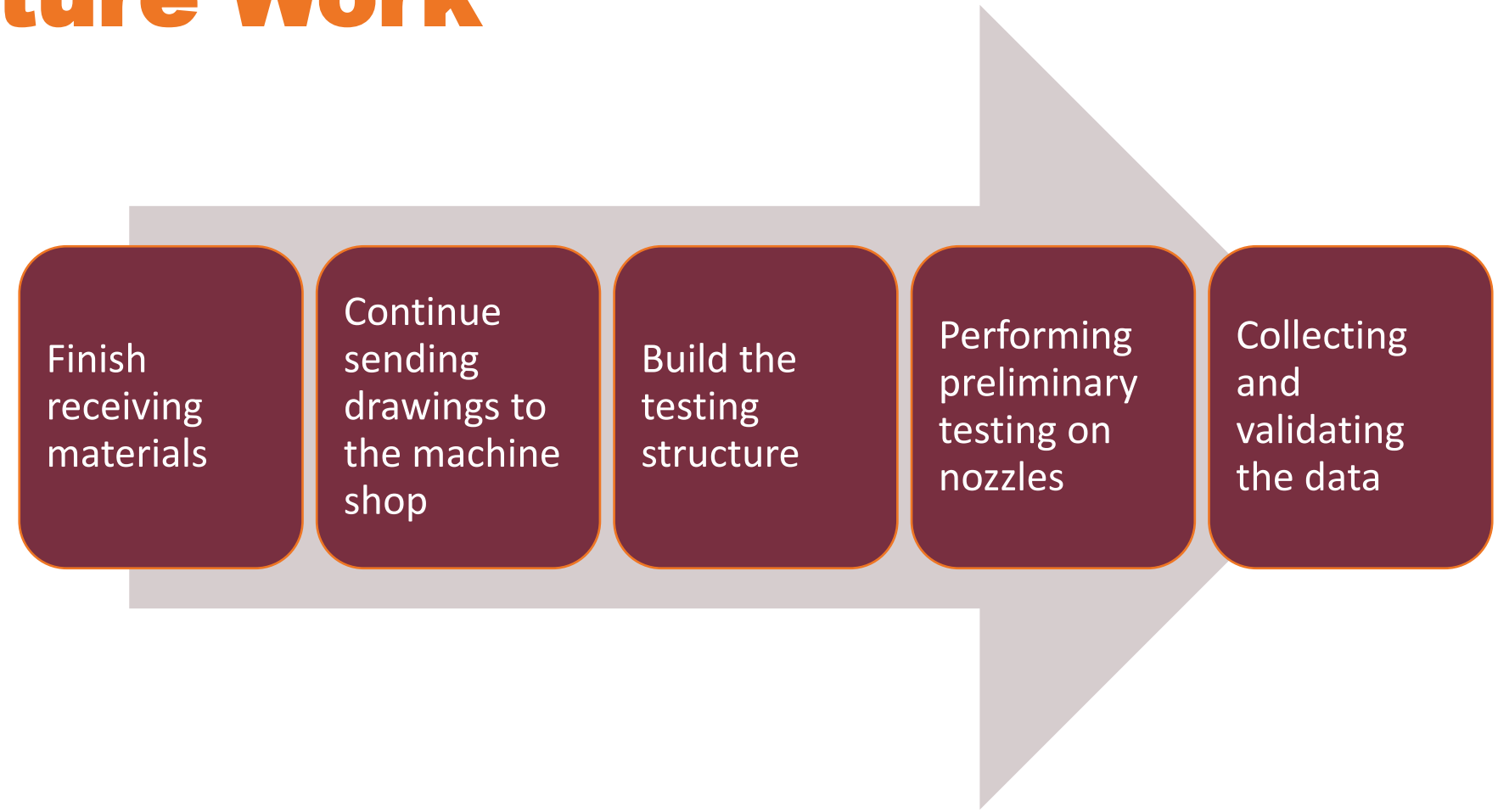
| Category | Description | Quantity | Cost | Order Status |
|---|---|---|---|---|
| External Fasteners | 40 Series 3 Hole Plate | 12 | $6.58 | |
| External Fasteners | 40 Series 4 Hole 30 Deg Plate | 2 | $8.95 | |
| External Fasteners | 40 Series 4 hole Bracket | 14 | $6.43 | |
| External Fasteners | 40 Series 4 Hole L Bracket | 4 | $10.90 | |
| External Fasteners | 40 Series 2 Hole Bracket | 6 | $4.50 | |
| Enclosure Materials | Acrylic Sheets (24x36", 1/4" thick) | 1 | $69.99 | |
| Enclosure Materials | Wooden Board (6ft x 24in, 3/4" thick) | 2 | $41.98 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 459mm | 4 | $14.54 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 499mm | 3 | $15.56 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 125mm | 4 | $5.99 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 359mm | 4 | $11.98 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 279mm | 2 | $9.93 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 500mm | 2 | $15.59 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 160mm | 2 | $6.89 | |
| 80/20 T-slotted Aluminum | 8020 T-slotted Aluminum 100mm | 2 | $5.35 | |
| Miscellaneous | 2in by 4in by 8ft | 1 | $3.65 | |
| Miscellaneous | Manifold | 1 | $53.31 | |
| Miscellaneous | Nozzle Plug | 3 | $21.93 | |
| Miscellaneous | Camera gimbal | 1 | | |
| Miscellaneous | Air Tank (Provided) | 1 | $0.00 | |
| Miscellaneous | 40 Series Linear Bearings | 2 | $69.89 | |
| Hardware | Manifold Plug | 2 | $3.01 | |
| Hardware | Pressure Gauge (3000 Psi) | 1 | | |
| Hardware | Connecting rod nut | 1 | $2.83 | |
| Hardware | Connecting rod washer | 1 | $6.85 | |
| Hardware | Connecting rods | 2 | $8.02 | |
| Hardware | Tubing | | | |
| Hardware | M6 x 16 mm screw (6 packs of 25, need 132) | 6 | $7.37 | |
| Hardware | Economy T nut | 132 | $0.42 | |
| Hardware | M5 x 50 mm screw | 4 | $6.01 | |
| Hardware | Nuts ( 1 pack of 25, need 16) | 1 | $8.62 | |
| Hardware | M12 x 1.75 mm Threaded Rods | 1 | $14.89 | |
| | | Total | $ 1,105.15 | |

# Budget

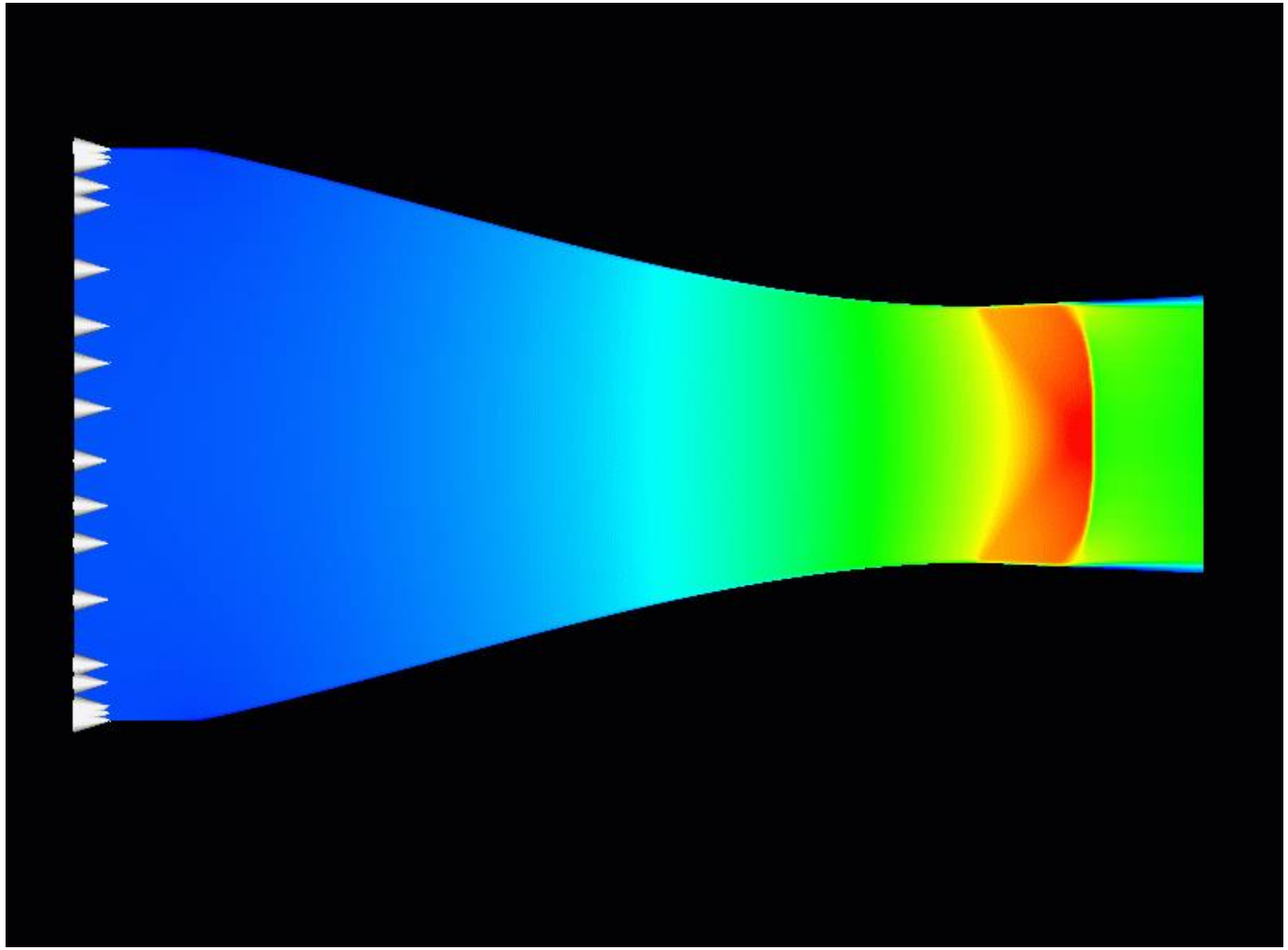



Total Cost: $1,105.15

# Future Work


Finish receiving materials
Continue sending drawings to the machine shop
Build the testing structure
Performing preliminary testing on nozzles
Collecting and validating the data

# Thank You!





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