NASA STUDENT LAUNCH 2019

FLIGHT READINESS REVIEW

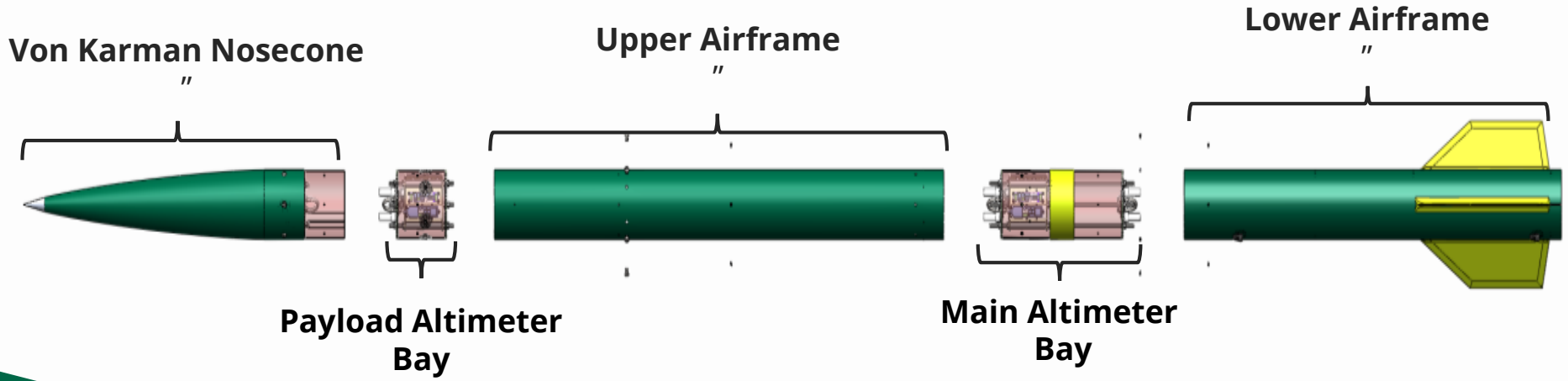
SOCIETY OF AERONAUTICS AND ROCKETRY
UNIVERSITY OF SOUTH FLORIDA

AGENDA

1. **Vehicle Criteria**
2. Recovery
3. Mission Performance Predictions
4. Testing
5. Payload
6. Project Plan

LAUNCH VEHICLE AND PAYLOAD DIMENSIONS

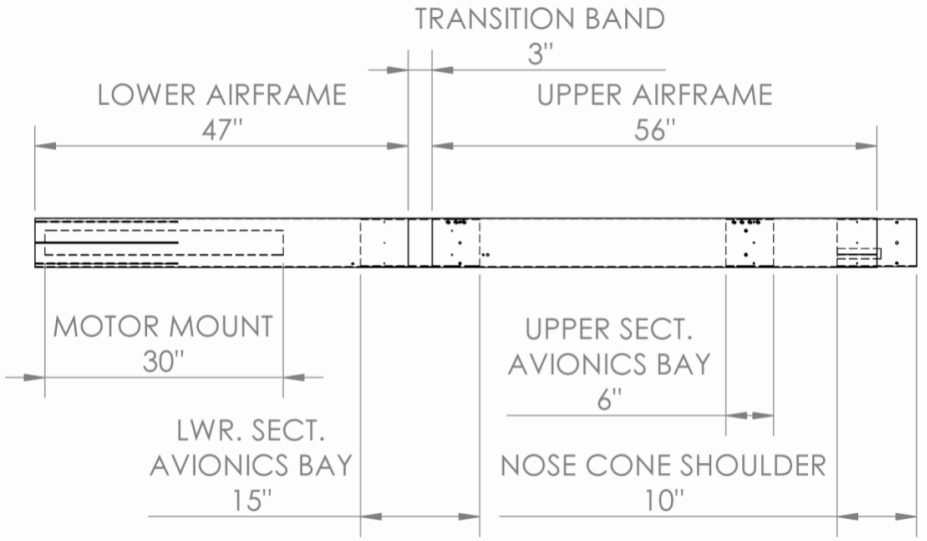
Vehicle Property	Value
Diameter	6”
Length	138”
Unloaded Weight	38.2 lb
Loaded Weight (with motor and payload)	56.3 lb
Payload Weight with Deployment System	7,19 lb
Max Payload Length	”

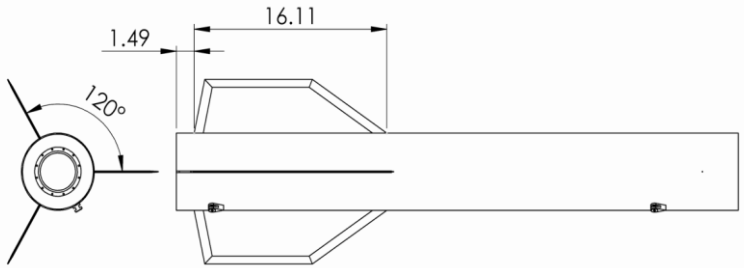


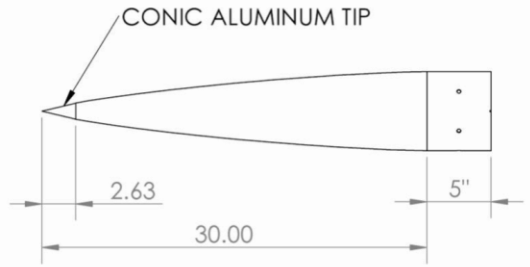
KEY DESIGN FEATURES

Two Separately Tethered Sections:

- Upper Section
  - Upper Section Avionics Bay
  - Upper Airframe
  - Payload Descent Leveling Subsystem (PDLS)
  - Upper Section Main Parachute
  - Adjustable Ballast Subsystem (ABS)
  - Payload
- Lower Section
  - Lower Section Avionics Bay
  - Lower Section Main Parachute
  - Drogue Parachute
  - Lower Airframe







KEY DESIGN FEATURES

Vehicle Subsystems

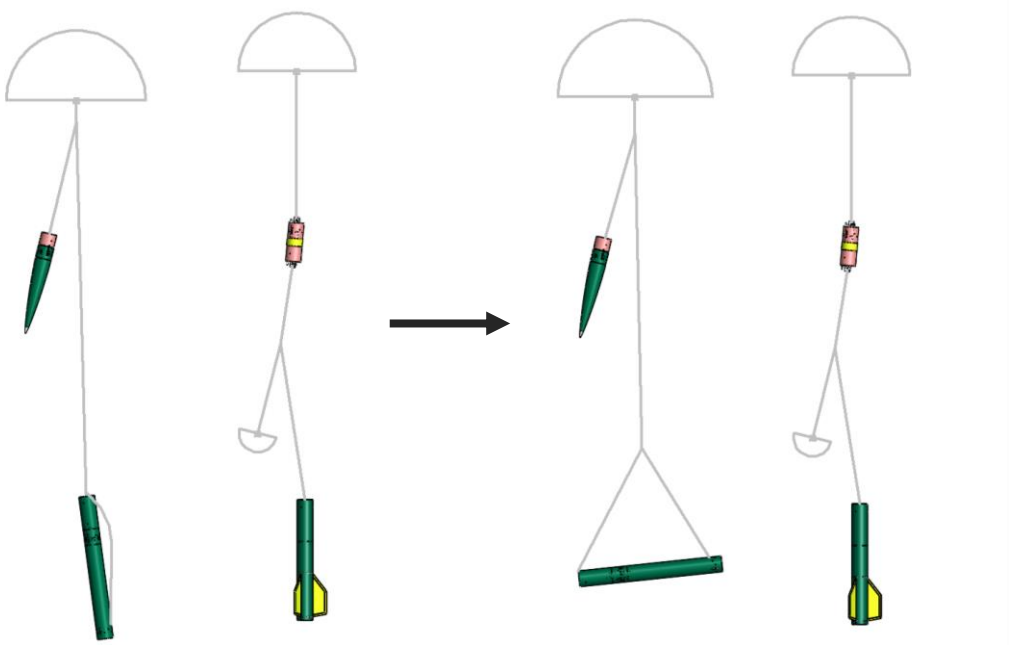
- Payload Descent Leveling Subsystem (PDLS)
  - Prevents the payload-exit side of upper airframe from impacting ground upon landing, instead causing the airframe to land horizontally under parachute.
- Adjustable Ballast System (ABS)
  - Removable mass within nosecone to allow for adjustment of the launch vehicle's mass and center of gravity (stability) prior to launch.

Recovery

- Upper section main parachute for recovery of payload, upper airframe, and nose cone
- Lower section main parachute for recovery of lower airframe and lower section avionics bay
- Full real time GPS and flight data streaming

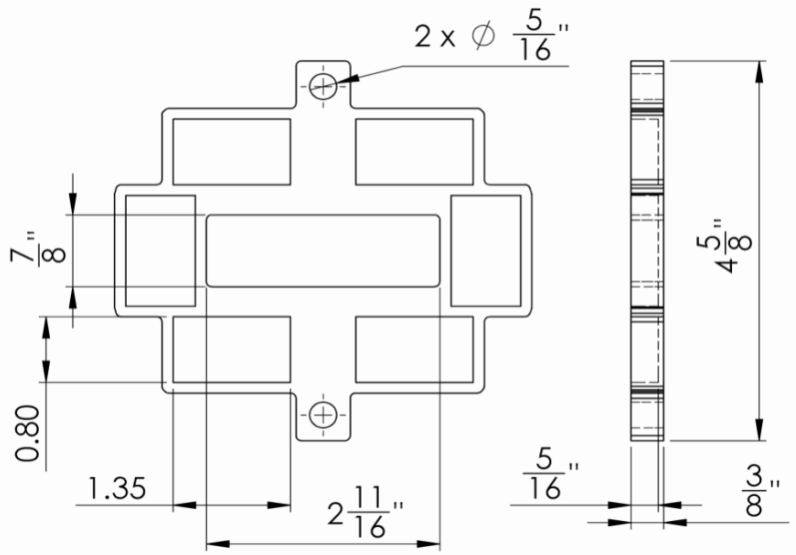
PAYLOAD DESCENT LEVELLING SUBSYSTEM (PDLS)

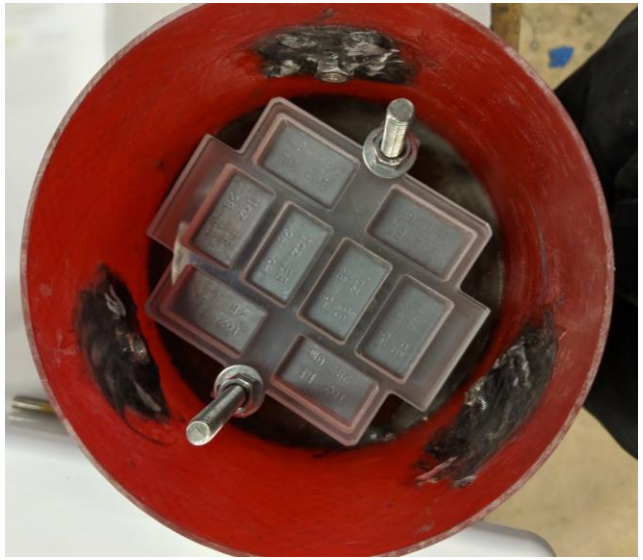
- Ensures a clear path for payload deployment A
- 1/16” stainless steel stranded wire will run along airframe exterior
- In lower end of the upper airframe, wire will be securely threaded into a standard 5/16” epoxy nut
- In upper end of the upper airframe, wire will attach to the upper section parachute shock cord
- Wire will be loosely taped to airframe to prevent entanglement
- Deployment will be controlled by Tender Descender and Missile Works RRC2+

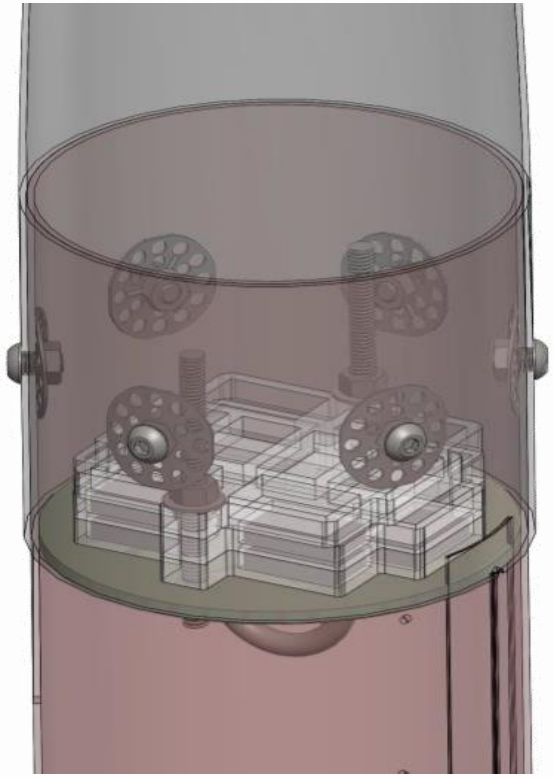


ADJUSTABLE BALLAST SUBSYSTEM (ABS)

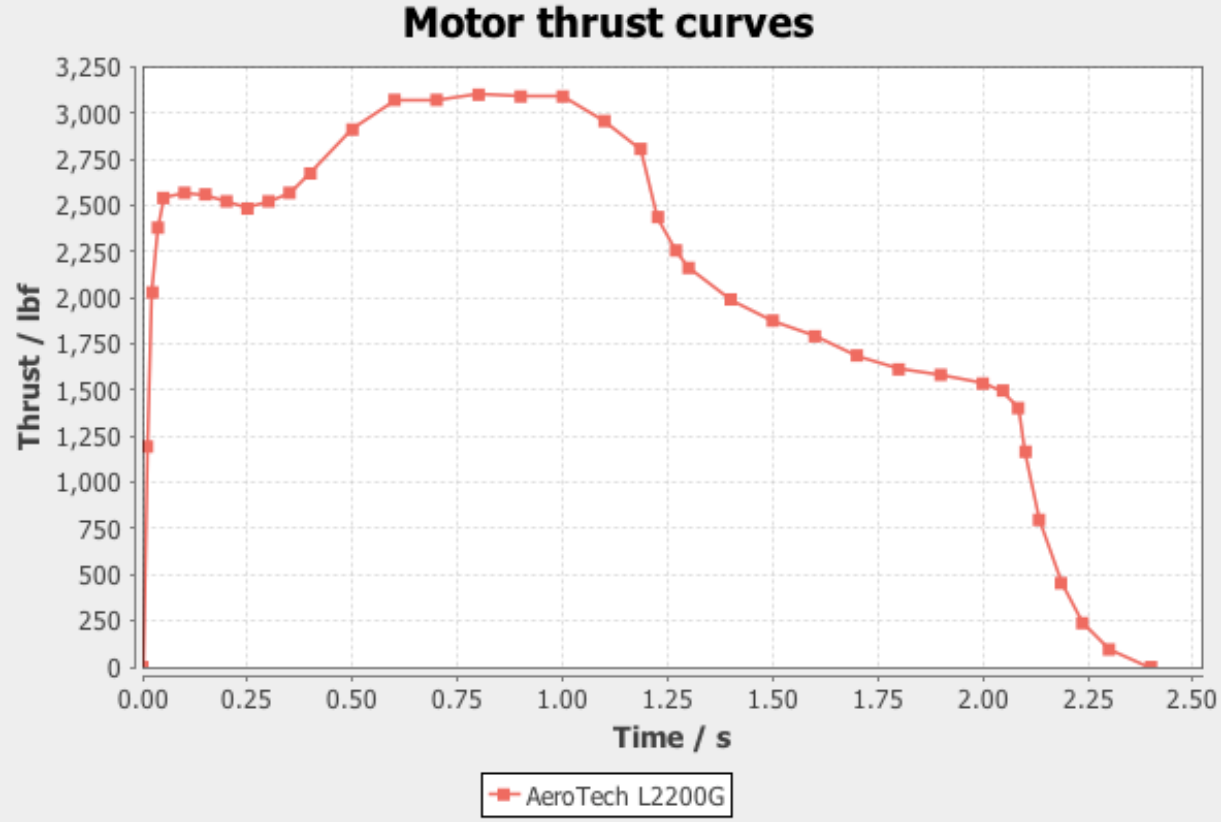
- Several stackable and removable weighted plates.
- Each plate will have several slots where 1-oz. weights can be placed
- Plates will be CNC-milled from clear acrylic for easy visibility







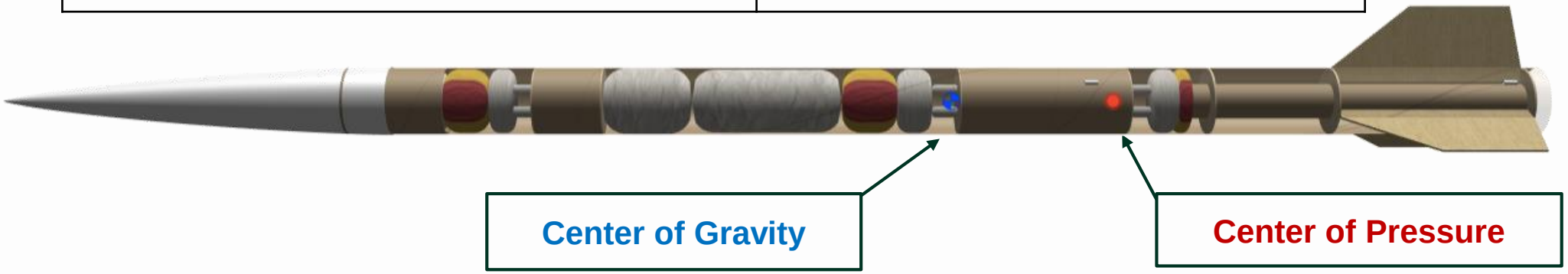
FINAL MOTOR SELECTION



Motor Property	Value
Name	Aerotech L220G
Average Thrust	2200 N
Total Impulse	5104 Ns
Burn Time	2.3 s
Propellant Weight	5.54 lbs

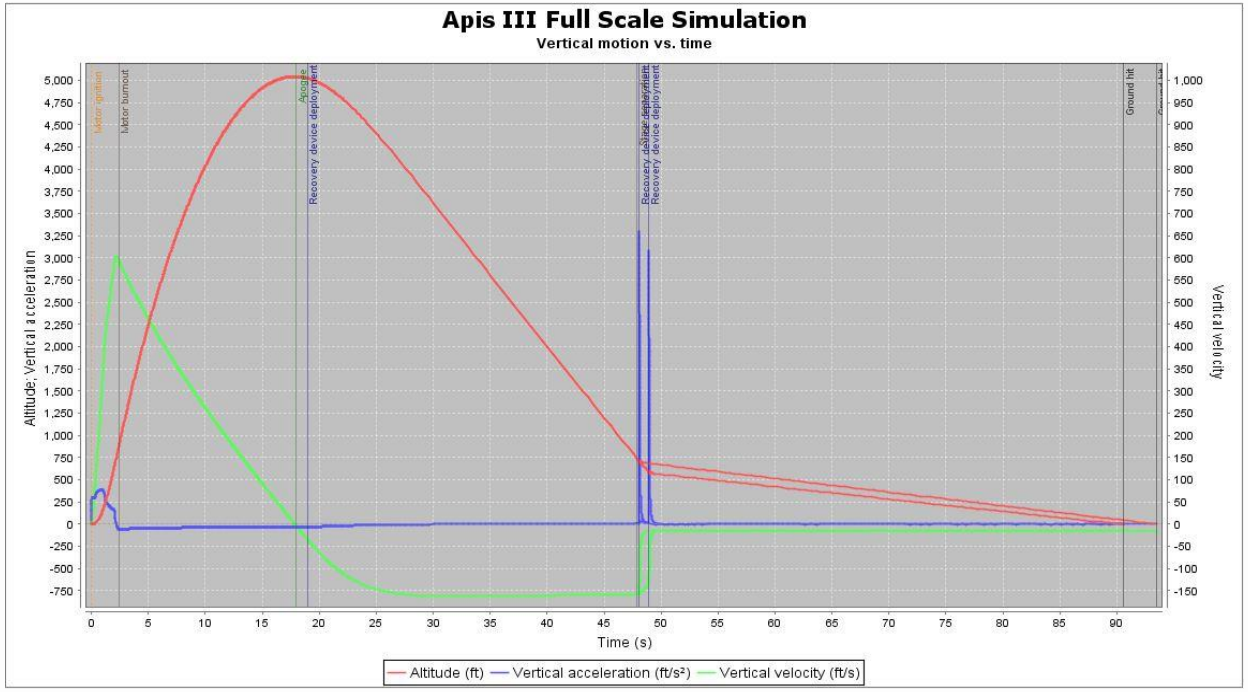
STABILITY

Stability Characteristic	Value
Center of Pressure (in. from nose)	99.94
Center of Gravity (in. from nose)	85.234
Static Stability Margin	2.41
Static Stability Margin (at rail exit)	2.49
Thrust-to-Weight Ratio	9.98
Rail Size/Type and Length (in)	1515, 144



FLIGHT CHARACTERISTICS

Selected Target Apogee: **5,000 ft**



Flight Property	Value
Apogee	4,606 ft
Velocity off Rail	77.8 ft/s
Max. Velocity	587 ft/s
Max. Acceleration	378 ft/s
Ascent Time	17 s

MASS STATEMENT

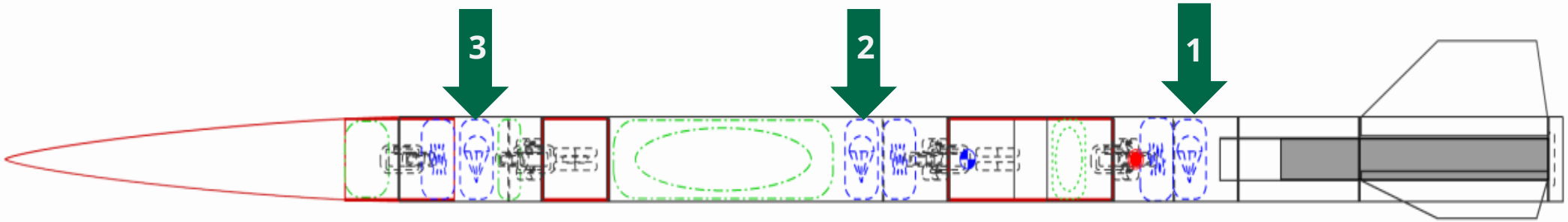
Component / Subsystem	Mass (lb)	Component / Subsystem	Mass (lb)
Nose Cone	3.25	Payload Deployment System	3.44
Shoulder	1.75	Lower Section Avionics Bay	4.69
Upper Section Shock Cord	1.12	Lower Section Main Parachute	1.31
Upper Section Main Parachute	1.56	Lower Section Shock Cord	.5
Upper Airframe	7.12	Lower Section Avionics	1.12
Payload Descent Leveling System	.312	Drogue Parachute	.331
Upper Section Avionics Bay	2.37	Lower Airframe + all components	11.2
Upper Section Avionics	1.12	Motor	10.5
Rover	3.75		

AGENDA

1. Vehicle Criteria
2. **Recovery**
3. Test Plans and Procedures
4. Payload
5. Project Plan

RECOVERY OVERVIEW

1. **Drogue Parachute**: Stored in lower airframe between lower section avionics bay and motor
2. **Lower Section Main Parachute**: Stored in upper airframe between payload and lower section avionics bay
3. **Upper Section Main Parachute**: Stored in upper airframe between nose cone and upper section avionics bay



RECOVERY Process

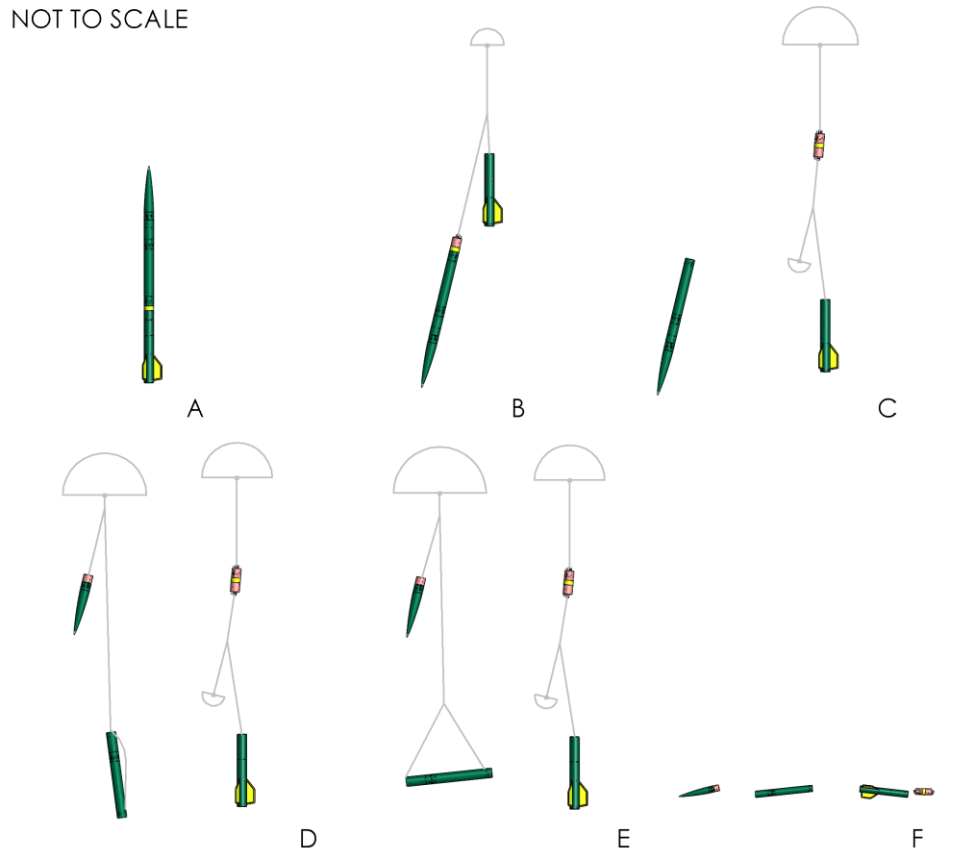
A. Vehicle is launched

B. Apogee: Lower airframe separates and drogue is deployed

C. 700 ft: Upper section separated and lower section main parachute is deployed. Nose cone separates from upper airframe and upper section main parachute is deployed

E. 500 ft: PDLS actives Tender Descender, causing upper airframe to drop to horizontal position

F. Vehicle lands, tracking system continues to broadcast GPS coordinates

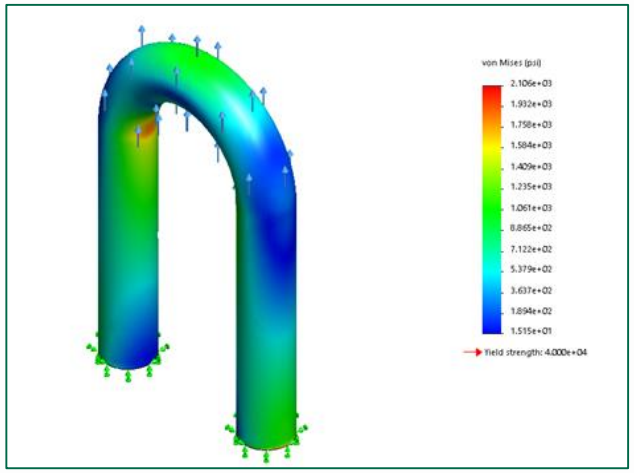


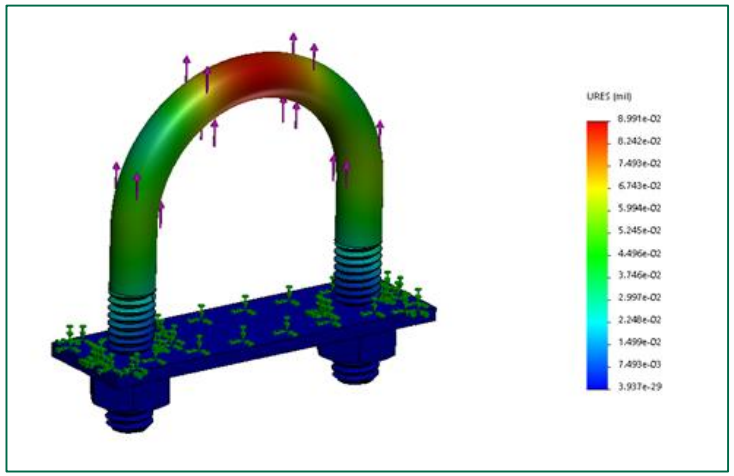
RECOVERY DETAILS

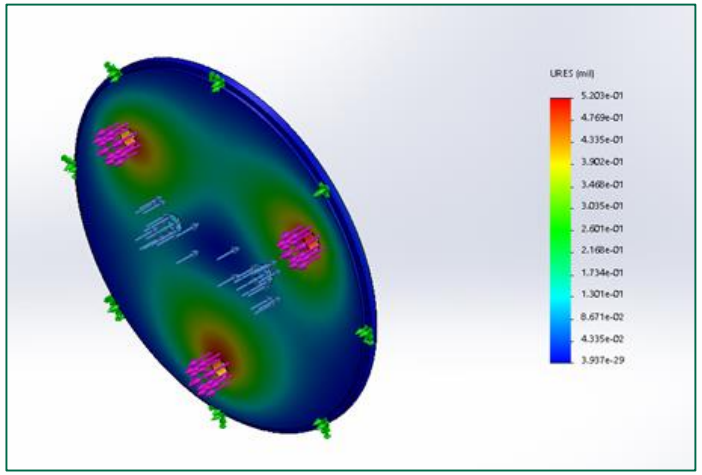
Parachute Name	Fruity Chutes Iris Ultra Standard 84”	Fruity Chutes Iris Ultra 96”	20’ inch SkyAngle Classic drogue
Deploy setting	700 ft	700 ft	Apogee
Backup Deploy Setting	710ft	735ft	Apogee + 1s
Material	1.1oz Ripstop Nylon	1.1oz Ripstop Nylon	Zero-porosity 1.9 oz. silicone-coated balloon cloth
Surface Area (sq ft)	38.48	50.2	4.4
Drag Coefficient	2.2	2.2	0.8
Number of Lines	13	13	3
Line Length (in)	33.5	33.5	25
Shock Cord	1/2" Tubular Kevlar	1/2" Tubular Kevlar	1/2" Tubular Kevlar
Descent Rate (fps)	15.01	13.49	133
Terminal Velocity (fps)	14.94	13.25	136

RECOVERY HARDWARE

- Built to have minimum factor of safety of 3.0
- Expected maximum payload deployment shock force of 61.93 lbf
- All stainless-steel hardware, except fiberglass bulkheads







KINETIC ENERGY

Kinetic Energy at Key Phases				
	Nosecone	Rover Compartment	Main Altimeter Bay	Booster Section
Drogue Deployment	129.42	304.2	134.12	188.24
Main #1 Deployment	2385.5	5607	2478.45	3470
Main #2 Deployment	2947.16	6927.75	3062	4286.78
Landing	22.34	52.52	28.9	40.45

DRIFT PREDICTIONS

Lower Section		
	OpenRocket Simulation	Manual Calculation $d = v_w t$
Wind Speed (mph)	**Drift (ft.)**	
0	0	0
5	554.15	594.46
10	1108.3	1188.93
15	1662.44	1783.4
20	2216.59	2377.85

Upper Section		
	OpenRocket Simulation	Manual Calculation $d = v_w t$
Wind Speed (mph)	**Drift (ft.)**	
0	0	0
5	532.89	585.67
10	1065.78	1171.33
15	1598.67	1757
20	2131.56	2342.67

AGENDA

1. Vehicle Criteria
2. Recovery
3. **Testing**
4. Payload
5. Project Plan

PAYLOAD DRIVE TEST

Objective

- To ensure Nautilus can drive on various terrains

What we learned

- Wheels often slipped when ground was moist.
- The electronics protective cover was too large and caused the rover to have little ground clearance.

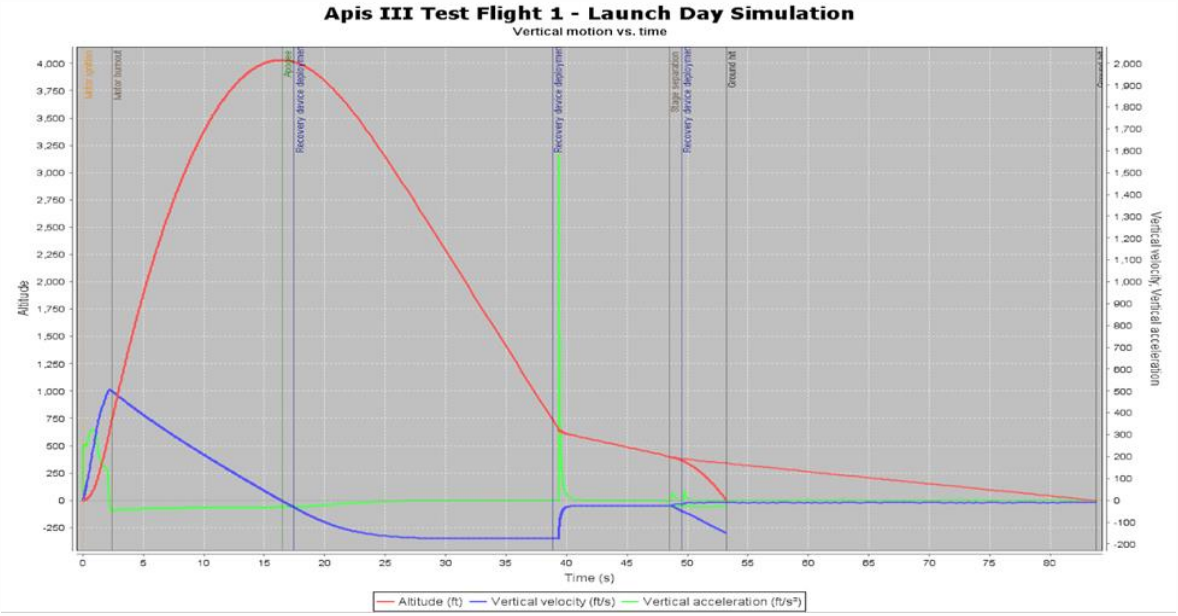
Fixes

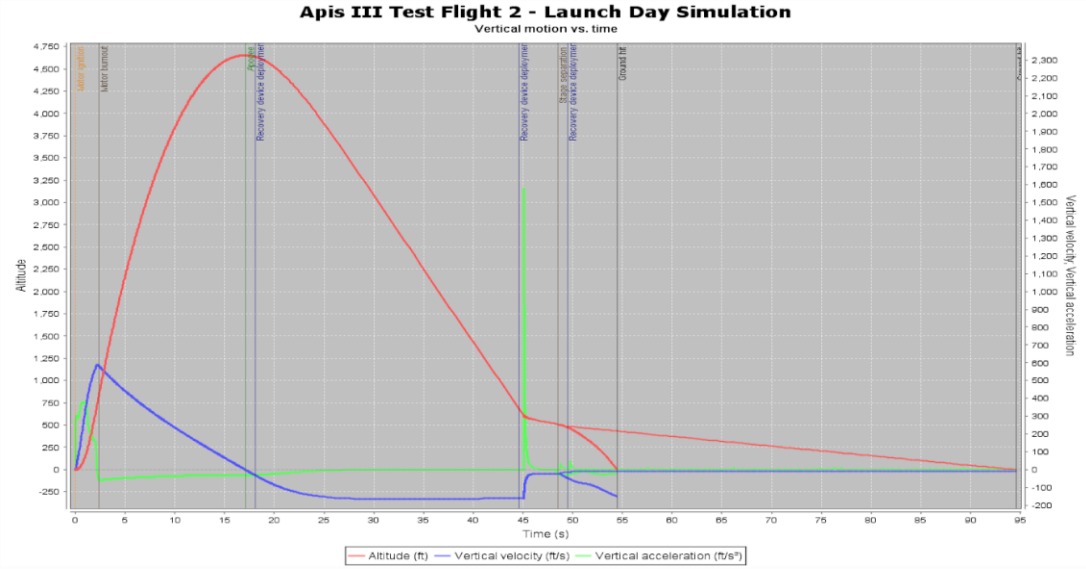
- Design wheels with pointed edges rather than flat edges to help with traction.
- Decrease size of electronics protective cover.

GROUND TESTING

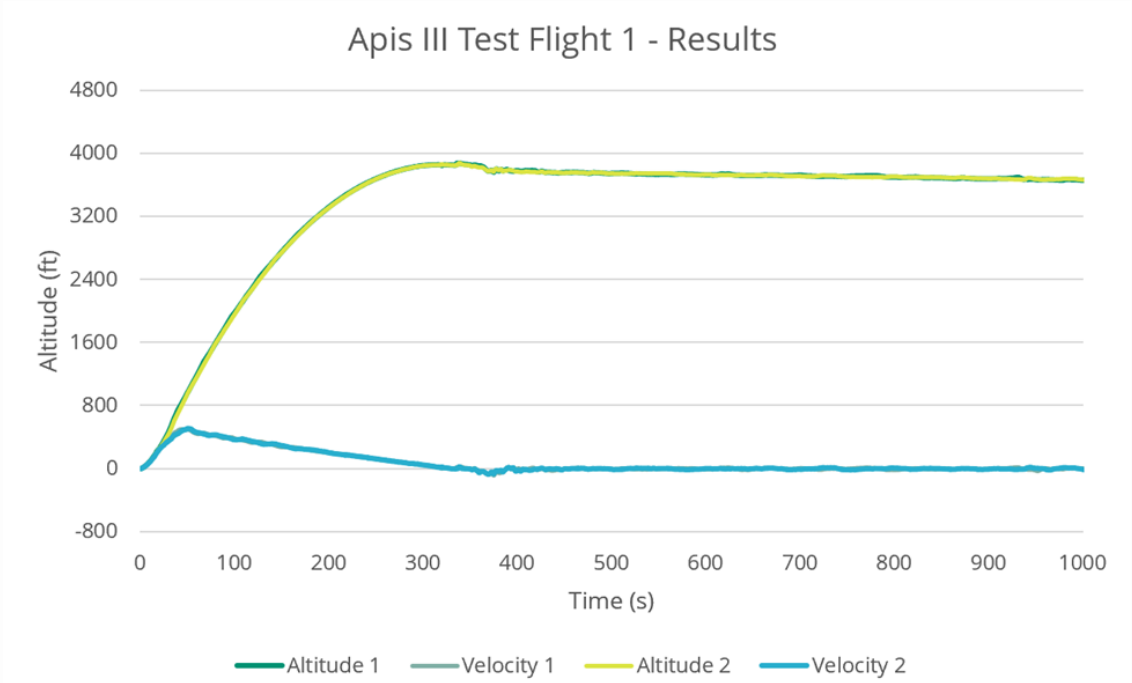
- Successful ground testing before each launch to confirm shear pins and black powder is sufficient.

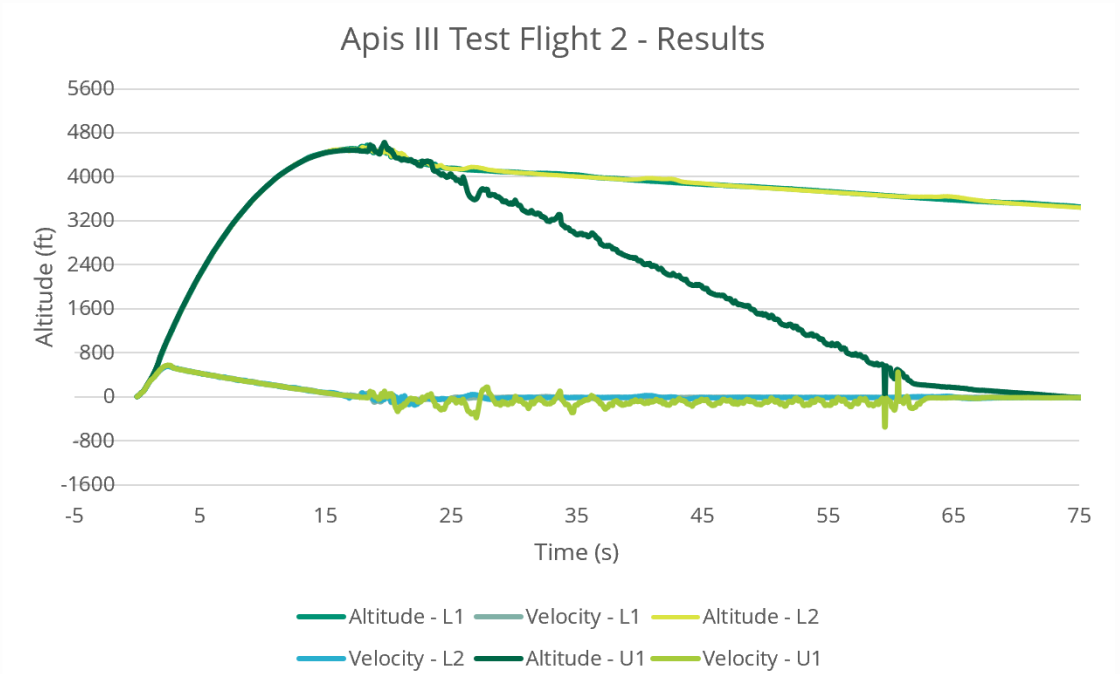
VEHICLE DEMONSTRATION TEST SIMULATION





VEHICLE DEMONSTRATION TEST RESULTS





PAYLOAD DESCENT LEVELLING SUBSYSTEM (PDLS) TEST

Full Scale PDLS Test Flight 1

Full Scale PDLS Test Flight 2

AGENDA

1. Vehicle Criteria
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4. **Payload**
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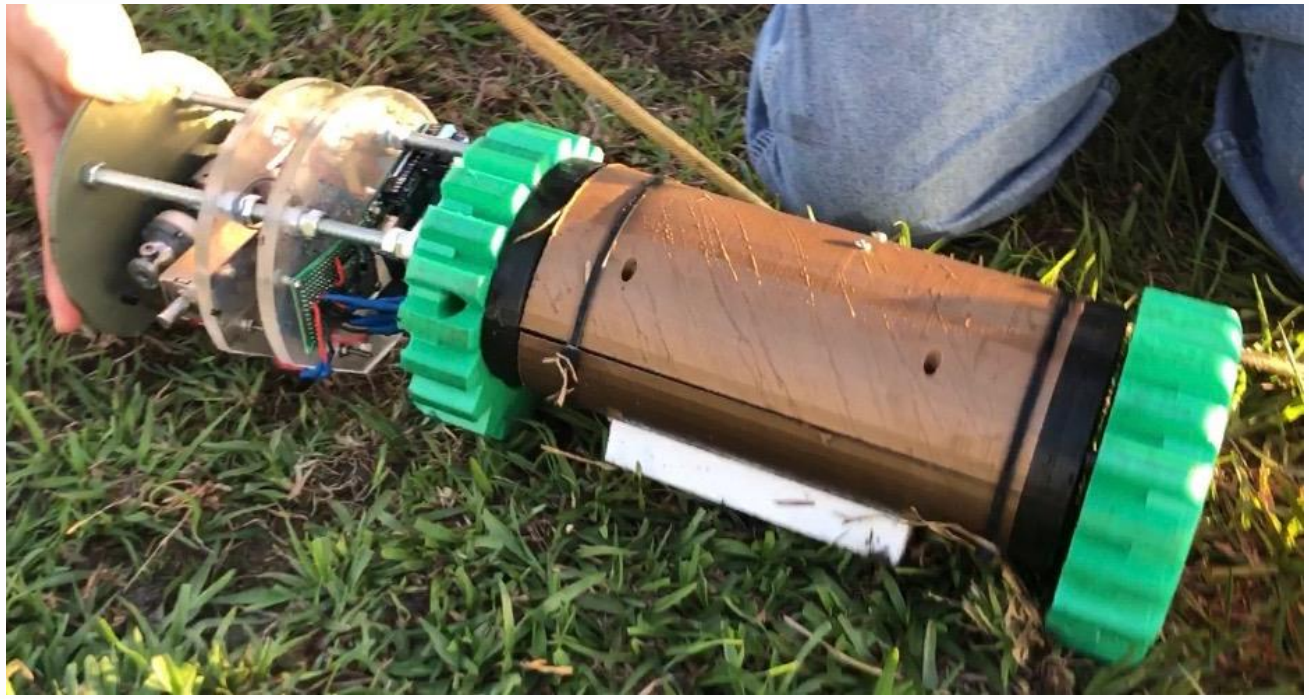
PAYLOAD SUMMARY

Component	Value
Max Weight	
Diameter	
Max Length	
Motor	
Projected Motor Run Time	
Stall Torque	



Nautilus attached to the deployment system

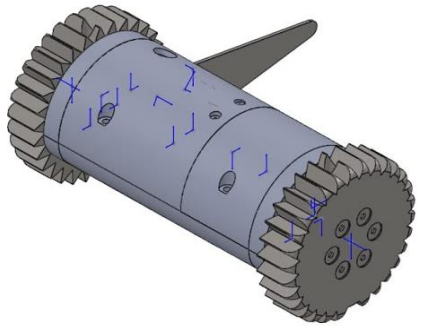
PAYLOAD DESIGN FEATURES

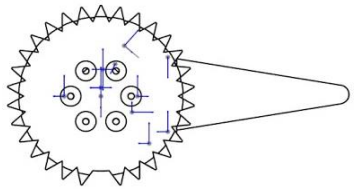
Vacuum System

- ....

Stabilizing Leg

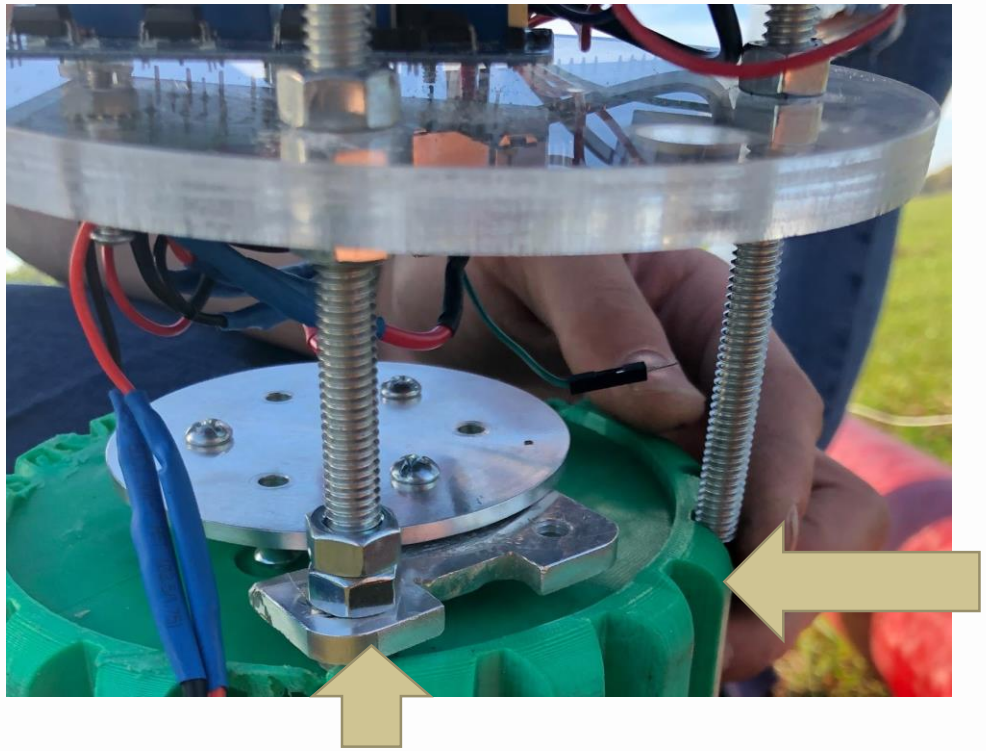
- Collapsible stabilizing arm that is spring loaded to release once Nautilus exits the upper airframe.





PAYLOAD RETENTION AND DEPLOYMENT

- Two solenoids will be attached to the deployment system and will secure the rover to the launch vehicle in a failsafe position.
- Once the ground team sends the signal the solenoids will release and allow the rover to me deployed from the launch vehicle.
- Proven reliability during two test flights.



Deployment system hook that secures the rover.
(Note this is not fastened all the way in)

INTERFACES WITH GROUND SYSTEMS

Turning on the payload

- …

Activating post-launch sequence

- …

PAYLOAD DEMONSTRATION FLIGHT

Objective

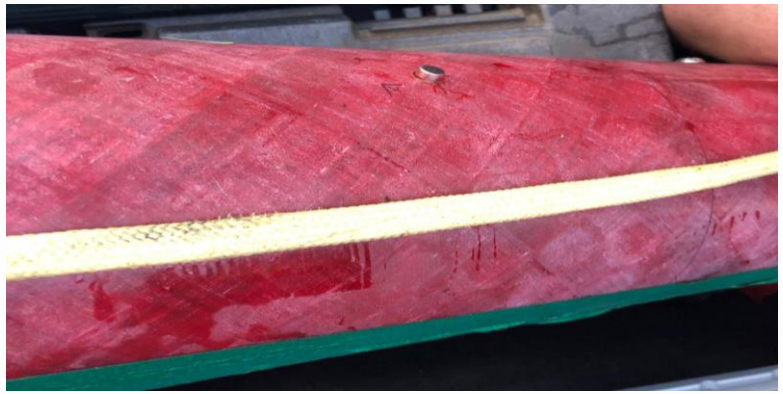
- To ensure the rover can stay retained inside the rocket during flight

Flight Results

- Successfully retained for two flights: 2/23/19 and 3/3/19

Issues

- The rover landed in water during the first flight so mission after landing was unable to be complete. We plan to complete this at our 3/16/19 launch.



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OUTREACH OVERVIEW

Participant's Grade Level	Education		Outreach	
	Direct Interactions	**Indirect Interactions**	**Direct Interactions**	**Indirect Interactions**
Preschool-4	164	-	50	50
5-9	528	-	45	710
10-12	100	-	30	485
University students	10	-	-	80
Educators	11	-	-	30
Adult non-students	20	50	75	260
Total	**833**	**50**	**200**	**1,615**
Grand Total	**2,698**			

REQUIREMENTS VERIFICATION SUMMARY

		General	Vehicle	Safety	Recovery	Payload
NASA Requirements	**Completed**	16	57	14	18	5
	Awaiting Completion	0	2	3	2	3
Derived Requirements	**Completed**	none	1	none	1	1
	Awaiting Completion	none	5 (Note 3 are no longer applicable)	none	0	2

NASA REQUIREMENTS NEEDING VERIFICATION

Launch Vehicle Requirements

- ***2.1*** *The vehicle will deliver the payload to an apogee altitude between 4,000 and 5,500 feet above ground level (AGL). Teams flying below 3,500 feet or above 6,000 feet on Launch Day will be disqualified and receive zero altitude points towards their overall project score.*
- ***2.21*** *An FRR Addendum will be required for any team completing a Payload Demonstration Flight or NASA-required Vehicle Demonstration Re-flight after the submission of the FRR Report.*

Recovery Requirements

- ***3.9*** *Recovery area will be limited to a 2500 ft. radius from the launch pads.*
- ***3.10*** *Descent time will be limited to 90 seconds (apogee to touch down).*

NASA REQUIREMENTS NEEDING VERIFICATION

Payload requirements

- ***4.3.3*** *At landing, and under the supervision of the Remote Deployment Officer, the team will remotely activate a trigger to deploy the rover from the rocket*
- ***4.3.4*** *After deployment, the rover will autonomously move at least 10 ft. (in any direction) from the launch vehicle. Once the rover has reached its final destination, it will recover a soil sample.*
- ***4.3.5*** *The soil sample will be a minimum of 10 milliliters (mL).*

Safety Requirements

- ***5.3.1.3*** *Safety officer will monitor all activities related to assembly of vehicle and payload*
- ***5.3.1.4*** *Safety officer will monitor all activities related to ground testing of vehicle and payload*
- ***5.3.1.7*** *Safety officer will monitor all activities related to launch day.*

SOCIETY OF AERONAUTICS AND ROCKETRY

Special thanks to our sponsor, CAE USA

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