TCNJ NASA HULC - HUMAN LANDER CHALLENGE

MITIGATION OF LUNAR PLUME-SURFACE INTERACTION

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Project Description/Scope

- **Overview of Problem**
  - PSI (Plume Surface Interaction) - The dust dispersal and erosion caused by the impingement of a rocket plume on regolith (unconsolidated rocky material over substrate or bedrock)
  - This poses significant risks to crew and existing surface infrastructure

Lan

- **TCNJ Adaptable Regolith Retention Platform**
  - Single-use, Deployable Landing Platform
- **Proposal Categories**
  - HLS Asset Safety (ejecta damage, excessive lander heating, etc.)
  - Reduction / Mitigation of Erosion and Ejecta during Descent, Landing, and Ascent

Figure 3.1: Lunar Landing Visual

Research and Proposed Solution

- Brainstorming Solutions (within TCNJ ability) to PSI problem
- Testing T.A.R.R.P. dust mitigation method
  - Creating a vacuum chamber
- Using scaled rocket to produce simulant plume
  - Utilize depth camera to characterize dust plume

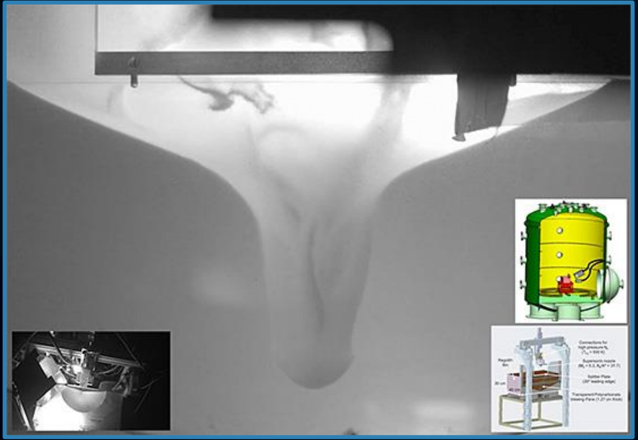


Fig 4.1*: NASA Run Vacuum Chamber PSI Test

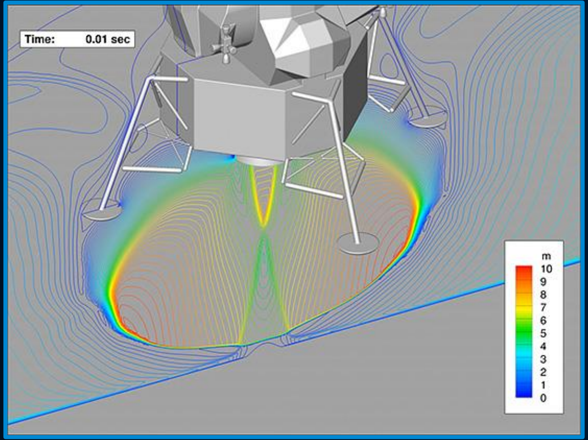


Fig 4.2*: NASA Run PSI 3D Simulation

*Images acquired from the research of Peter Liever and Jeff West at the NASA Marshall Space Flight Center

Initial Design Summary

- Single - Use Design
  - Consumable Landing Platform
  - Inherently Unsustainable
- Intended to Provide a Temporary Solution
  - CLPS and HLS systems can deliver mission critical assets to surface
  - Increase service life of surface assets
- Mechanically Simple
  - Redundancies ensure proper function in event of a single asset failure

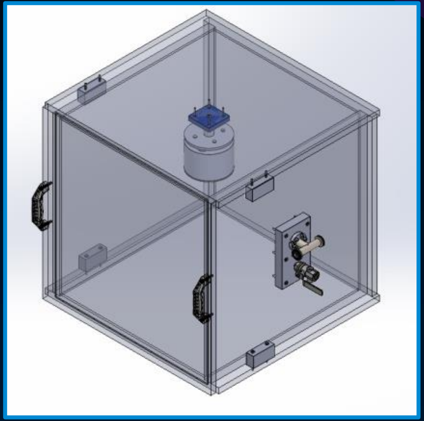


Fig 5.1: Vacuum Chamber Assembly

Fig 5.2: TAARP Animation

The T.A.R.R.P

T.A.R.R.P. Concept

- Top Surface
  - Graphite Foil and Carbon Felt
- Baseplate and Fins
  - Carbon Matrix Carbon Composite material
- Hollow Aluminum Rods
- 17.3 ft unfolded diameter
  - Dimensions based on Apollo lander without landing gear

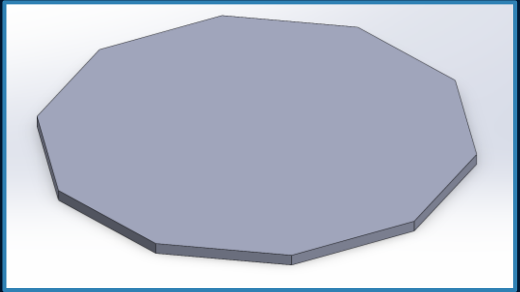


Fig 7.1: Decagonal Base Platform

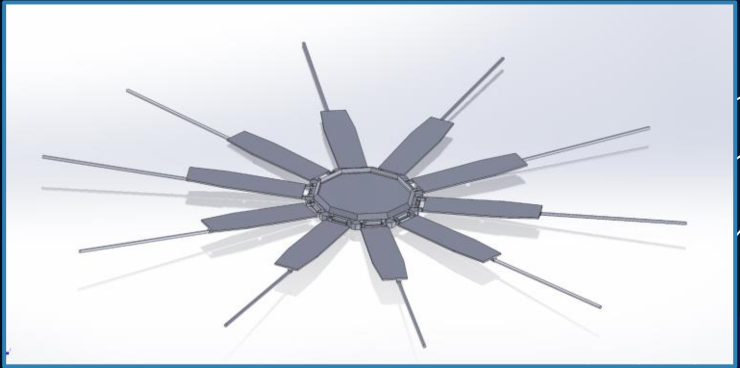


Fig 7.2: Fully Expanded TAARP

T.A.R.R.P. Deployment

- Torsional springs stored in compression released upon a controller signal
- Designed so when one fin falls, the remaining fins fall in sequence
- Selection of springs would be dependent on the size of the descent vehicle

Fig 8.1: TAARP Deployment Animation

Fin Locking System

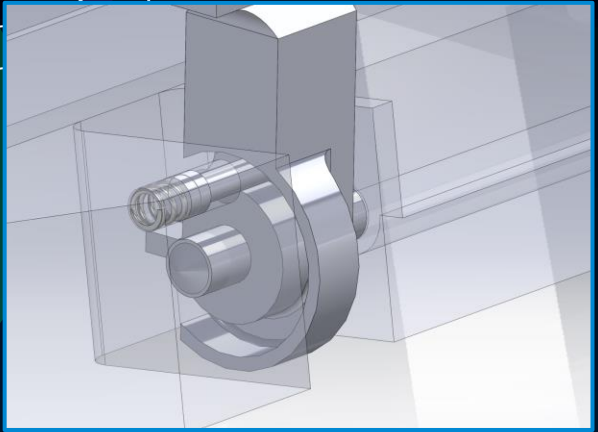


Fig 9.1: TARRP Unlocked Position

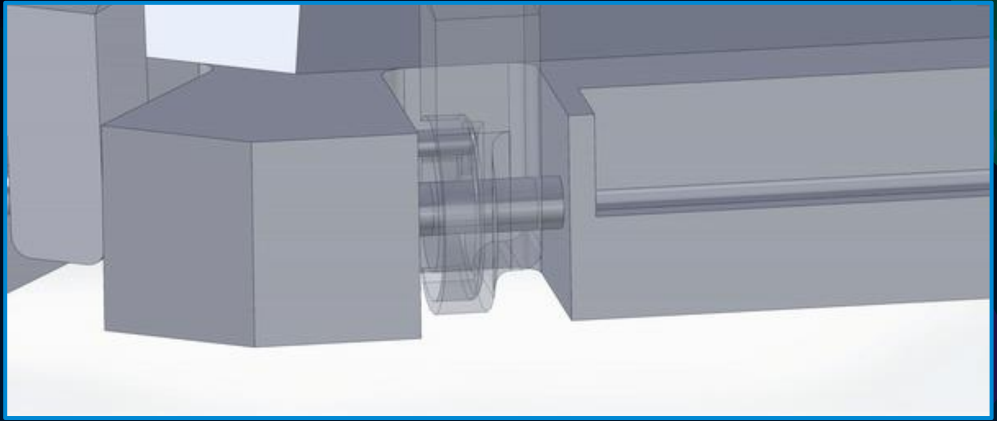


Fig 9.3: Locking System Animation

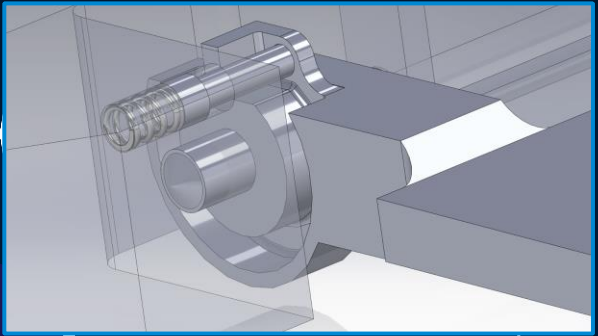
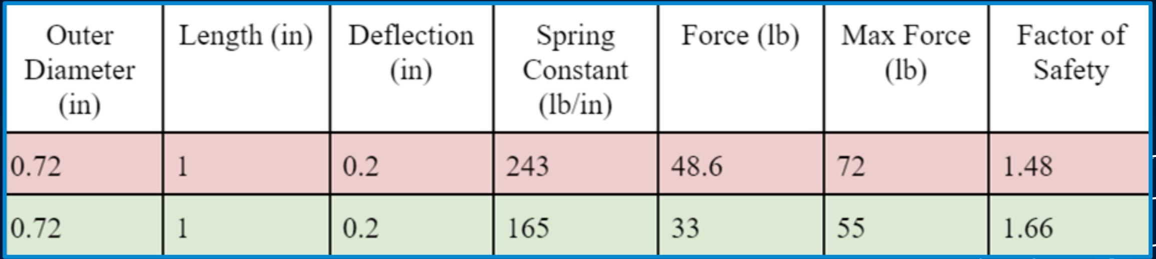


Fig 9.2: TARRP Locked Position



Outer Diameter (in)	Length (in)	Deflection (in)	Spring Constant (lb/in)	Force (lb)	Max Force (lb)	Factor of Safety
0.72	1	0.2	243	48.6	72	1.48
0.72	1	0.2	165	33	55	1.66

Fig 9.4: Spring Decision Matrix

T.A.R.R.P. Delivery Mechanism

- Assumed that a suitable landing zone would be identified prior to descent vehicle launch
- 2-Stage Delivery Mechanism
    - Housing Attached to the Exterior of the Descent Vehicle
        - Contains TARRP, Cold Gas Attitude Thrusters, and Solid Main Thrusters
        - Independent Guidance, Navigation, and Control
        - Radalt & Lidar Scanning Systems
            - Allows for proper orientation over desired landing zone
    - Upon reaching the surface, the TARRP will deploy and the HLS or CLPS will land
        - Attitude thrusters used to ensure housing mechanism clears landing zone prior to descent vehicle approach

Prototyping

- Two independent parts were 3D modeled and tested for compatibility.
    - Decagonal Base Plate
    - Ten Polygonal Fins
- Created to demonstrate the functionality of the TARRP.

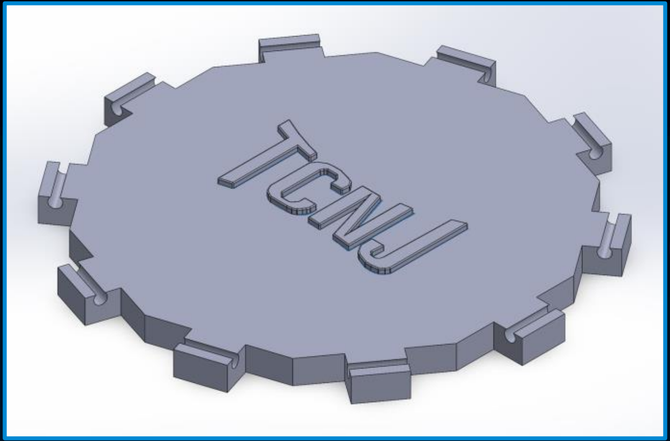


Fig 11.1: 3D Base Plate Model

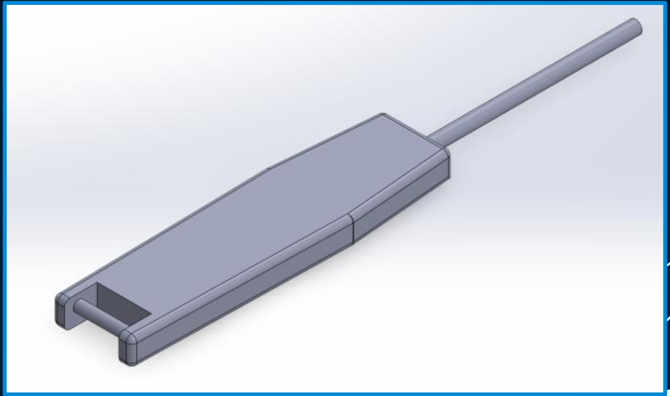


Fig 11.2: 3D Fin Model

3D Printed Model

- Fully assembled expanded model is 11" in diameter
- Folded is 4.2" in diameter
- With carbon felt material attached to rods to fill in the gaps
    - Diameter expands to 16" across

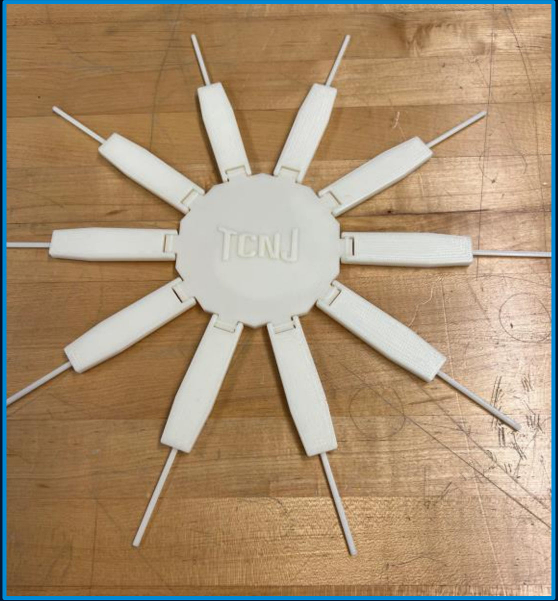


Fig 12.1: Fully Expanded 3D Printed TARRP Model

Fig 12.2: Folded 3D Printed TARRP Model

Test Chamber

Vacuum Chamber Design

- 2x2x2ft vacuum chamber
  - Walls made entirely of clear 1” acrylic
  - Attached using epoxy ‘Weld-On’
  - Additional silicone sealant
- Incorporates 0.1” rubber O-ring
  - Utilizes 4 C Clamps to properly seal front door
  - Lubricated with silicone gel

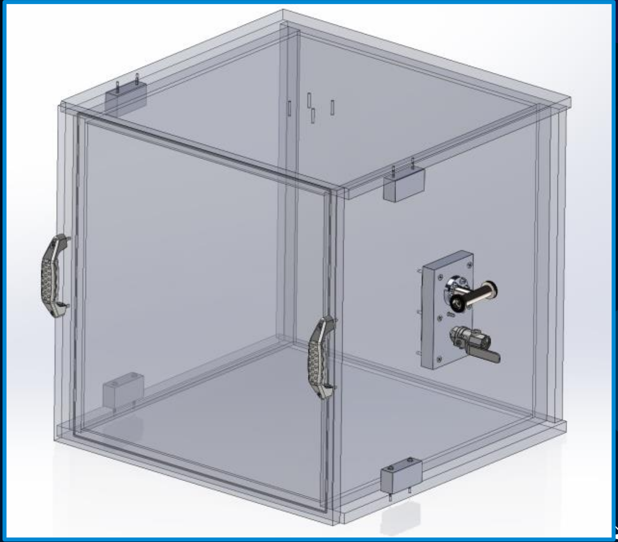


Fig 14.1: Vacuum Chamber

ANSYS Analysis of Vacuum Chamber

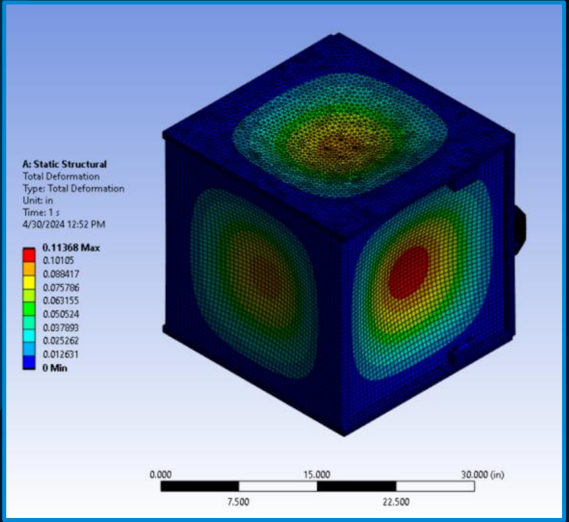


Fig 15.1: Vacuum Chamber Deformation

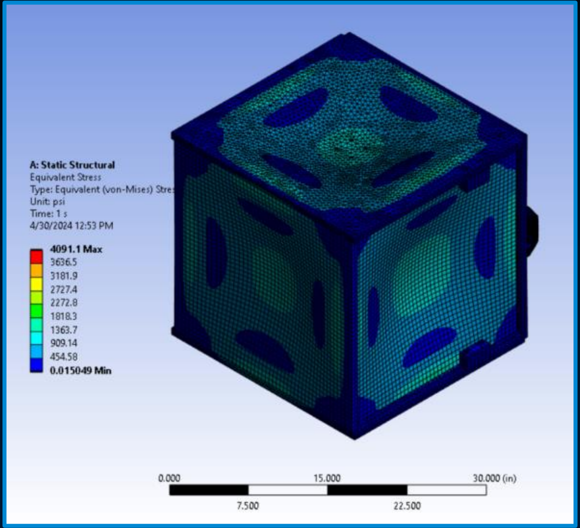


Fig 15.2: Vacuum Chamber Stress

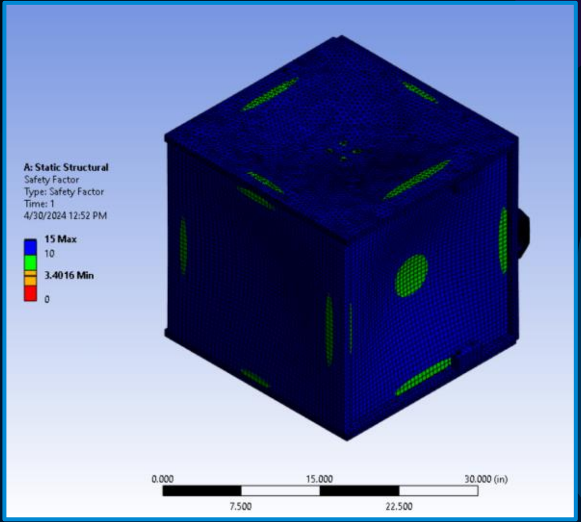


Fig 15.3: Vacuum Chamber FoS

Static Deformation: 0.113 " Max

Factor of Safety: 3.4 Min.

*Assuming Perfect Vacuum Conditions of **14.7 Psi***

Vacuum Chamber Access Port Design

- Using Klein Flange 16 attachment for the vacuum
  - Wire passthrough
  - Pressure gauge
  - Safety valve
  - Additional KF-16 input for potential future use


Fig 16.1: O-Ring Groove Testing


Fig 16.2: O-Ring Groove


Fig 16.3: Access Port Assembly

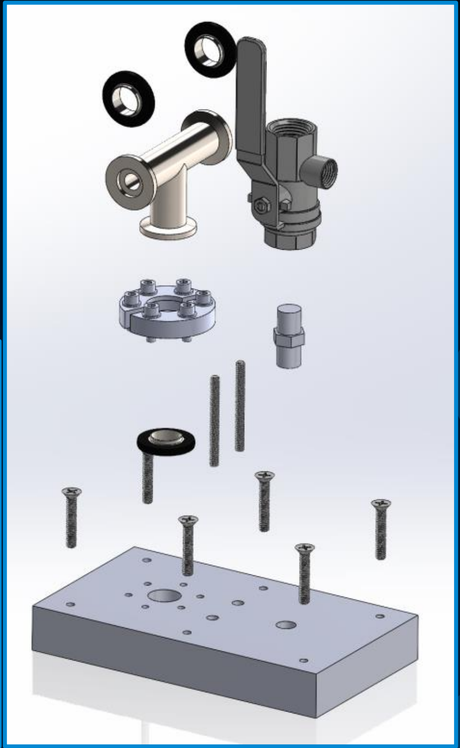


Fig 16.4: Access Port Assembly Exploded View

Thruster Mount Testing

- Video from Sony Alpha A7R IVA camera
- 16″ Flame
  - Measured with inch ticks on cardboard backdrop
- 1.5 second discharge

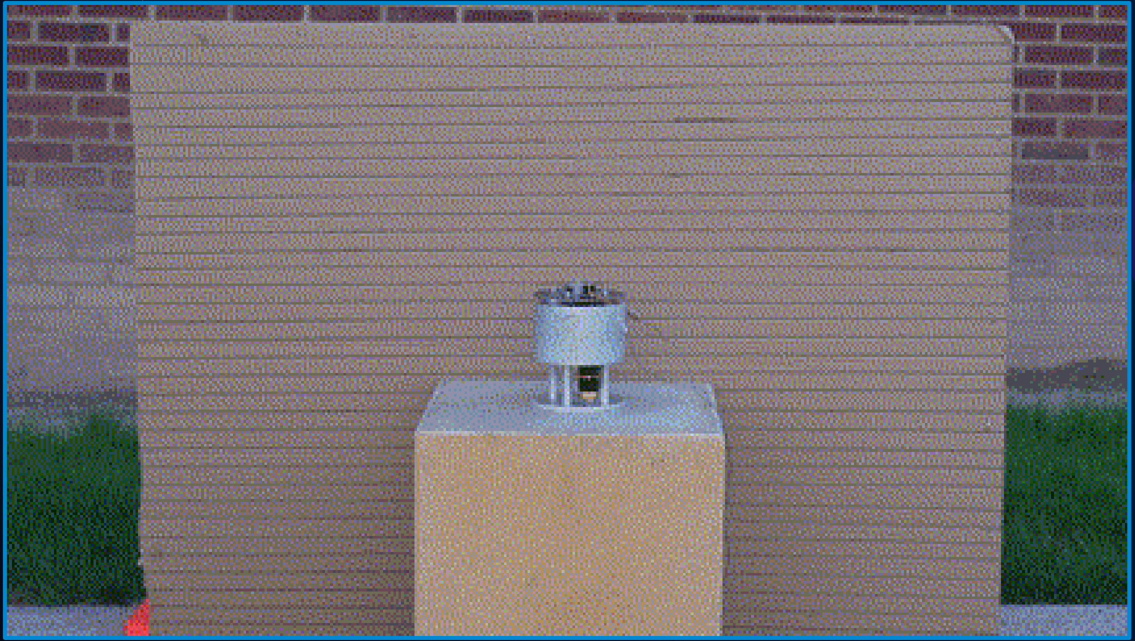


Figure 17.1: Set-up for Thruster Mount Testing

Data Collection

Scanning Systems Components

- Intel Realsense D435
  - Max Resolution of 1920x1080
  - Max Frame rate of 30fps
- NVIDIA Jetson Nano Developer Kit
  - AI developer kit
  - Multipliple ports for device connection
  - Computer Vision

Fig 19.1: Intel Realsense Depth Camera D435

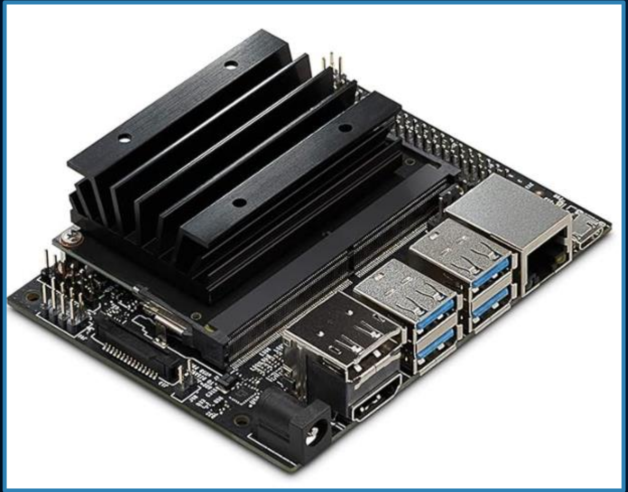
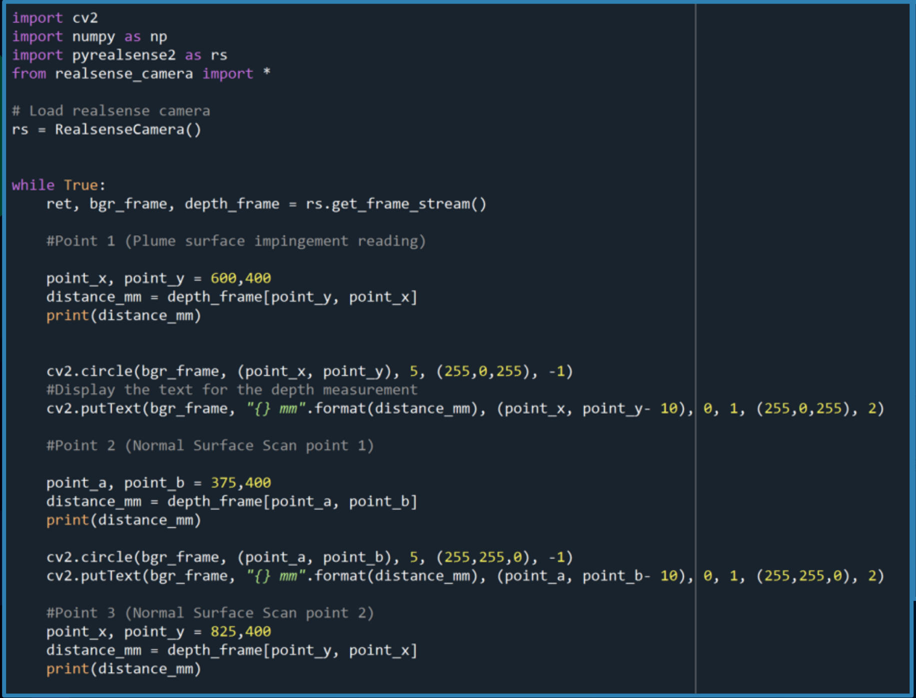


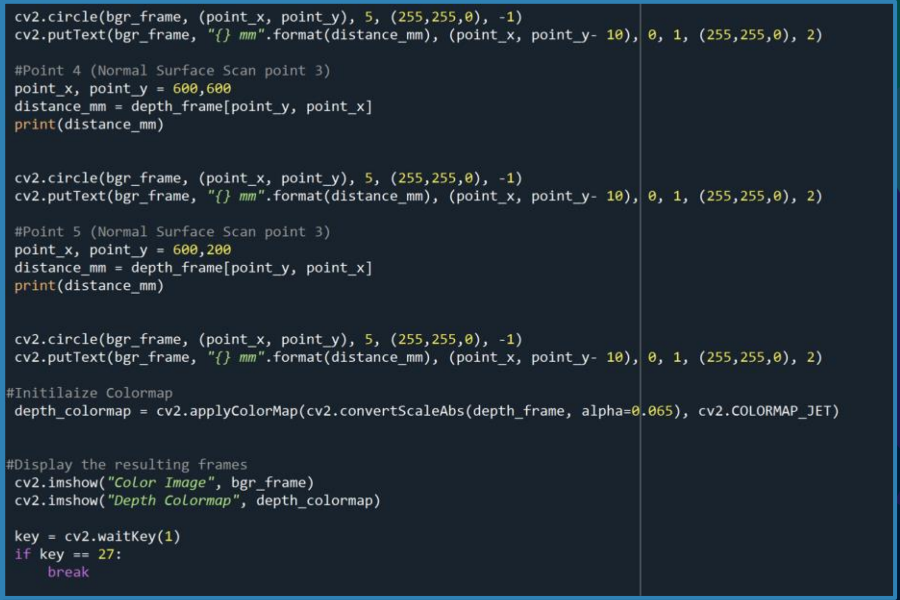
Fig 19.2: NVIDIA Jetson Nano Developer Kit

Scanning Systems Program



```
import cv2
import numpy as np
import pyrealsense2 as rs
from realsense_camera import *

# Load realsense camera
rs = RealsenseCamera()


while True:
    ret, bgr_frame, depth_frame = rs.get_frame_stream()

    #Point 1 (Plume surface impingement reading)

    point_x, point_y = 600,400
    distance_mm = depth_frame[point_y, point_x]
    print(distance_mm)


    cv2.circle(bgr_frame, (point_x, point_y), 5, (255,0,255), -1)
    #Display the text for the depth measurement
    cv2.putText(bgr_frame, "{} mm".format(distance_mm), (point_x, point_y- 10), 0, 1, (255,0,255), 2)

    #Point 2 (Normal Surface Scan point 1)

    point_a, point_b = 375,400
    distance_mm = depth_frame[point_a, point_b]
    print(distance_mm)

    cv2.circle(bgr_frame, (point_a, point_b), 5, (255,255,0), -1)
    cv2.putText(bgr_frame, "{} mm".format(distance_mm), (point_a, point_b- 10), 0, 1, (255,255,0), 2)

    #Point 3 (Normal Surface Scan point 2)
    point_x, point_y = 825,400
    distance_mm = depth_frame[point_y, point_x]
    print(distance_mm)
```

Figure 20.1: Code Snippet 1



```
 cv2.circle(bgr_frame, (point_x, point_y), 5, (255,255,0), -1)
 cv2.putText(bgr_frame, "{} mm".format(distance_mm), (point_x, point_y- 10), 0, 1, (255,255,0), 2)

 #Point 4 (Normal Surface Scan point 3)
 point_x, point_y = 600,600
 distance_mm = depth_frame[point_y, point_x]
 print(distance_mm)


 cv2.circle(bgr_frame, (point_x, point_y), 5, (255,255,0), -1)
 cv2.putText(bgr_frame, "{} mm".format(distance_mm), (point_x, point_y- 10), 0, 1, (255,255,0), 2)

 #Point 5 (Normal Surface Scan point 3)
 point_x, point_y = 600,200
 distance_mm = depth_frame[point_y, point_x]
 print(distance_mm)


 cv2.circle(bgr_frame, (point_x, point_y), 5, (255,255,0), -1)
 cv2.putText(bgr_frame, "{} mm".format(distance_mm), (point_x, point_y- 10), 0, 1, (255,255,0), 2)

#Initilaize Colormap
 depth_colormap = cv2.applyColorMap(cv2.convertScaleAbs(depth_frame, alpha=0.065), cv2.COLORMAP_JET)


#Display the resulting frames
 cv2.imshow("Color Image", bgr_frame)
 cv2.imshow("Depth Colormap", depth_colormap)

 key = cv2.waitKey(1)
 if key == 27:
     break
```

Figure 20.2: Code Snippet 2

Scanning Program Continued

Figure 21.1: Color Image output test

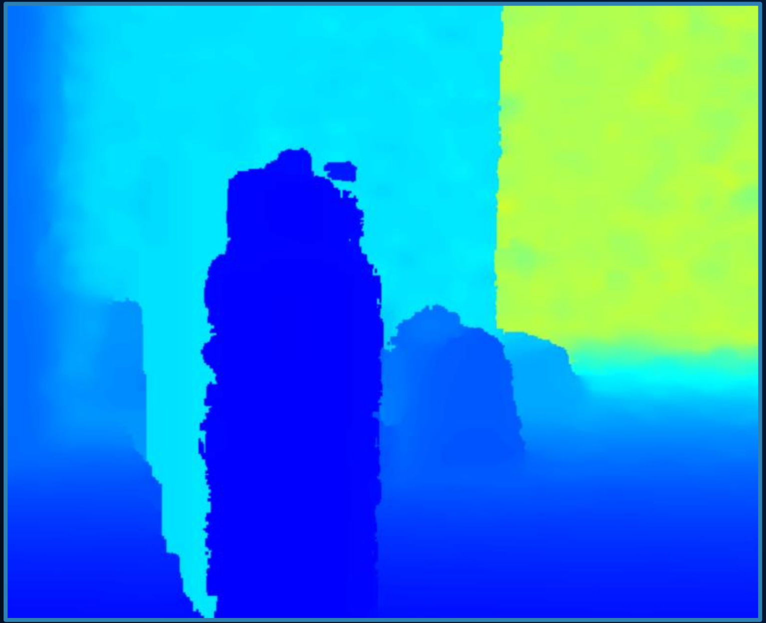


Figure 21.2: Depth Colormap output test

Scanning Systems Testing

- Conducted testing to gather images for MASK RCNN training.
- Tracking simulant regolith in a controlled testing environment.

Figure 22.1: Testing Apparatus

Figure 22.2: Air Duster

Figure 22.3: Top View of Regolith in Testing Apparatus

Fig 22.4: Active Testing

Scanning Testing Continued

Figure 23.1: Testing Demonstration

Machine Learning Dust Tracking System

- Object detection with Mask RCNN.
- Implementing a dust tracking system using Mask RCNN.
- Extremely fine particles resulted in chaotic response

Figure 24.1: Object detection demonstration

Figure 24.2: Attempt to gather images

Simulation

Simulations

- **ANSYS Simulations**
  - 2-Dimensional, Symmetric
    - Multiphase Euler-Euler
    - 15 - 30 mm Regolith Depth
    - 50 - 200 mm Nozzle Height
  - 20 Total Simulations Run
    - 16 With TARRP
    - 4 Without TARRP
- **Limitations**
  - Assume Spherical Regolith Particles
  - TARRP Modeled as Stationary Boundary
  - Ignores Particle-Particle Interactions

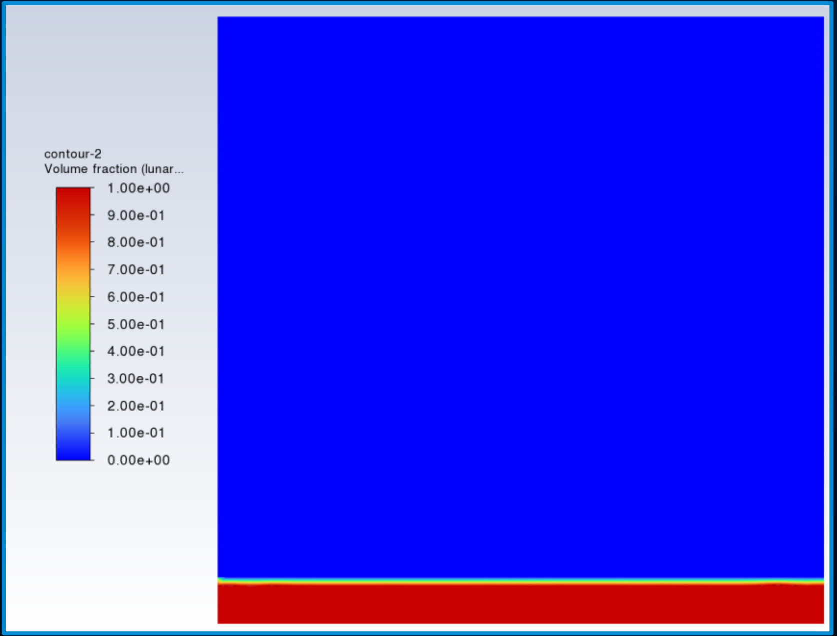
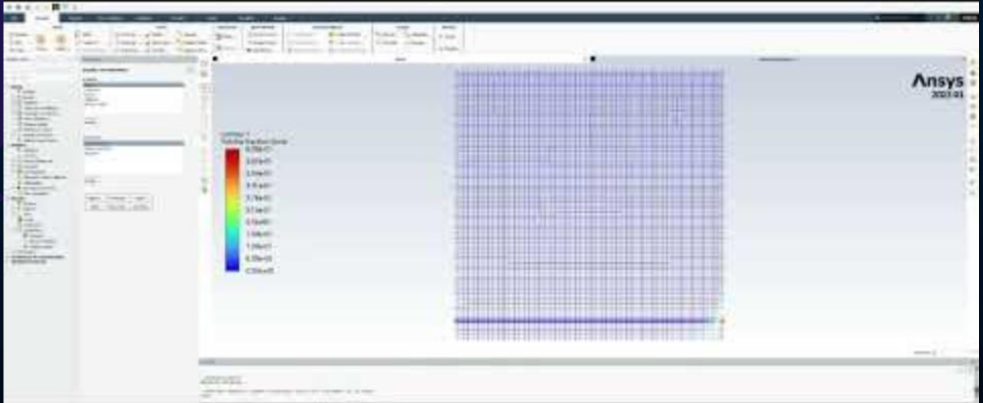
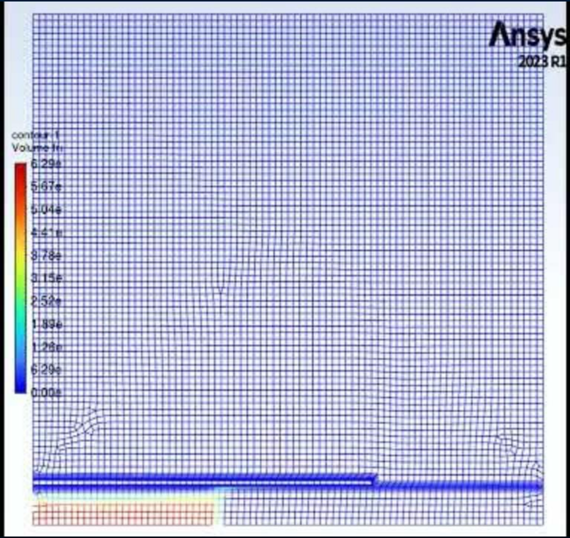


Figure 26.1. Initialized Simulation Geometry With Patched Lunar Regolith

Simulations





Simulation Results

- Without TARRP
    - All four simulations run w/o TARRP completely evacuate regolith within 10 milliseconds
- With TARRP
    - All 16 simulations run for 2.5 seconds of simulation time.
    - Some regolith is still evacuated, however presence of TARRP significantly mitigates this
    - All simulations end with regolith remaining in chamber
- Conclusions
    - Simulation confirms that TARRP serves as an effective mitigation strategy for PSI
    - Recent research suggests that TARRP effectiveness could be enhanced by incorporating a slight incline to the terminal edges of the top surface

Testing Results

In Chamber Testing

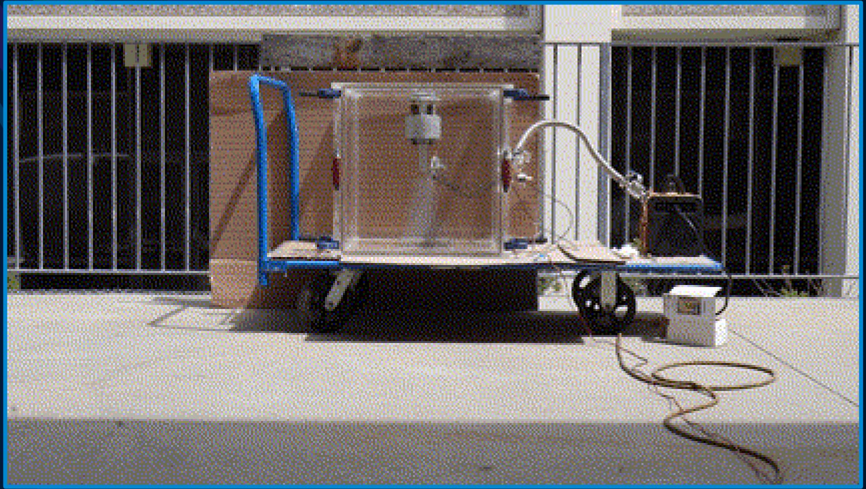


Fig 30.1: In Chamber Test 1

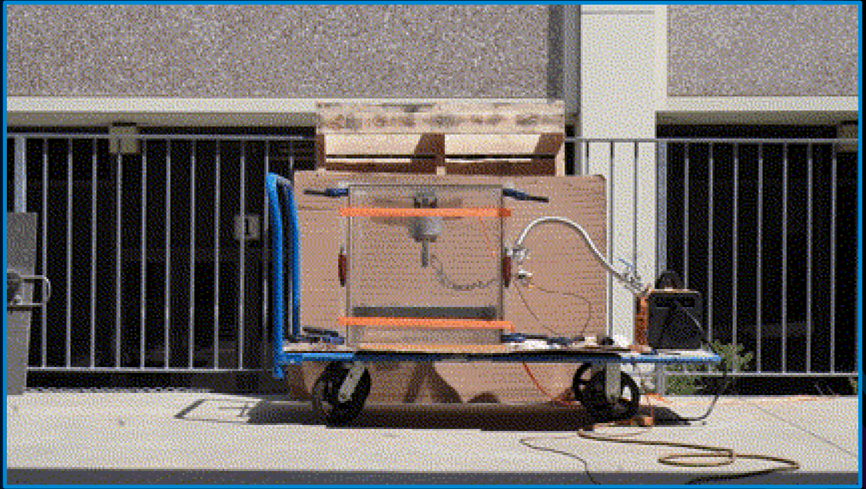


Fig 30.2: In Chamber Test 2

In Chamber Testing

Fig 31.1: Thruster Mount Post Test 2

Testing Modification for Data Collection

Fig 32.1: 30mm of Testing Regolith

Fig 32.2: TARPP During Test

Fig 32.3: Modified Testing

Findings

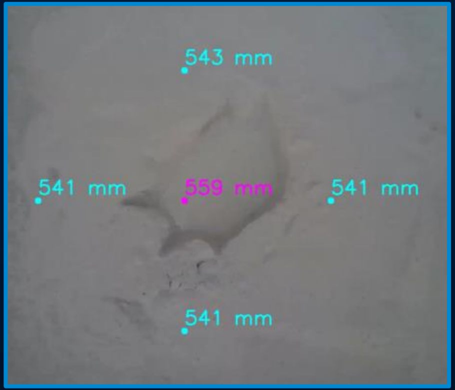


Fig 33.1: Test 1 on bare surface

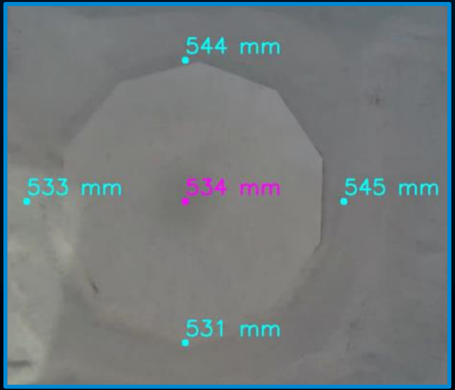


Fig 33.2: Test 1 on TARRP

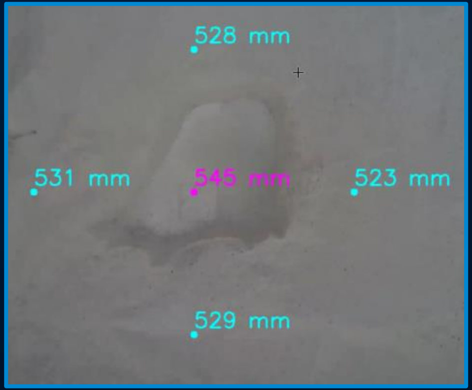


Fig 33.3: Test 2 on bare surface

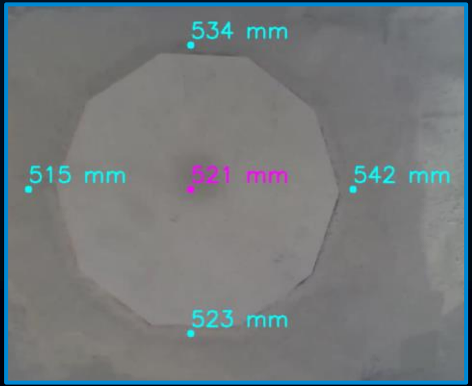


Fig 33.4: Test 2 on TARRP

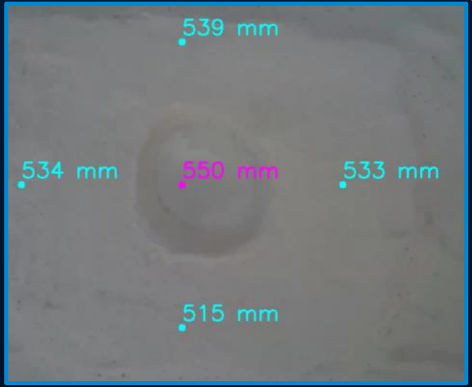


Fig 33.5: Test 3 on bare surface

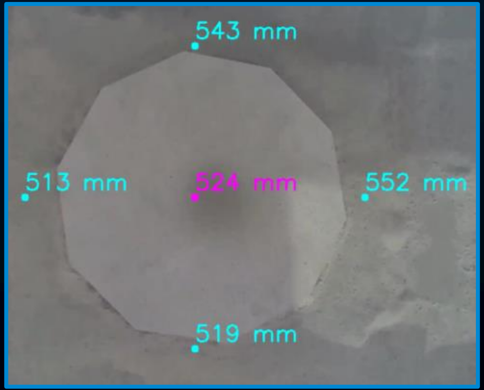


Fig 33.6: Test 3 on TARRP

Findings

Table 34.1: Results

Constant fire height of 5" was maintained with a fire time of 5 seconds			
Average Central Impingement (mm)	**Average Outer Deformation (mm)**	**Regolith Depth (mm)**	**Test #**
No Mitigation Tactics			
17.5 mm	N/A	27 mm	1
17.25mm	N/A	27 mm	2
19.75 mm	N/A	26 mm	3
TARRP Covered Surface			
0 mm	6.25 mm	25 mm	4
0 mm	10.5 mm	27 mm	5
0 mm	15.75 mm	25 mm	6

- With no mitigation tactics in place, an average impingement of 18.2mm was observed
- With the TARRP, 0mm of impingement was recorded at the heart of the plume.
- 10mm of average deformation were observed along the edges of the TARRP
    - Includes impingement and build-up

Future Design Recommendations

Vacuum Chamber:

- Increase Volume of Vacuum Chamber
- Larger Vacuum Pump
- Implement ‘Trap-Door’ Exhaust to Relieve Pressure
- Use silicone for O-rings

TARRP:

- Reduce Packed Volume of Platform
- Perform Material Analysis of Graphite Foil / Carbon Felt “Thermal Mesh”

Scanning:

- MASK RCNN Object Detection Training on Regolith Clouds

Budget & Path-to-Flight

NASA Proposal

Cost: $593.5 M

Project Time: 2 yr.

Size: 17.3 ft dia.

Total Mass: 309.8 kg

Total Volume: 2.42 ft^3

Fig 37.1: NASA Logo

Carbon Composite Volume: 1.736 ft^3

Aluminum Volume:0.660 ft^3

Base Plate - 1.03 ft^3

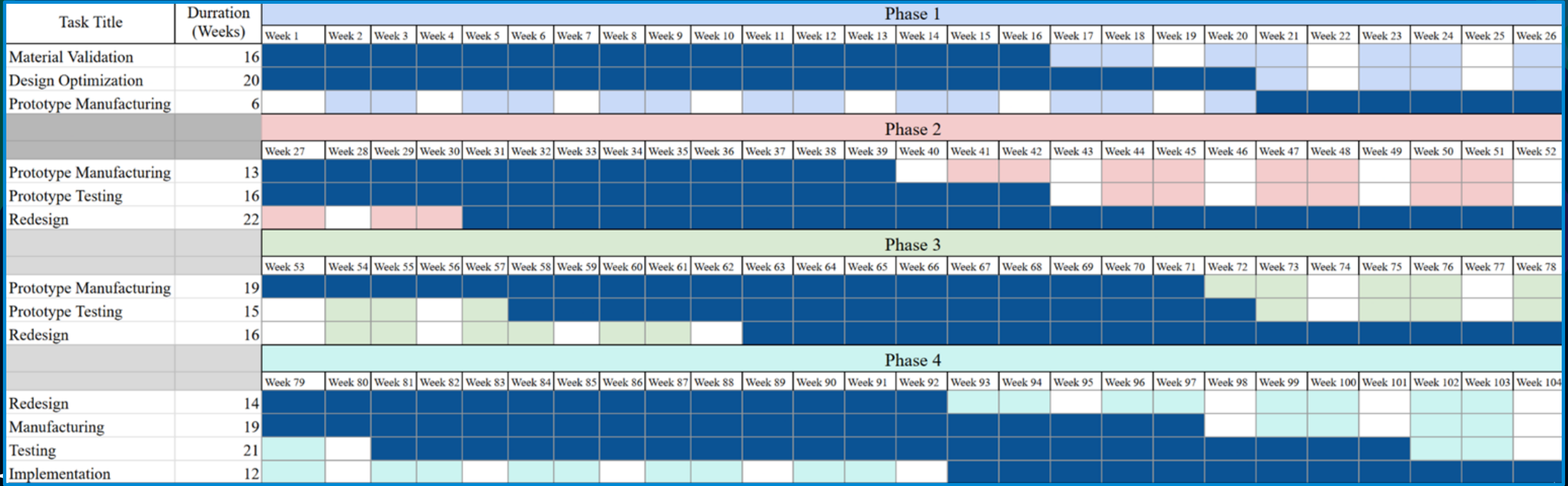
Rods - 0.660 ft^3

Fins - 0.706 ft^3

Carbon Composite Mass: 108.375 lbm

Aluminum Mass: 111 lbm

NASA Project Proposal Timeline

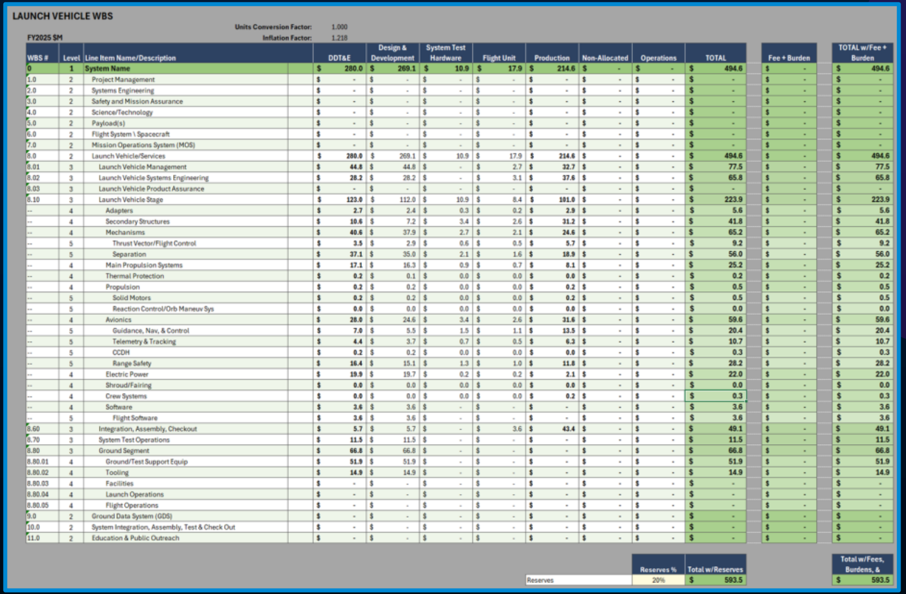


Task Title	Durration (Weeks)	Phase 1																									
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26
Material Validation	16	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
Design Optimization	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Prototype Manufacturing	6																					■	■	■	■	■	■
		Phase 2																									
		Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39	Week 40	Week 41	Week 42	Week 43	Week 44	Week 45	Week 46	Week 47	Week 48	Week 49	Week 50	Week 51	Week 52
Prototype Manufacturing	13	■	■	■	■	■	■	■	■	■	■	■	■	■													
Prototype Testing	16	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
Redesign	22					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Phase 3																									
		Week 53	Week 54	Week 55	Week 56	Week 57	Week 58	Week 59	Week 60	Week 61	Week 62	Week 63	Week 64	Week 65	Week 66	Week 67	Week 68	Week 69	Week 70	Week 71	Week 72	Week 73	Week 74	Week 75	Week 76	Week 77	Week 78
Prototype Manufacturing	19	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Prototype Testing	15						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Redesign	16											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		Phase 4																									
		Week 79	Week 80	Week 81	Week 82	Week 83	Week 84	Week 85	Week 86	Week 87	Week 88	Week 89	Week 90	Week 91	Week 92	Week 93	Week 94	Week 95	Week 96	Week 97	Week 98	Week 99	Week 100	Week 101	Week 102	Week 103	Week 104
Redesign	14	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
Manufacturing	19	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Testing	21			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Implementation	12															■	■	■	■	■	■	■	■	■	■	■	■

Fig 38.1: NASA Proposed Gantt Chart

Project Budget

- Cost Estimation Made using NASA Project Cost Estimation Capability (PCEC) Software
    - $593.5 M estimated budget
        - Includes 20% Reserve
    - 2 yr. Timeline to Final Prototype
    - 5 yr. Production Run
    - 12 Flight Total
    - 20 Production Units
- Estimation Built Based on Launch Vehicle Template



LAUNCH VEHICLE WBS

Units Conversion Factor: 1.000

FY2025 $M

Inflation Factor: 1.218

WBS #	Level	Line Item Name/Description	DDT&E	Design & Development	System Test Hardware	Flight Unit	Production	Non-Allocated	Operations	TOTAL	Fee + Burden	TOTAL w/Fee + Burden
0	1	System Name	$ 280.0	$ 269.1	$ 10.9	$ 17.9	$ 214.6	$ -	$ -	$ 494.6	$ -	$ 494.6
1.0	2	Project Management	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2.0	2	Systems Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3.0	2	Safety and Mission Assurance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4.0	2	Science/Technology	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5.0	2	Payload(s)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6.0	2	Flight System \ Spacecraft	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7.0	2	Mission Operations System (MOS)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8.0	2	Launch Vehicle/Services	$ 280.0	$ 269.1	$ 10.9	$ 17.9	$ 214.6	$ -	$ -	$ 494.6	$ -	$ 494.6
8.01	3	Launch Vehicle Management	$ 44.8	$ 44.8	$ -	$ 2.7	$ 32.7	$ -	$ -	$ 77.5	$ -	$ 77.5
8.02	3	Launch Vehicle Systems Engineering	$ 28.2	$ 28.2	$ -	$ 3.1	$ 37.6	$ -	$ -	$ 65.8	$ -	$ 65.8
8.03	3	Launch Vehicle Product Assurance	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8.10	3	Launch Vehicle Stage	$ 123.0	$ 112.0	$ 10.9	$ 8.4	$ 101.0	$ -	$ -	$ 223.9	$ -	$ 223.9
--	4	Adapters	$ 2.7	$ 2.4	$ 0.3	$ 0.2	$ 2.9	$ -	$ -	$ 5.6	$ -	$ 5.6
--	4	Secondary Structures	$ 10.6	$ 7.2	$ 3.4	$ 2.6	$ 31.2	$ -	$ -	$ 41.8	$ -	$ 41.8
--	4	Mechanisms	$ 40.6	$ 37.9	$ 2.7	$ 2.1	$ 24.6	$ -	$ -	$ 65.2	$ -	$ 65.2
--	5	Thrust Vector/Flight Control	$ 3.5	$ 2.9	$ 0.6	$ 0.5	$ 5.7	$ -	$ -	$ 9.2	$ -	$ 9.2
--	5	Separation	$ 37.1	$ 35.0	$ 2.1	$ 1.6	$ 18.9	$ -	$ -	$ 56.0	$ -	$ 56.0
--	4	Main Propulsion Systems	$ 17.1	$ 16.3	$ 0.9	$ 0.7	$ 8.1	$ -	$ -	$ 25.2	$ -	$ 25.2
--	4	Thermal Protection	$ 0.2	$ 0.1	$ 0.0	$ 0.0	$ 0.0	$ -	$ -	$ 0.2	$ -	$ 0.2
--	4	Propulsion	$ 0.2	$ 0.2	$ 0.0	$ 0.0	$ 0.2	$ -	$ -	$ 0.5	$ -	$ 0.5
--	5	Solid Motors	$ 0.2	$ 0.2	$ 0.0	$ 0.0	$ 0.2	$ -	$ -	$ 0.5	$ -	$ 0.5
--	5	Reaction Control/Orb Maneuv Sys	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ -	$ -	$ 0.0	$ -	$ 0.0
--	4	Avionics	$ 28.0	$ 24.6	$ 3.4	$ 2.6	$ 31.6	$ -	$ -	$ 59.6	$ -	$ 59.6
--	5	Guidance, Nav, & Control	$ 7.0	$ 5.5	$ 1.5	$ 1.1	$ 13.5	$ -	$ -	$ 20.4	$ -	$ 20.4
--	5	Telemetry & Tracking	$ 4.4	$ 3.7	$ 0.7	$ 0.5	$ 6.3	$ -	$ -	$ 10.7	$ -	$ 10.7
--	5	CCDH	$ 0.2	$ 0.2	$ 0.0	$ 0.0	$ 0.0	$ -	$ -	$ 0.3	$ -	$ 0.3
--	5	Range Safety	$ 16.4	$ 15.1	$ 1.3	$ 1.0	$ 11.8	$ -	$ -	$ 28.2	$ -	$ 28.2
--	4	Electric Power	$ 19.9	$ 19.7	$ 0.2	$ 0.2	$ 2.1	$ -	$ -	$ 22.0	$ -	$ 22.0
--	4	Shroud/Fairing	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ -	$ -	$ 0.0	$ -	$ 0.0
--	4	Crew Systems	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.2	$ -	$ -	$ 0.3	$ -	$ 0.3
--	4	Software	$ 3.6	$ 3.6	$ -	$ -	$ -	$ -	$ -	$ 3.6	$ -	$ 3.6
--	5	Flight Software	$ 3.6	$ 3.6	$ -	$ -	$ -	$ -	$ -	$ 3.6	$ -	$ 3.6
8.60	3	Integration, Assembly, Checkout	$ 5.7	$ 5.7	$ -	$ 3.6	$ 43.4	$ -	$ -	$ 49.1	$ -	$ 49.1
8.70	3	System Test Operations	$ 11.5	$ 11.5	$ -	$ -	$ -	$ -	$ -	$ 11.5	$ -	$ 11.5
8.80	3	Ground Segment	$ 66.8	$ 66.8	$ -	$ -	$ -	$ -	$ -	$ 66.8	$ -	$ 66.8
8.80.01	4	Ground/Test Support Equip	$ 51.9	$ 51.9	$ -	$ -	$ -	$ -	$ -	$ 51.9	$ -	$ 51.9
8.80.02	4	Tooling	$ 14.9	$ 14.9	$ -	$ -	$ -	$ -	$ -	$ 14.9	$ -	$ 14.9
8.80.03	4	Facilities	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8.80.04	4	Launch Operations	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8.80.05	4	Flight Operations	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
9.0	2	Ground Data System (GDS)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
10.0	2	System Integration, Assembly, Test & Check Out	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
11.0	2	Education & Public Outreach	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

	Reserves %	Total w/Reserves	Total w/Fees, Burdens, &
Reserves	20%	$ 593.5	$ 593.5

Figure 39.1. Work Breakdown Structure of Project (Adj. to 2025)

Website

Link to Website: https://engprojects.tcnj.edu/nasa-hulc/

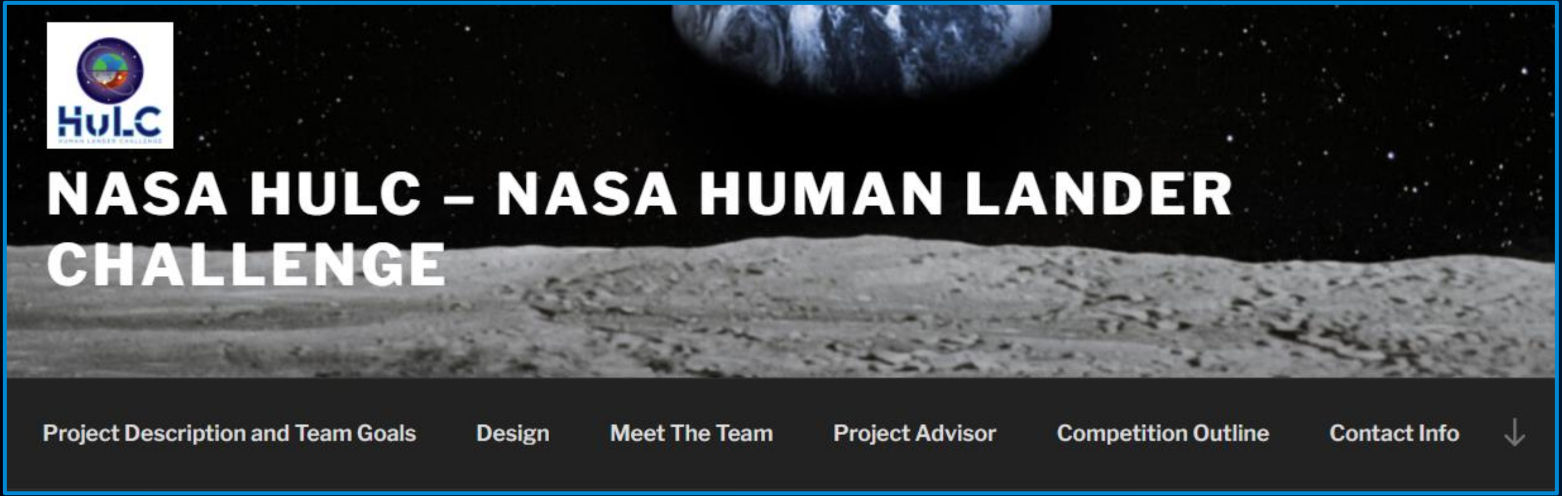


Figure 40.1: Screenshot of Website Homepage

Any Questions?