PRELIMINARY DESIGN REVIEW

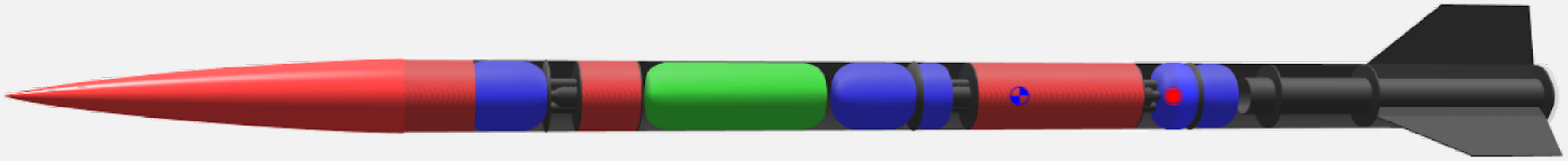
University of South Florida
Society of Aeronautics and Rocketry
NASA Student Launch 2018 - 2019

AGENDA

1. **Vehicle Criteria**
2. Recovery
3. Mission Performance Predictions
4. Payload
5. Requirements Compliance Plan

Vehicle Dimensions with Justifications

Measurement	Value	Justification
Diameter	6 in	In 2018, we launched a smaller rocket and determined 5" was not large enough to meet the requirements of the payload. This year we decided to go with 6".
Length	134 in	Similar to reasons stated above, we decided to go with a rocket longer then last year's which was 111" in order to allow for more space.
Projected Unloaded Weight	35.2 lbs	--
Projected Loaded Weight	46.2 lbs	--



Vehicle Materials with Justifications

Part of Rocket	Supplier	Model	Material	Justification
Nose Cone	Wildman Rocketry	FNC6.0-5-1VK-FW-MT	Fiberglass	Von Karman shape, 6’’ diameter, Moderately inexpensive, Lighter than the MadCow 6”
Shock Cord	Top Flight Recovery	TUK-1⁄2”	1/2” tubular nylon	Strong, durable, positive prior experiences with it
Rover Compartment	*Laid In-House*	--	Carbon fiber	Lightweight, Strong, Very inexpensive, Members gain manufacturing experience
Nose Cone Parachute	SkyAngle	Classic 20”	Low-porosity 1.3 oz. silicone-coated ripstop nylon	Reliable, positive prior experience, inexpensive, easy to fold
Rover body	Custom	--	machined aluminum or acrylic	Material not decided yet.

Vehicle Materials with Justifications

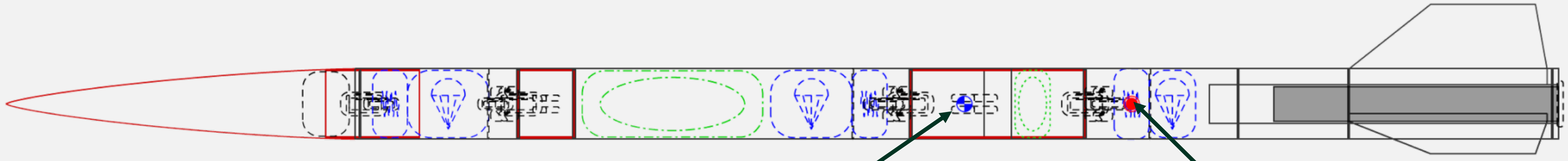
Part of Rocket	Supplier	Model	Material	Justification
Altimeter bays	*Laid In-House*	--	Carbon fiber	Lightweight, Strong, Very inexpensive, Members gain manufacturing experience
Internal Coupling Stage	*Laid In-House*	--	Carbon fiber	Lightweight, Strong, Very inexpensive, Members gain manufacturing experience
Piston system	Custom	CERT-3 XLarge - SkyAngle	ABS/PLA	Reliable, positive prior experience, less expensive, easy to fold
Altimeter bay bulkheads	Custom (McMaster-Carr)	--	1/8” Fiberglass Sheets	lightweight, durable, used it before
Altimeter Sled and Batteries	SkyAngle	--	3/8” Tubular Nylon	Strong, durable, positive prior experiences with it
Booster Section	*Laid In-House*	--	Carbon fiber	Lightweight, Strong, Very inexpensive, Members gain manufacturing experience

Vehicle Materials with Justifications

Part of Rocket	Supplier	Model	Material	Justification
Epoxy	Aeropoxy	Laminating Epoxy	Aeropoxy Laminating Epoxy	Extremely strong, Long working time (good for filament winding), High viscosity (forms excellent fin fillets), Extensive prior member experience
	Soller Composites	820 Epoxy	Soller Composites 820 Epoxy	Low viscosity, Very strong, Long working time, Intended for filament winding
Fins	*Laid In-House*	--	Carbon fiber	Lighter, Stronger, Consistent with body material
Centering ring	Custom	--	1/8” Fiberglass Sheets	lightweight, durable, used it before
Motor adapter/ retainer	AeroPack (Apogee Components)	24055	6061-T6 Aluminum	Durable, heat resistant
Motor mount	*Laid In-House*	--	Carbon fiber	Lightweight, Strong, Very inexpensive, Members gain manufacturing experience

Static Stability Margin and CP/CG Locations

Property	Value
Center of Gravity (from nose cone)	82 in
Center of Pressure (from nose cone)	96.7 in
Static Stability (calipers)	2.45



Center of Gravity (blue)

Center of Pressure (red)

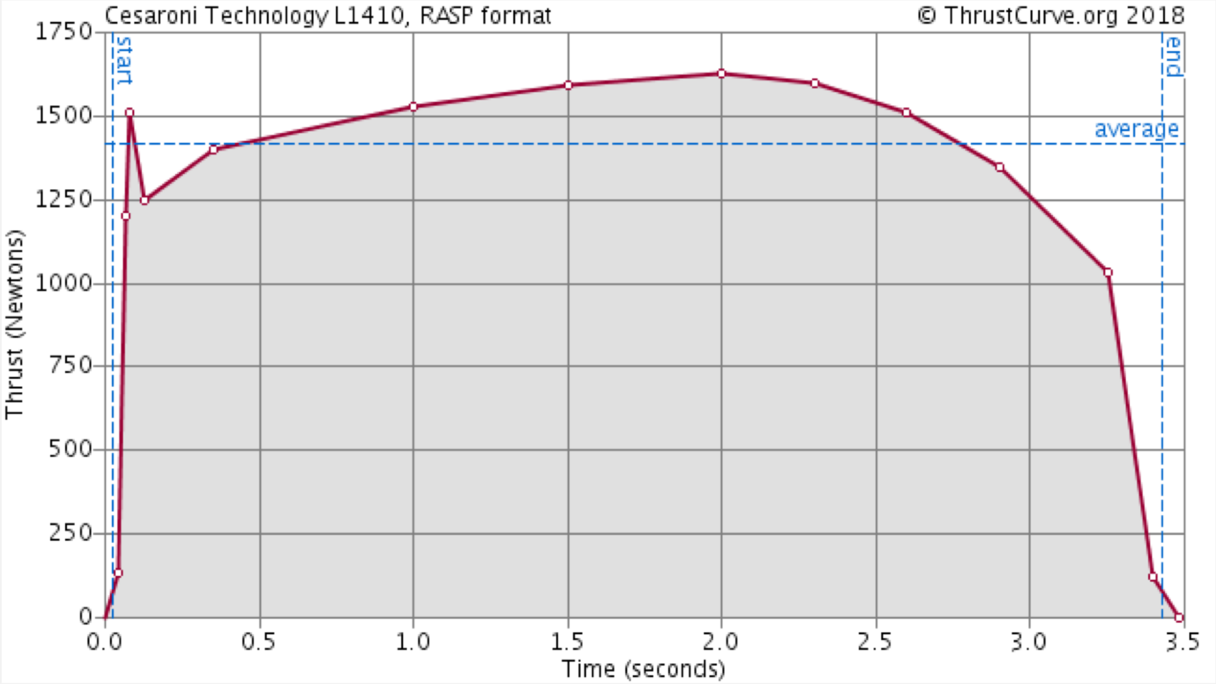
Motor Selection Justification

Motor	Simulated Velocity off Rod (ft/s)	Simulated Apogee (ft)
L1420	63.8	4964
L1365	61.8	5117
L2375	82.1	5741
L1210	58.6	5144
L1090	59.6	4839

Justification: This motor was selected for reaching the altitude closest to our target altitude of 5,000 feet given the rocket dimensions and subsystems. It will allow for some mass changes without having to choose a new motor.

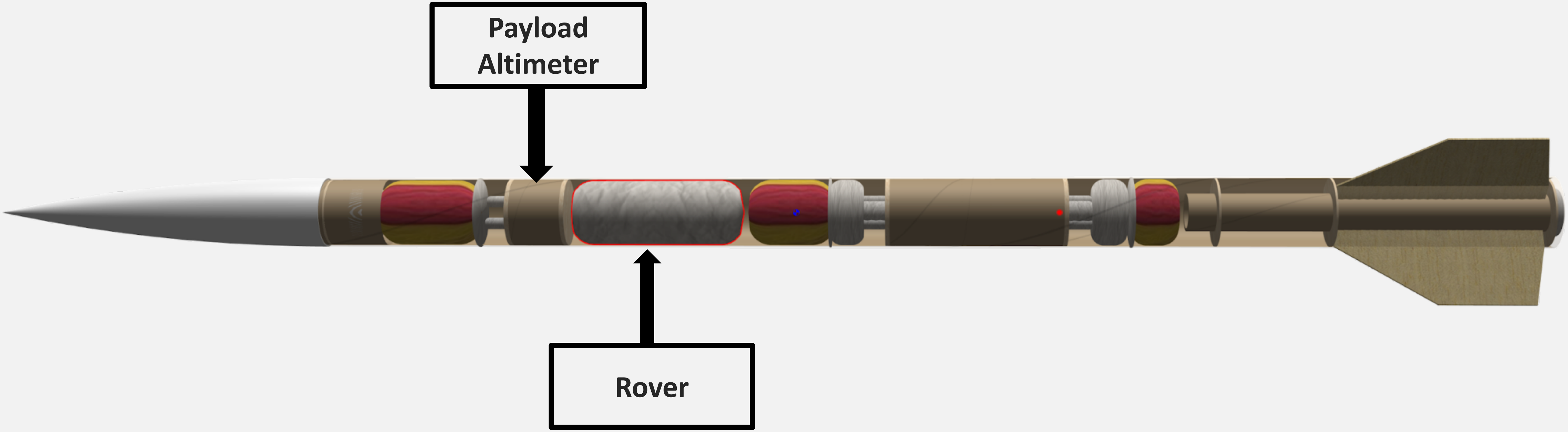
Motor Details

Cesaroni L1410	
Simulated Apogee	5144 ft
Total Impulse	4828.3 Ns
Burn Time	3.4 s
Diameter	75 mm
Length	75.5 cm
Propellant Weight	2875 g
Thrust-to-weight ratio	6.11
Exit Velocity	58.6 ft/s

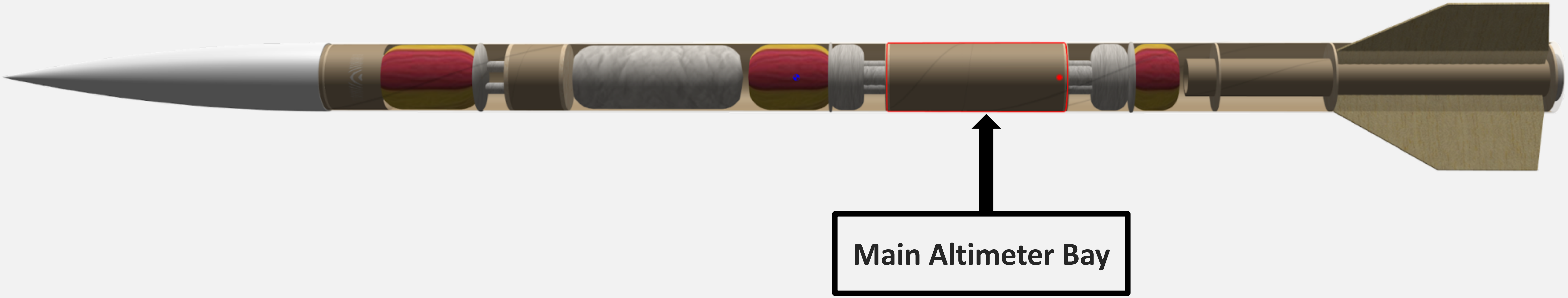


Major Component: Nose Cone

Major Component: Rover Compartment

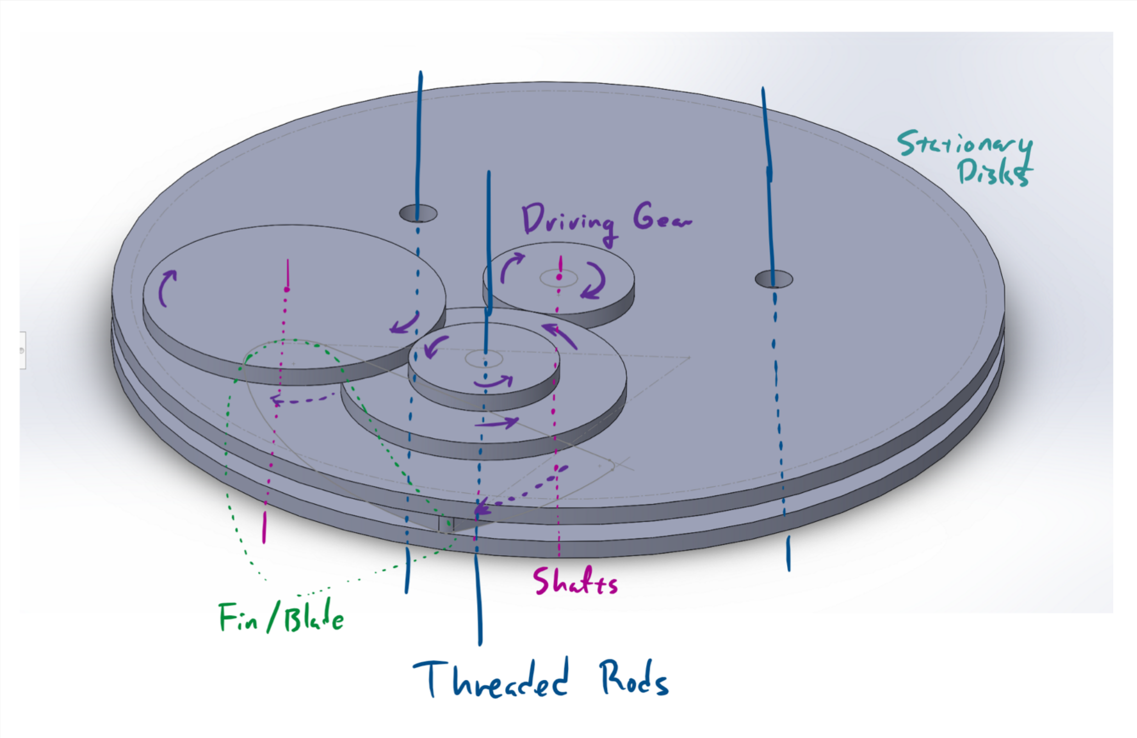


Major Component: Main Altimeter Bay



Major Component: Booster Section

Vehicle Subsystem: Airbrakes



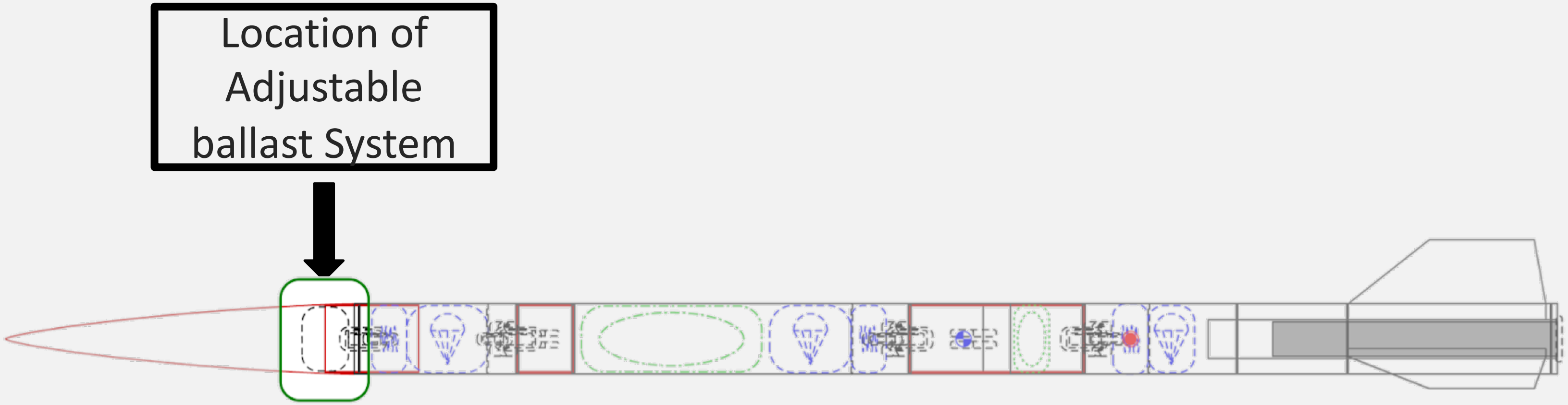
Airbrakes Key Features:

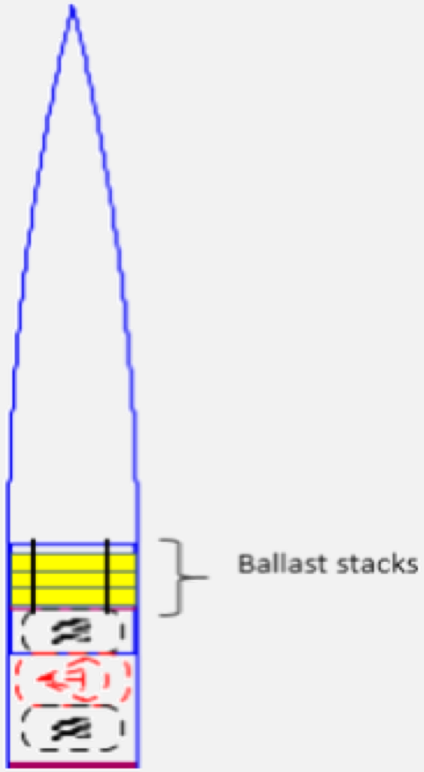
- Dynamic gear-actuated fin deployment employs the use of a gear system to transmit motor torque from a center shaft to the fins
- Consists of a central servo with a spur gear attached, three surrounding compound spur gears, and three pivoting fins with spur gears
- Allows for dynamic and fine-tuned fin deployment
- Increases torque to move fins

Vehicle Subsystem: Adjustable Ballast System

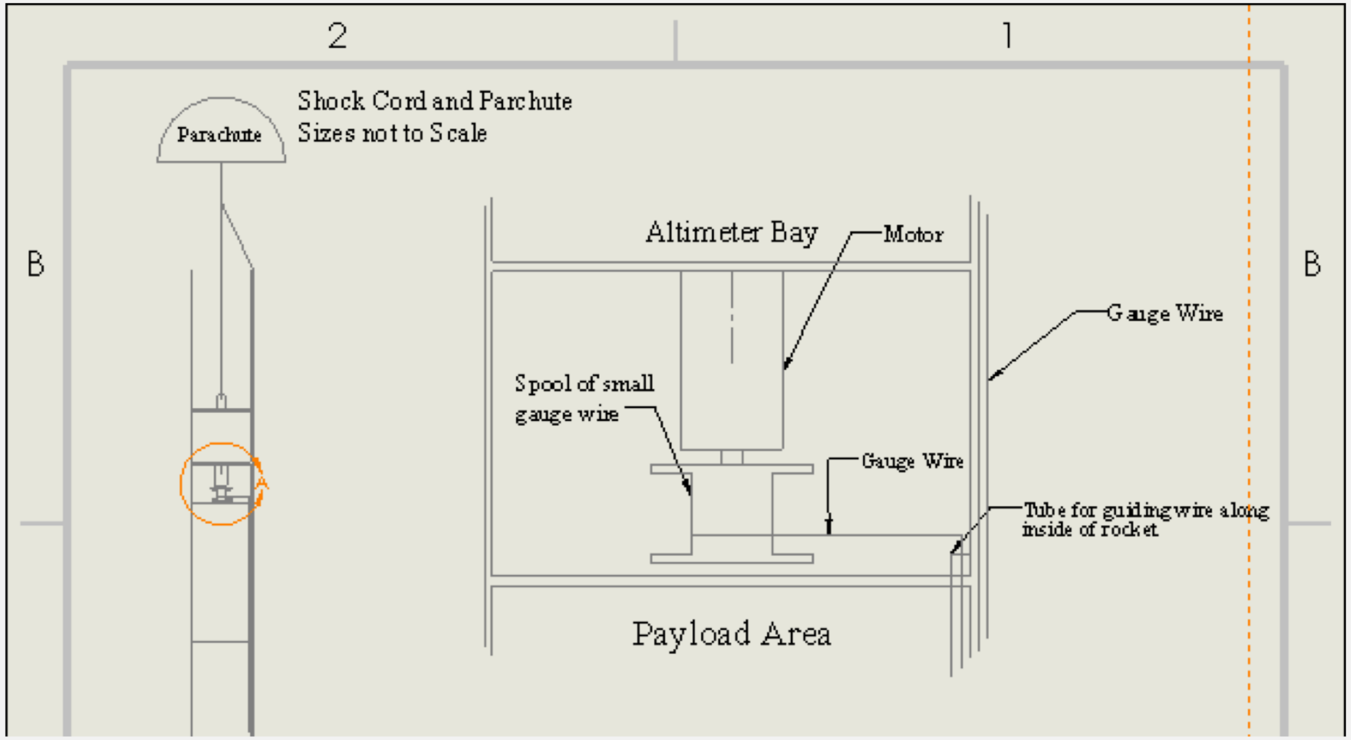
Adjustable Ballast System Key Feature:

- Will allow the nose cone weight to be adjusted
- Able to manipulate the flight path and apogee.
- consists of several stackable and removable ballast sleds.
- Each sled can hold up to 6 oz. of ballast, not including the mass of the sled itself.





Vehicle Subsystem: Payload Compartment Leveling System



Dynamic leveling system Key Features:

- A small-gauge wire be run along the outside of the rocket
- The wire would attach at the bottom of the upper altimeter bay, run through a hole to the top of the body tube, and back into the rocket to attach to the parachute shock cord
- A motor would run to tension the wire and pull the rocket into a horizontal position

AGENDA

1. Vehicle Criteria
2. **Recovery**
3. Mission Performance Predictions
4. Payload
5. Requirements Compliance Plan

Recovery Subsystem

Parachute Name	2 SkyAngle CERT-3 XL Parachutes	1 SkyAngle Classic 20" Parachute
Deployed at	650 ft / 1 s delay	Apogee
Material	Zero-porosity 1.9 oz balloon cloth	Low-porosity 1.3 oz. silicone-coated ripstop nylon.
Surface Area (sq ft)	89	4.4
Drag Coefficient	2.59	.80
Number of Lines	4	3
Line Length (in)	100	20
Line Material	5/8" Tubular Nylon (2,250 lbs.)	3/8" tubular nylon (950 lbs)
Attachment Type	Heavy-duty 1,500 lb. size 12/0 nickel-plated swivel	Heavy-duty 1,000 lb. size 9/0 nickel-plated swivel.
Terminal Velocity (ft/s)	-10.5	-133 .58

Recovery Subsystem

SkyAngle Cert-3 XL Info	
Velocity at Deployment	-132 f/s
Terminal Velocity	-10.5 f/s
Kinetic Energy of Nose cone and Rover Compartment at Impact	62.08 ft-lbf
Kinetic Energy of Booster and Altimeter Bay at Impact	37.93 ft-lbf

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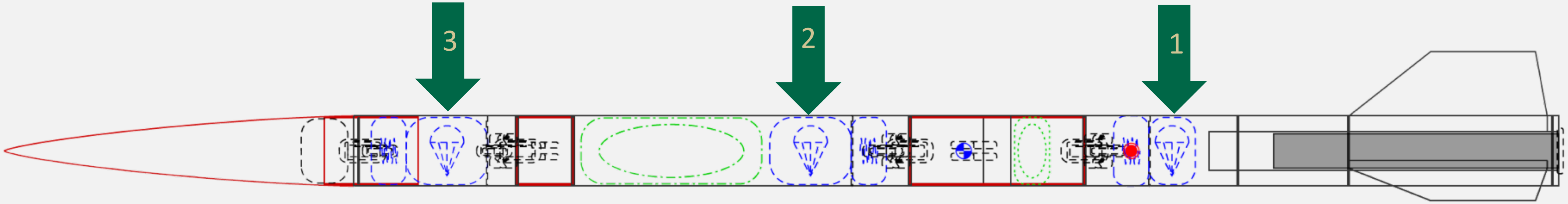
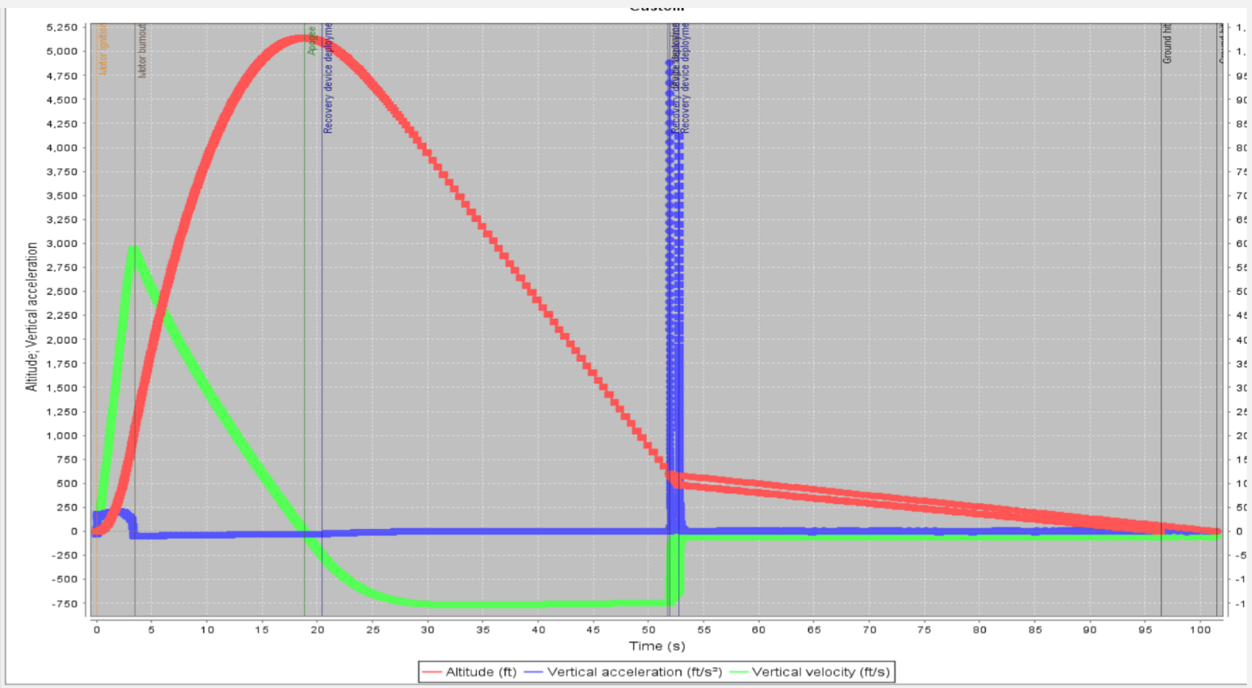
Recovery Subsystem location

1. SkyAngle Classic 20"/ Drogue parachute: Attached to shock cord that is attached to a U-bolt
2. SkyAngle CERT-3 XL /Booster Section parachute: Attached to shock cord that is attached to a U-bolt
3. SkyAngle CERT-3 XL/ Rover Compartment parachute: Attached to nosecone U-bolt and Payload Altimeter Bay U-bolt



Current Mission Performance Predictions: Launch Vehicle Flight

Property	Value
Target Apogee	5,000 ft
Simulated Apogee	5,144 ft
Unloaded Weight	39.8 lbs
Motor Weight	11.2 lbs
Total Weight	51 lbs



OpenRocket simulation of launch vehicle flight with the selected motor.

Current Mission Performance Predictions:

	Descent Time				Kinetic Energy at landing
	Method 1 {*V=sqrt(8mg/((pi)(rho)CdD^2))*}		Method 2 {Open Rocket}		
Section	Descent velocity (f/s)	Descent time (s)	Descent velocity (f/s)	Descent time (s)	Minimum A.Cd (ft^2)
Nose Cone and Payload	11.09	74.83	10.5	79.2	79.16
Booster (with Main Altimeter bay)	10.7	76.47	10.5	81.9	48.07

Current Mission Performance Predictions:

	Primary Method				Alternate Method			
	Booster Section		Nosecone and Rover Compartment		Booster Section		Nosecone and Rover Compartment	
Wind Speed (mph)	Wind Speed (ft./s)	Drift (ft.)	Wind Speed (ft./s)	Drift (ft.)	Wind Speed (ft./s)	Drift (ft.)	Wind Speed (ft./s)	Drift (ft.)
0	0	0	0	0	0	0	0	0
5	7.33	605.46	7.33	584.2	7.33	698.28	7.33	667.465
10	14.66	1210.92	14.66	1168.4	14.66	1350.08	14.66	1306.19
15	23.46	1937.8	23.46	1869.76	23.46	1928.22	23.46	1899.53
20	29.33	2422.66	29.33	2337.6	29.33	2296.03	29.33	2337.17

Primary Calculation Method
Calculated using OpenRocket simulations while overriding rocket mass.

Alternate Calculation Method
Calculated using OpenRocket lateral position at main parachute deployment then subtracting the wind velocity times the descent time.

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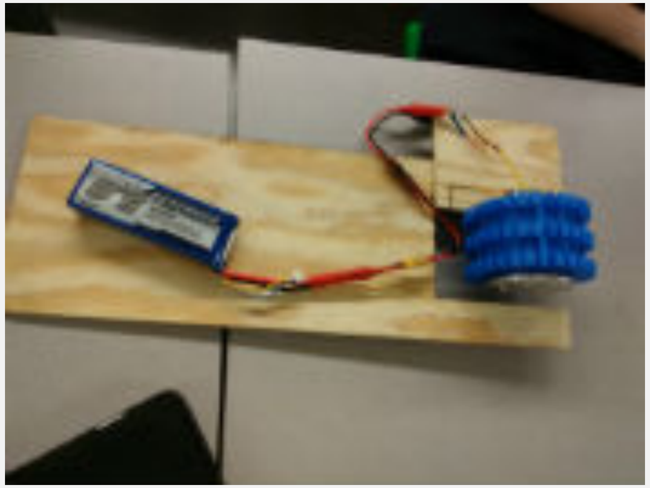
4. **Payload**
5. Requirements Compliance Plan

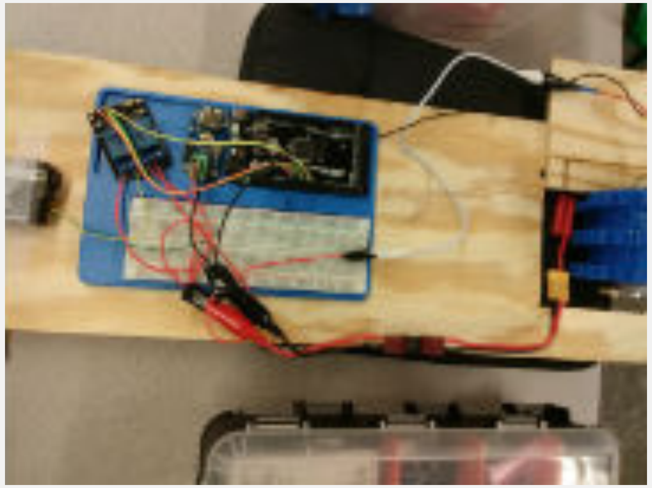
Preliminary Payload Design: Rover Body

Rover Body Key Features:

- Long flat body to fit into the vehicle body
- <6” diameter
- One or more drive wheels located in the front of the body in order to pull the rover
- Wheel(s) will be in direct contact with rocket body walls
- Modularity

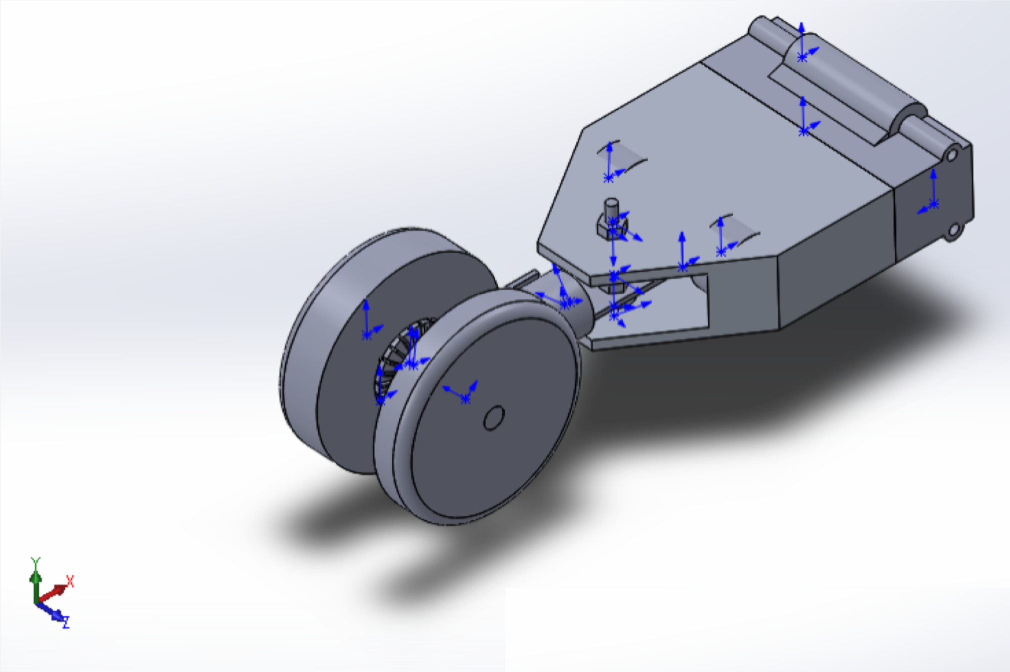


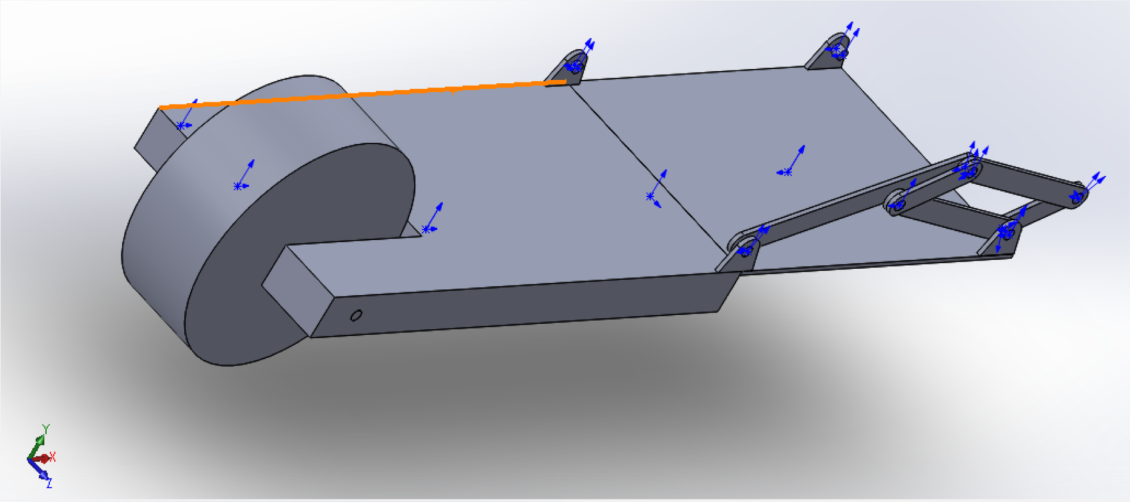
Prototype 1 Mk1 “Dragon”

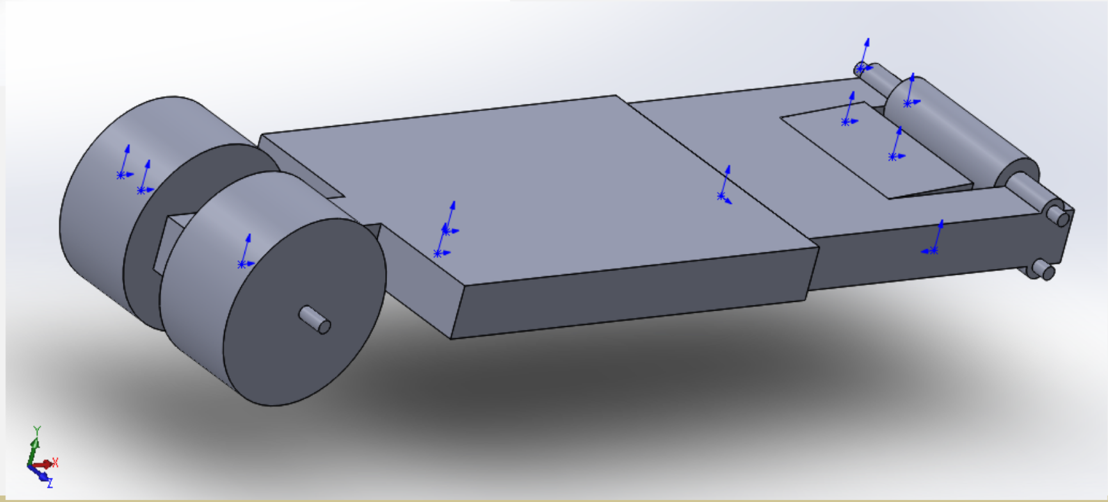


Prototype 1 Mk2 “Dragon 2 ”

Rover Body Early Concept







Preliminary Payload Design: Soil Retrieval

Soil Retrieval System Key Features:

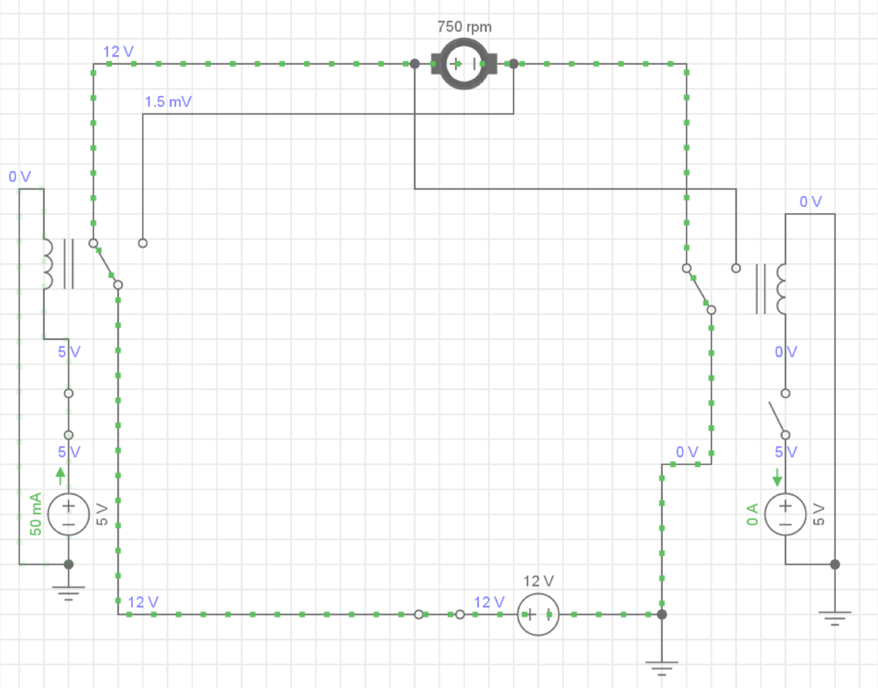
- Interchangeable designs
- Choose from multiple designs on launch day
- Mounting holes on the rover body
- All systems will have a singular motor and an additional servo for an auger system

Design	Pros	Cons
Auger	• Can collect soil over a wide range of soil conditions	• Large and complicated deployment mechanism. • Could potentially jam on a rock
Spinning dirt-throwing arm	• Will be able to break up hard dirt	• Will require a high RPM motor • May not throw dirt given wet or muddy conditions
Wheel scooper	• Able to collect dirt while rover is moving	• There will be resistance when driving the vehicle • Possible power draw if the drive motors and scooping system end up fighting each other
Sweeper	• Could be able to collect 10 mL of dirt without needing to physically penetrate the ground	• May not be able to sweep up packed, wet dirt

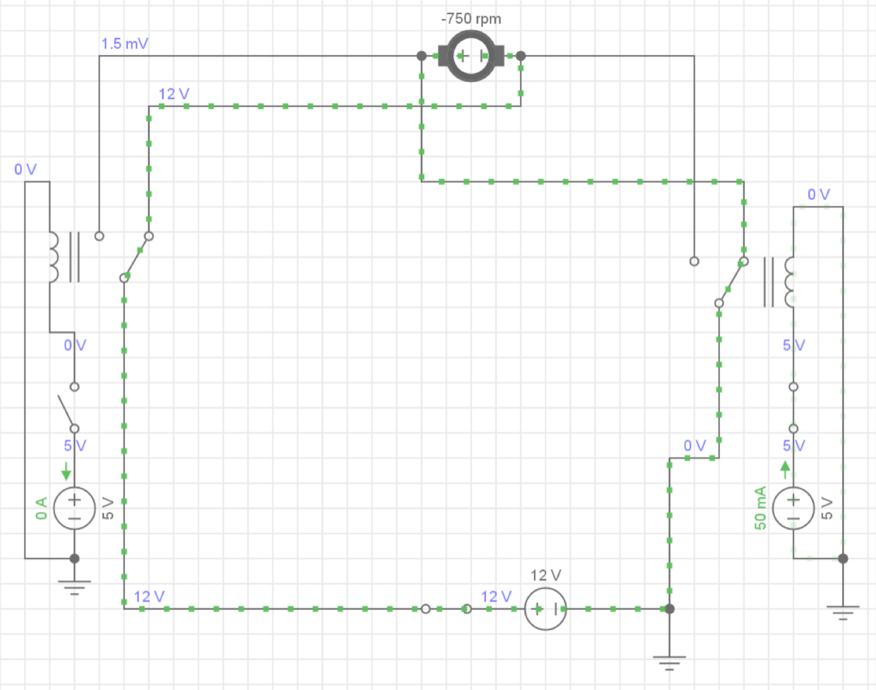
Preliminary Payload Design: Steering System

Steering system Key Features:

- Flexibility to move around obstacles
- Will consist of a combination of an arduino, relays, a DC motor, electromagnets and various sensors.
- Confirmed that the motor's direction can be changed
- Drive shaft will pivot laterally in order to move the main drive wheel



Current travelling through the positive terminal of the DC motor



Current travelling through the negative terminal of the DC motor

Preliminary Payload Design: Rover Deployment System

Payload Deployment System Key Features:

- Rover will be pulled out of the body
- Solenoids will hold the payload in place during flight and set to a fail safe default
- Solenoids will have extended arms to secure the payload
- Upon deployment, power will be supplied to the solenoid and the arms will retract

Winch Design	
Pros	Cons
• Proven reliable • Already have a successful design from NSL 2017-18 • Ability to pull the rover out of rocket body regardless of orientation	• Heavy weight • Takes up valuable space in the vehicle • More power required to power deployment system • Less room for payload

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Requirements Compliance Plan

		General Requirements	Vehicle Requirements	Safety Requirements	Recovery Requirements	Payload Requirements
Regular Requirements	Completed	6	27	1	6	1
	Awaiting Completion	10	31	17	14	7
Derived Requirements	Completed	0	0	none	none	0
	Awaiting Completion	1	6	none	none	3

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