Preliminary Design Review

TEXAS TECH UNIVERSITY SPACE RAIDERS

Our Team

Leadership

- Faculty Advisor: Andrew Mosedale
- Team Mentor: Bill Balash
- Team Leader: Davis Hall
- Safety Officer: Derrick Slatton
- Vehicle Lead: Edward Heib
- Recovery Lead: Matthew Rowe
- Payload Lead: Jacob Hinojos
- Adult Educator: Barre Wheatly

Team Members

To Be Discussed

- Vehicle Mission & Success
- Vehicle Design Information
- Recovery Design Information
- Payload Design Information
- General Requirements
- Safety Equipment
- Flight Predictions > Vehicle, Recovery, and Payload
- Summary

Vehicle Mission & Success

Success Criteria

- Raider Aerospace Society is the premier aerospace-centered organization at Texas Tech University. Founded in 2016, it has worked to provide student's opportunity to explore and gain experience in the fields of aerospace and aviation. Space Raiders is a subsect of Raider Aerospace Society, and is geared towards aerospace competition and long term projects. Our team is comprised of 24 undergraduate engineering students covering a spectrum of engineering disciplines and interests.

Success Criteria

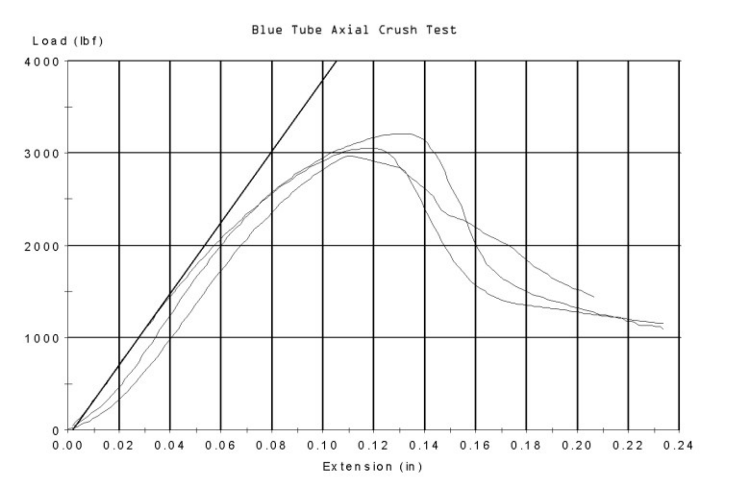
- Stay within a $2000 budget
- Maintain stable flight
- Achieve target altitude of 5280 ft
- Provide secure mounting frame for payload bay
- Implement Dynamic Apogee Control System (DACS) to control vehicle velocity after burnout
- Reach 52 ft/s rail exit velocity
- Safely fabricate and test all rocket components
- Make vehicle completely reusable

Vehicle

Vehicle Material Comparison

Blue Tube 2.0

- Good Balance of strength and pricing



Carbon Fiber

- Strongest option
- Most expensive option

Phenolic Tubing

- Weakest material
- Cheapest material

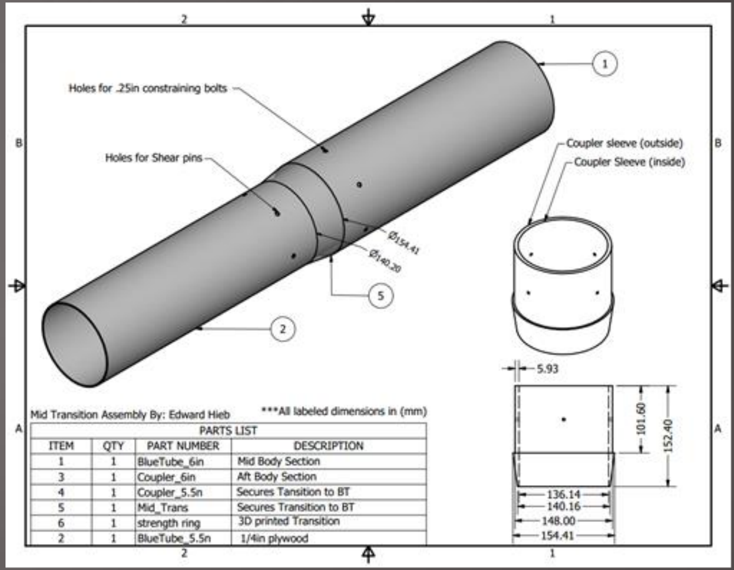
Vehicle Design Comparison

Constant Tube Diameter

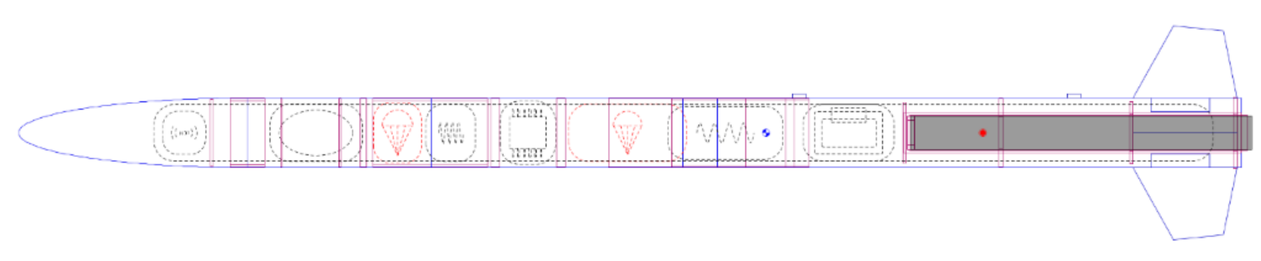
- Less complexity
- Cost effective
- Greater rigidity compared to the Drag Eliminating Teardrop Shape (DETS) design
- Higher drag coefficient

Tapering Tube Diameter, DETS

- Reduces drag
- Adds complexity
- Loss of rigidity
- Possible failure point
- Adds cost



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	BlueTube_6in	Mid Body Section
3	1	Coupler_6in	Aft Body Section
4	1	Coupler_5.5n	Secures Tansition to BT
5	1	Mid_Trans	Secures Transition to BT
6	1	strength ring	3D printed Transition
2	1	BlueTube_5.5n	1/4in plywood



Fin Design

G10

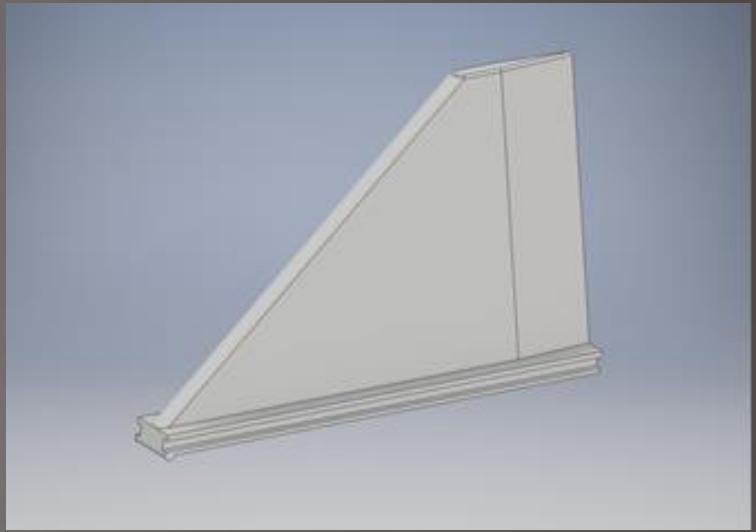
- Heat resistant
- High tensile strength
- Expensive in comparison

Plywood

- Alternating wood grains
- Affordable and testable

Our Decision – G10

- Team familiarity and experience handling G10
- Extremely high tensile strength, more than capable for function
- Purchased at 0.635 cm (1/4 inch) and may be sanded down to desired width for slot



Nose Cone Design

Public Missiles, 15.240cm (6”) diameter fiberglass Ogive

- Benefit – Strength of fiberglass
- Exposed length of 60.960cm (24").

Apogee, 15.240cm (6”) diameter fiberglass ogive

- Benefit – Strength of fiberglass
- Exposed length of 76.2cm (30")

ABS plastic 3D printed long elliptical shape

- Long elliptical shape has least amount of drag
- Significantly more affordable
- Challenge of design complexity

Rail Buttons

Considerations

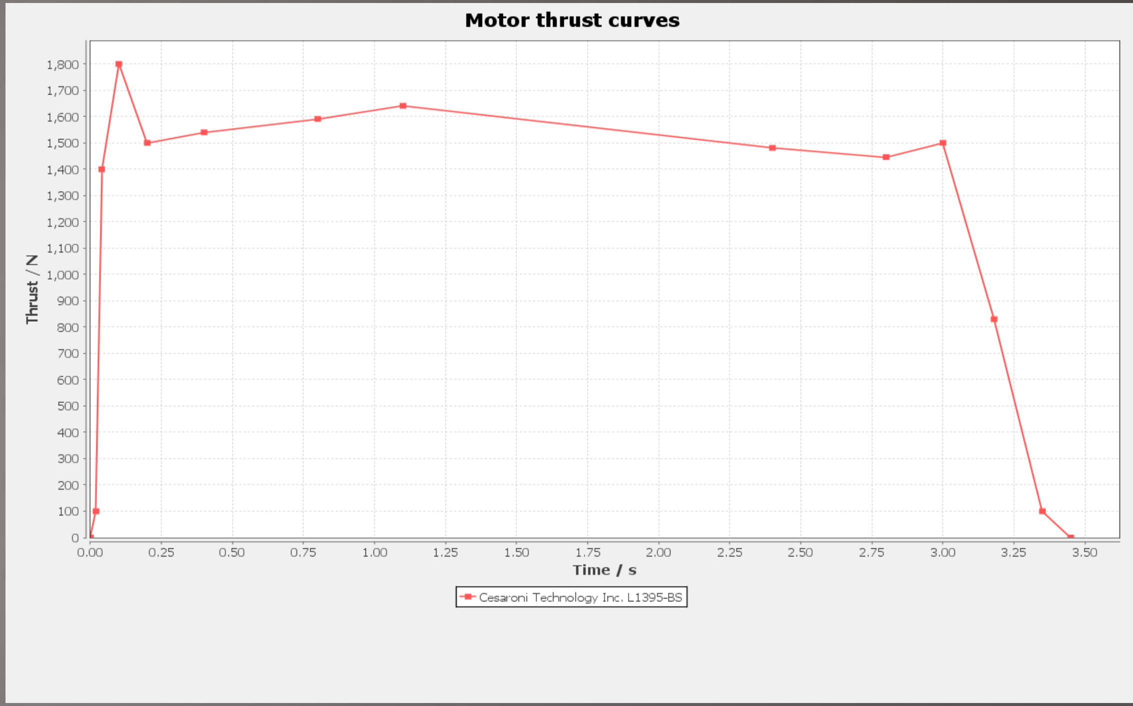
- 3D printed from ABS plastic
- Rail button failure, ballistic flight

Decision

- Decided against 3D printing due to the shear being applied
- Commercially available Derlin 1515 rail buttons, ensure functionality

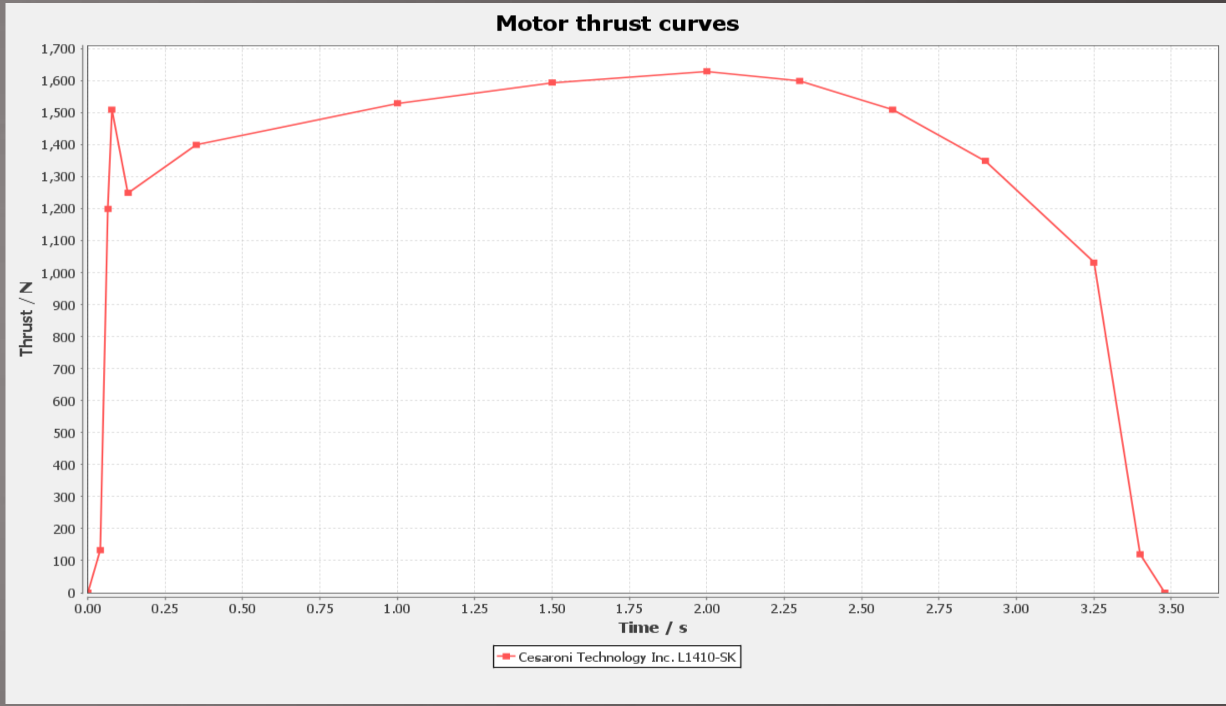
Cesaroni L1395 – BS (Motor)

- 4 Grain, 75mm (2.953")
- Total Impulse: 4895N-s (1100.439 lbf-s)
- Average Thrust: 1463N (328.895 lbf)
- Max Thrust: 1800N (404.656 lbf)
- Launch Mass: 4323g (9.531lbm)
- Empty Mass: 1848g (4.074 lbm)



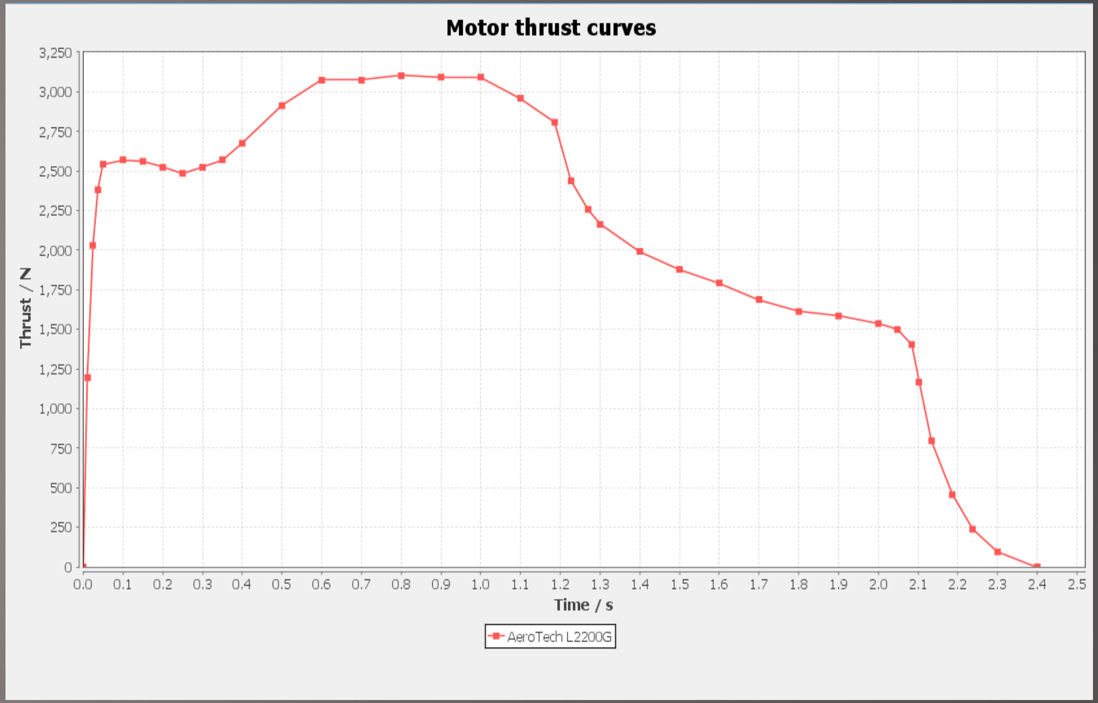
Cesaroni L1410-SK

- 5 Grains, 75mm (2.953")
- Total Impulse: 4828N·s (1085.378 lbf·s)
- Average Thrust: 1419N (319.003 lbf)
- Max Thrust: 1630N (366.439)
- Burn Time: 3.4s
- Launch Mass: 5115g (11.277 lbm)
- Empty Mass: 2240g (4.938 lbm)



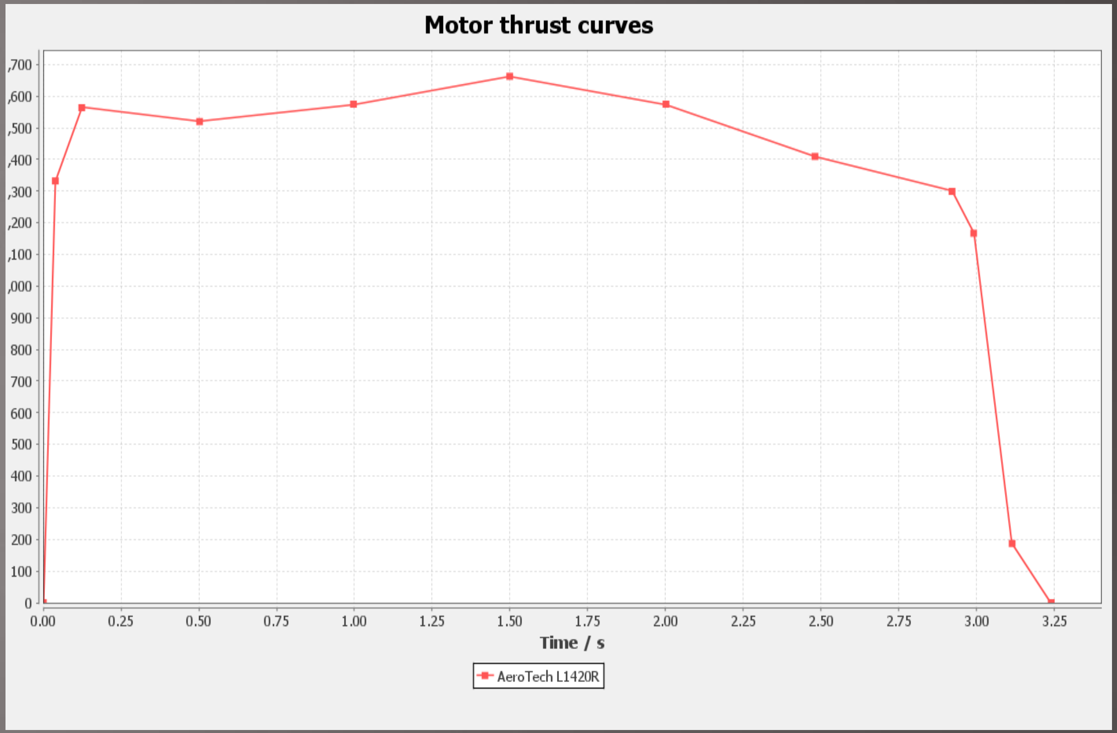
Aerotech L2200G

- 4 Grain, 75mm (2.953")
- Total Impulse: 5104N·s (1147.425 lbf·s)
- Average Thrust: 2243N (504.246 lbf)
- Max Thrust: 3102N (697.357 lbf)
- Burn Time: 2.27s
- Launch Mass: 4751g (10.474 lbm)
- Empty Mass: 2235g (4.927 lbm)



Aerotech L1420R

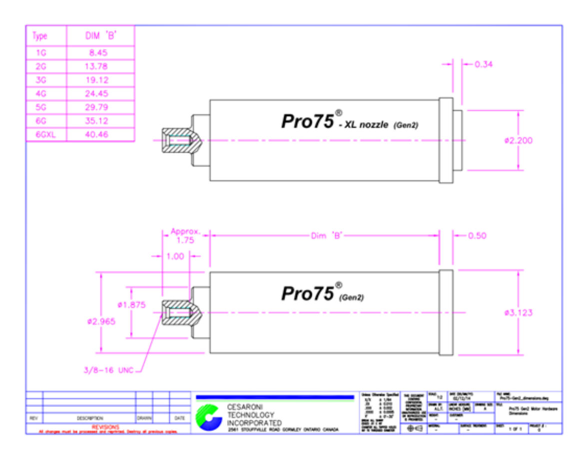
- 4 Grain, 75mm (2.953")
- Total Impulse: 4603N·s (1034.795 lbf·s)
- Average Thrust: 1420 N (319.228 lbf)
- Max Thrust: 1814 N (407.803 lbf)
- Burn Time: 3.2s
- Launch Mass: 4562g (10.057 lbm)
- Empty Mass: 2002g (4.414 lbm)



Motor Hardware

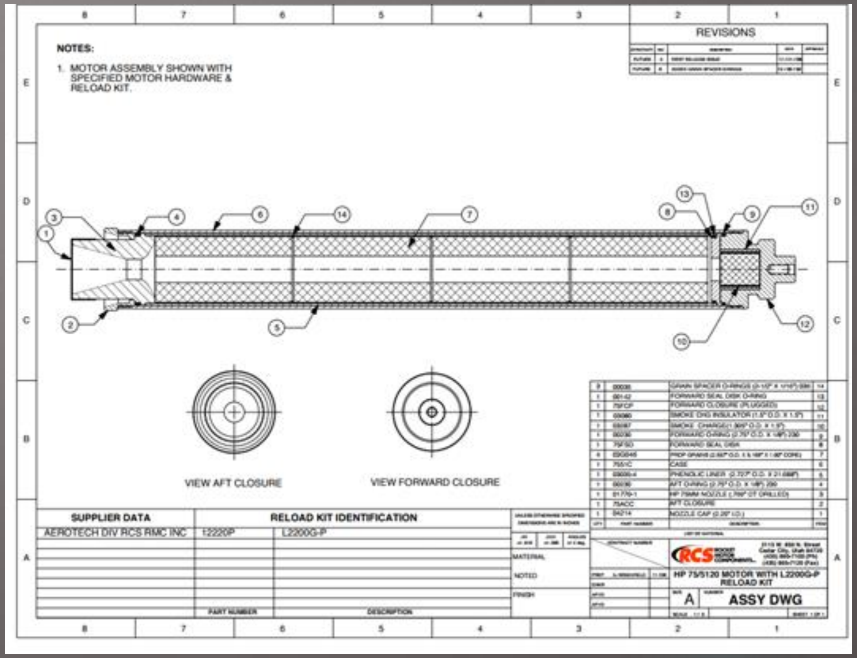
Cesaroni Casing

- Cesaroni manufactures casings for there motors therefore they are directly compatible with any of their motors
- CNC machined 6061 – T6 anodized aluminum



Aerotech Casings

- More expensive
- Dependent on motor selection

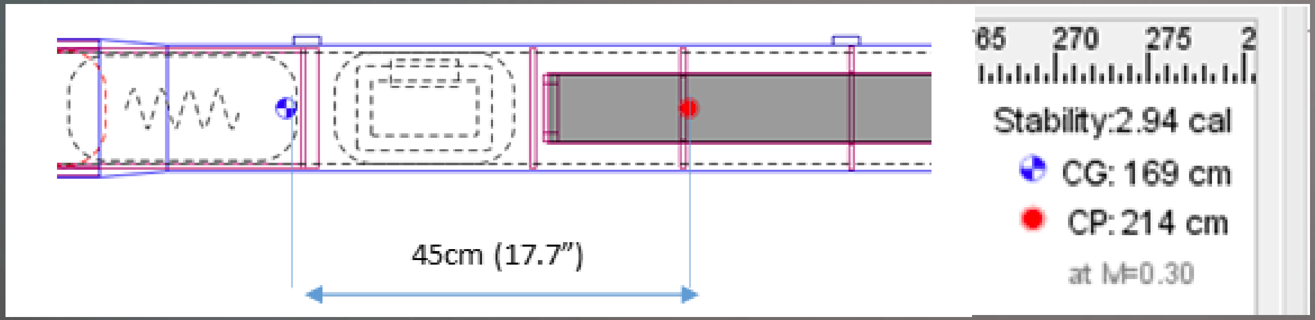


Flight Stability & Characteristics

Stability Factor

- Hand calculated data = 2.97
- RockSim data = 2.94

(CP−CG)d=Stability Factor



Contributing Characteristics of Stability

- DETS Increases stability at a cost
- G10 fins provides stability

Leading Vehicle Design

- Rocket Body: 6 in Blue Tube 2.0
- Fin Design: G10 – Design TBD with more concrete mass
- Commercial Derlin 1515 Rail Button
- Nose Cone Design: 3-D Printed Long Elliptical Shape
- Motor & Casing: Cesaroni L1410 SK

Launch Vehicle Summary

Rocket Dimensions

- Overall Length: 107.5 in
- Body Outer Diameter: 6 in
- Body Inner Diameter: 5.98 in
- Rocket Launch Weight: 20918g

Motor – Cesaroni L1410 SK

- $5\ Grains, 75mm$ (2.953")
- $Total\ Impulse$: $4828N \cdot s$ (1085.378 $lbf \cdot s$)
- $Average\ Thrust$: $1419N$ (319.003 lbf) $Max\ Thrust$: $1630N$ (366.439)
- $Burn\ Time$: 3.4s $Launch\ Mass$: $5115g$ (11.277 lbm)
- $Empty\ Mass$: $2240g$ (4.938 lbm)

Recovery

Parachute Method

Hand Made

- Time consuming
- More affordable
- Inexperienced

Commercial Bought

- Varity of shapes/designs
- More Expensive
- Spill hole ($$$)
- Elliptical ($)

Our Decision

- Commercial bought – Spill hole parachute

Main Parachute Determination and Energy

- Assuming Rocket Weight and Desired Kenetic Energy
- Approximate Parachute Diameter
- Determine Best Parachute Diameter
- Ans >> d = 16 in ø, v = 10.03 ft/s

$$KE = \frac{1}{2}mv^2 < 75\,ft \bullet lbf \qquad v < \sqrt{\frac{2 * g * KE}{W}}$$

$$v < \sqrt{\frac{2 * 32.2 ft/s^2 * 75 ft \bullet lbf}{47.1\ lbs}} < 10.127\ ft/s$$

$$S = \frac{2W}{\rho v^2 C_d} = \frac{2 * 47.1\ lbs}{0.075 \frac{lb}{ft^3} * \left(10.127 \frac{ft}{s}\right)^2 * 2} * \frac{32.2\ lb}{1 \frac{lbf s^2}{ft}} = 190.460\, ft^2$$

$$d = \text{minimum diameter of the main parachute}$$

$$A = \text{area of circle} = \frac{\pi}{4} d^4$$

$$d = \sqrt{\frac{4 * S}{\pi}} = \sqrt{\frac{4 * 183.979\, ft^2}{\pi}} = 15.572\, ft$$

$$A = S = \frac{\pi}{4} d^2 = \frac{\pi}{4} * (16 ft)^2 = 201.062\, ft^2$$

$$v = \sqrt{\frac{2W}{\rho C_d S}} = \sqrt{\frac{2 * 47.1\ lbs * 32.2\ ft/s^2}{0.075 \frac{lb}{ft^3} * 2 * 201.062\, ft^2}} = 10.029\ ft/s$$

1ft Drogue Wind Drift

DRIFT CALCULATIONS FOR ALTERNATING CONDITIONS

1 Foot Drogue Drift					
Drift Calculations, Minimum Decent Velocity					
Wind Speed (mph)	0.000	5.000	10.000	15.000	20.000
Wind Speed (ft/s)	0.000	7.333	14.667	22.000	29.333
Wind Speed (m/s)	0.000	1.524	3.048	4.572	6.096
Drift - Main (ft)	0.000	366.259	732.569	1098.828	1465.087
Drift - Drogue (ft)	0.000	139.193	278.404	417.597	556.789
Drift - Main (m)	0.000	111.636	223.287	334.923	446.559
Drift - Drogue (m)	0.000	42.426	84.858	127.283	169.709
Total Drift (ft)	0.000	505.452	1010.973	1516.425	2021.876
Total Drift (m)	0.000	154.062	308.144	462.206	616.268
Drift Calculations, Average Decent Velocity					
Wind Speed (mph)	0.000	5.000	10.000	15.000	20.000
Wind Speed (ft/s)	0.000	7.333	14.667	22.000	29.333
Wind Speed (m/s)	0.000	1.524	3.048	4.572	6.096
Drift - Main (ft)	0.000	66.096	132.200	198.296	264.391
Drift - Drogue (ft)	0.000	224.362	448.755	673.118	897.480
Drift - Main (m)	0.000	20.146	40.295	60.441	80.587
Drift - Drogue (m)	0.000	68.386	136.781	205.166	273.552
Total Drift (ft)	0.000	290.458	580.956	871.414	1161.871
Total Drift (m)	0.000	88.532	177.075	265.607	354.138

2ft Drogue Wind Drift

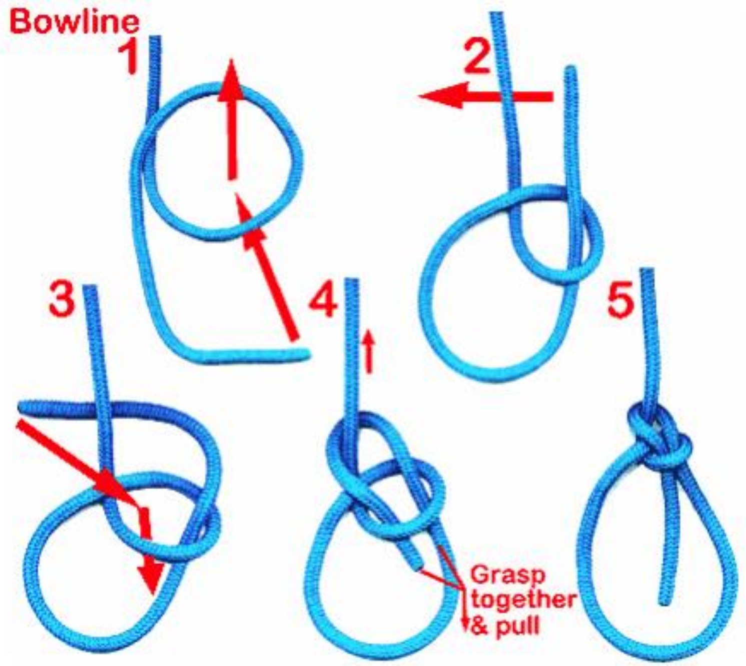
DRIFT CALCULATIONS FOR ALTERNATING CONDITIONS

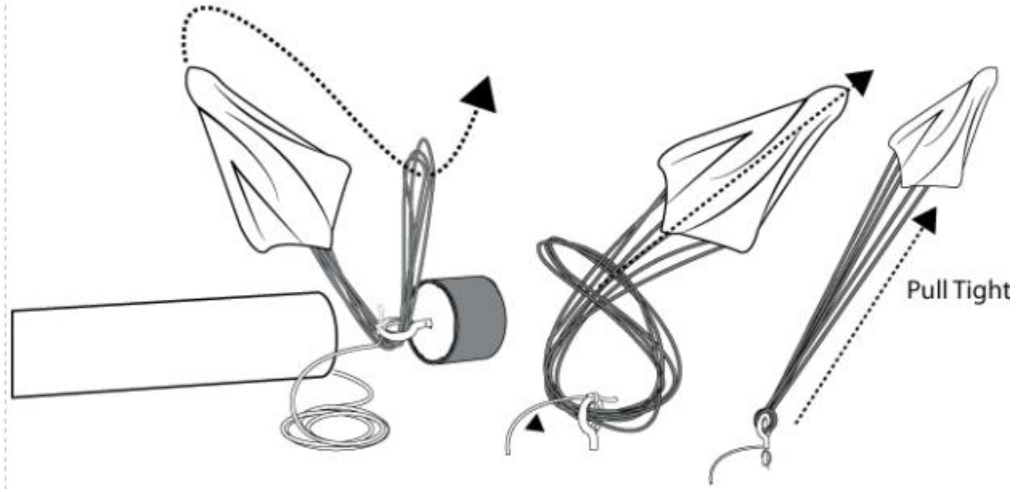
2 Foot Drogue Drift

Drift Calculations, Minimum Decent Velocity					
Wind Speed (mph)	0.000	5.000	10.000	15.000	20.000
Wind Speed (ft/s)	0.000	7.333	14.667	22.000	29.333
Wind Speed (m/s)	0.000	1.524	3.048	4.572	6.096
Drift - Main (ft)	0.000	362.302	724.654	1086.957	1449.259
Drift - Drogue (ft)	0.000	269.145	538.328	807.473	1076.618
Drift - Main (m)	0.000	110.430	220.875	331.304	441.734
Drift - Drogue (m)	0.000	82.036	164.082	246.118	328.153
Total Drift (ft)	0.000	631.448	1262.982	1894.429	2525.877
Total Drift (m)	0.000	192.465	384.957	577.422	769.887
Drift Calculations, Average Decent Velocity					
Wind Speed (mph)	0.000	5.000	10.000	15.000	20.000
Wind Speed (ft/s)	0.000	7.333	14.667	22.000	29.333
Wind Speed (m/s)	0.000	1.524	3.048	4.572	6.096
Drift - Main (ft)	0.000	155.071	310.163	465.234	620.305
Drift - Drogue (ft)	0.000	330.787	661.619	992.406	1323.193
Drift - Main (m)	0.000	47.266	94.538	141.803	189.069
Drift - Drogue (m)	0.000	100.824	201.661	302.485	403.309
Total Drift (ft)	0.000	485.858	971.782	1457.640	1943.498
Total Drift (m)	0.000	148.089	296.199	444.289	592.378

Shock Cords

Swivel and Quick Links		
Distributor	Model (Diameter)	Price
RocketMan	Kevlar Covered Tubing with Nylon Webbing - 1" x 30'	$ 55.00
RocketMan	Tubular Nylon Webbing - 1" x 30'	$ 40.00
RocketTarium	Red Elastic - 5/8" x 30'	$ 12.50
RocketTarium	Neon Orange Tubular Nylon - 5/8" x 30'	$ 20.90
RocketTarium	Neon Orange Tubular Nylon - 1" x 30'	$ 24.90





Parachute Connections to Shock Cord

Black Powder Selection

FFF

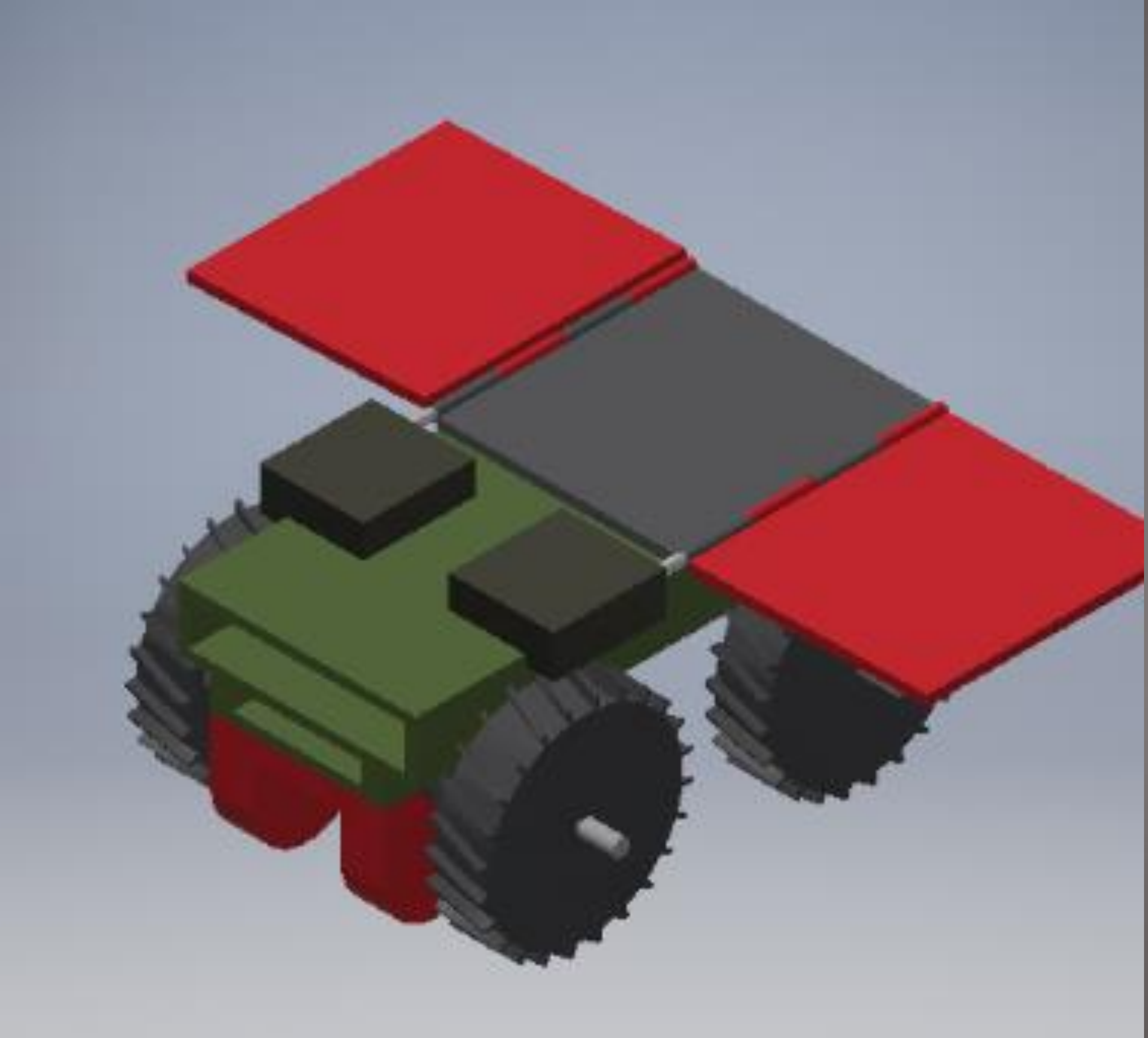
- Low Force Explosive
- Affordable

FFFF

- More Expensive
- Limited Supply
- Highly Explosive

Leading Recovery Design

	Parts	Quantity	Unit Cost	Total Cost
Electronics Bay				
	Plywood	1	$ -	$ -
	1/2" carrage bolts Long	2	$ 2.65	$ 5.30
	1/2" Nuts	6	$ 0.20	$ 1.20
	Terminal block	2	$ 3.41	$ 6.82
	Perfect Flight StratologgerCF	2	$ 60.00	$ 120.00
	9v Battery	4	$ 11.03	$ 44.12
Chute				
	1000lbs Swivle	2	$ 6.00	$ 12.00
	Standard Low-Porsity Ripstop	1	$ 170.00	$ 170.00
	2' Drogue - Pro 1.9	1	$ 25.00	$ 25.00
	2ft Deployment Bag	1	$ 17.00	$ 17.00
	16ft Deployment Bag	1	$ 15.00	$ 15.00
	Tubular Nylon Webbing - 1" x 30'	2	$ 40.00	$ 80.00
Seperation				
	Apogee XL Ejection Charge Canister	4	$ 2.75	$ 11.00
	Black Powder 6.8g max	4	$ -	$ -
	1" 30ft Tubular Kevelar / Nylon	2	$ 55.00	$ 110.00
	1/4" 50ft solid braid KnotRite Nylon Rope	1	$ 8.50	$ 8.50
Nose Cone				
	Apogee XL Ejection Charge Canister	2	$ 2.75	$ 5.50
	Missile Works T3 GPS Tracking System	1	$ 75.00	$ 75.00
	9V Battery	2	$ 11.03	$ 22.06
	Terminal block	1	$ 3.41	$ 3.41
	Adafruit Feather 32u4 RFM96 LoRa Radio	1	$ 34.95	$ 34.95
			Total Cost:	$ 766.86



Payload

Payload Summary

Red Rover

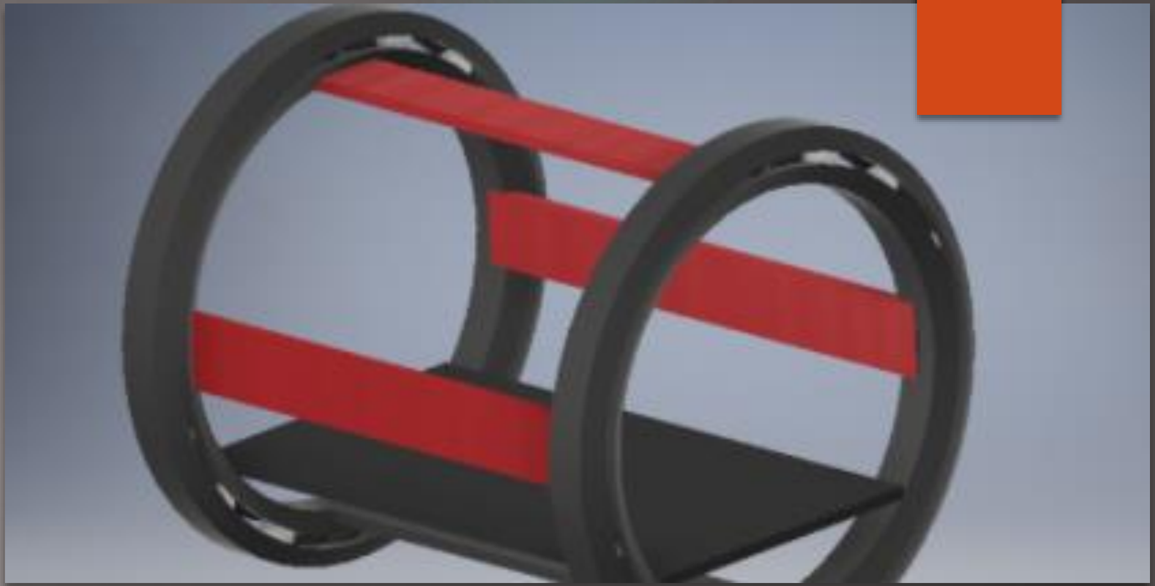
- Rover deployed upon landing
- Rover will travel at least 5 ft. in any direction
- Rover will collect atmospheric data ie: Temperature, Pressure, humidity…
- Rover will utilize ultrasound system and torque steering to avoid obstacles

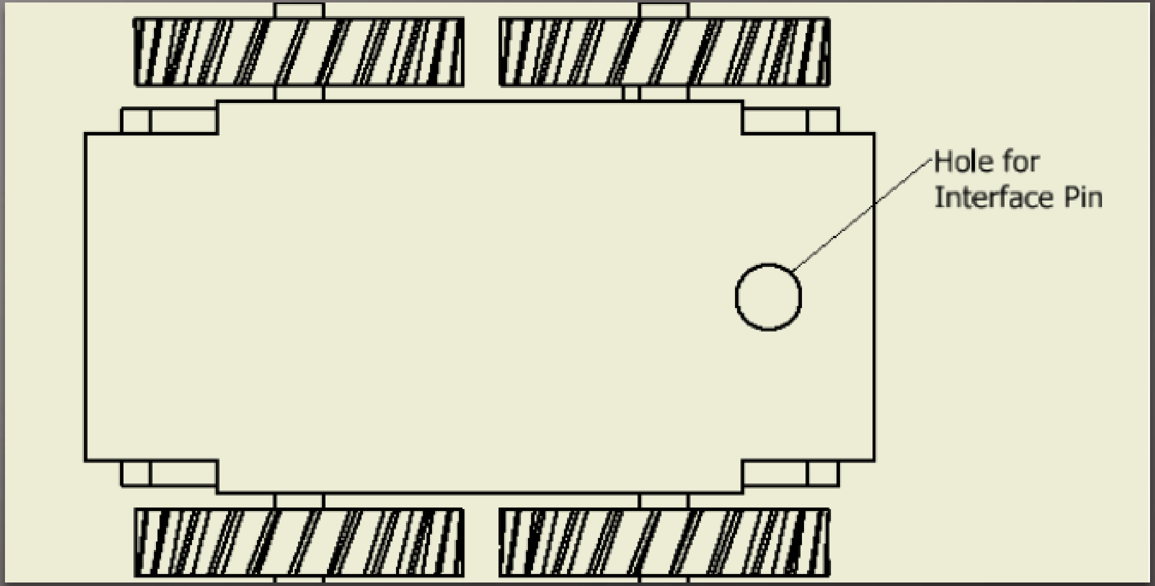
Payload Experiment Goals

- Expandable Rover
- Atmospheric Data Collection
- Naviagation based on UltraSonic Sensors

Rover Deployment Design

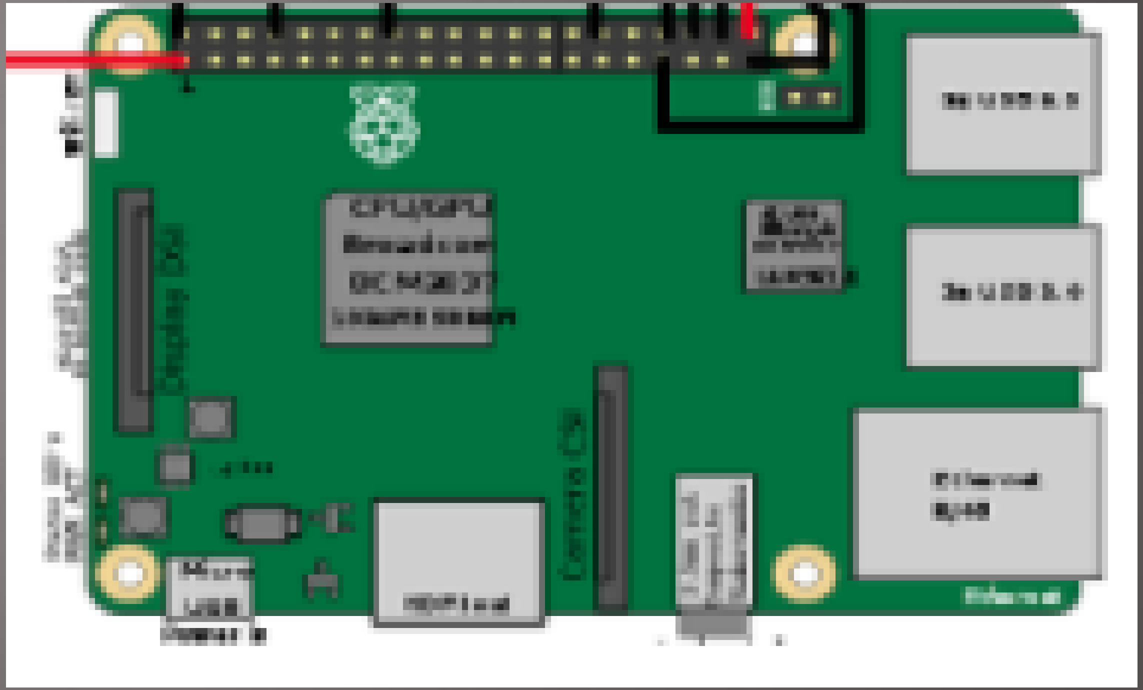
- Hatch Exit
- Cross-Section Exit
  - Multi-Orientation Rover
  - Rotating Payload Housing
    - 4 Pin-Locking positions
    - Bayonet Fitting





Payload Microcontrollers – Rasberry Pi & Arduino

- Size
- Mass
- Complexity
- Capabilities
- power consumption.

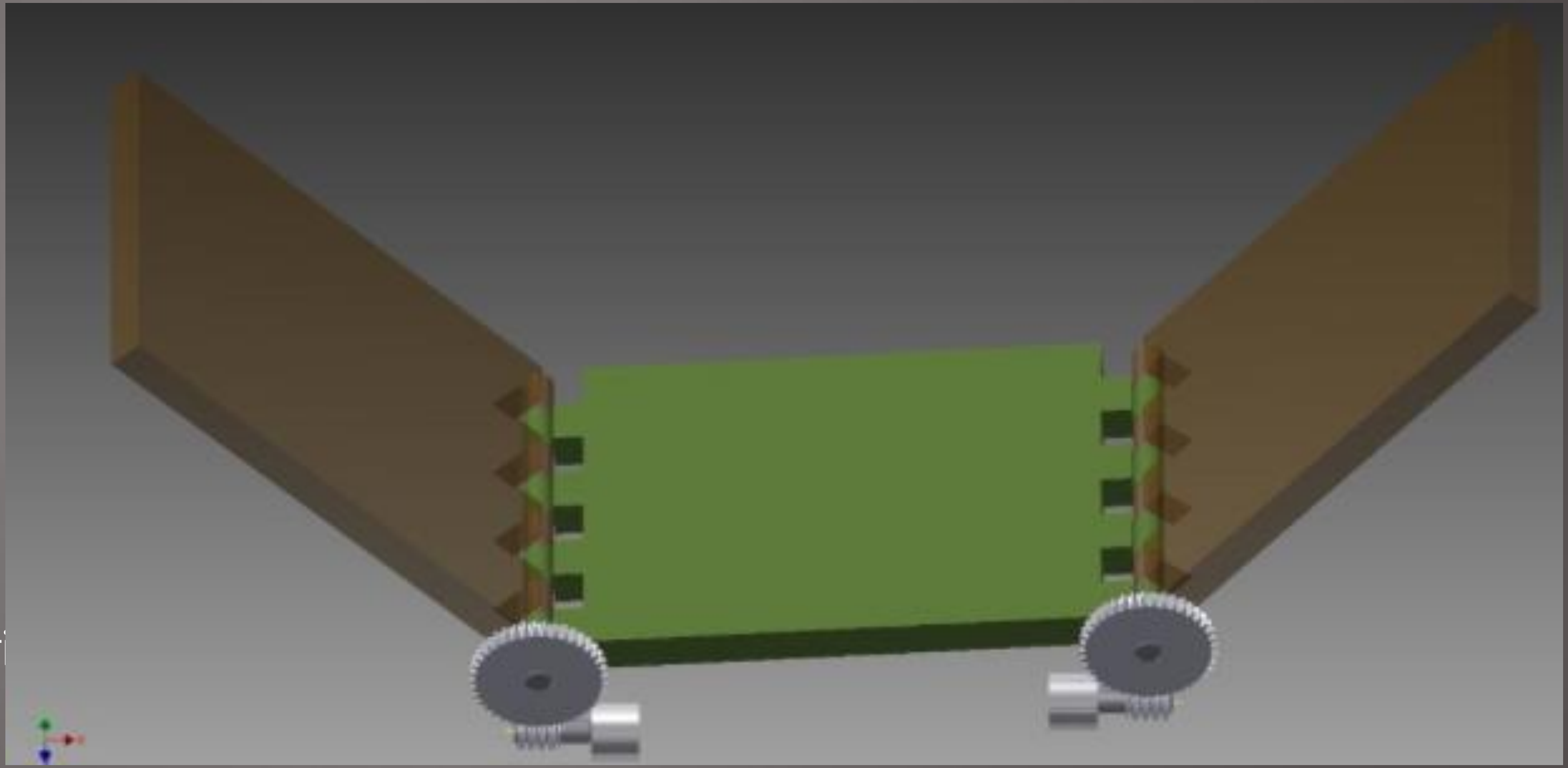


Payload Sensors

- Pressure/Altitude/Temperature Sensor
- MPL3115A2 Sensor Board
- Humidity and Temperature
- Adafruit Si7021 Breakout Board
- DHT22 temperature-humidity sensor
- UV Radiation Sensor
- Wind Speed Sensor
- Spectrometers/Radiation Detectors

Solar Panal Deployment

- Rail System
- Hinge System
- Gear System
- Rotation Using a Conti



Steering, Stowing, and Drive Train System

Steering

- TraditionalAckermann Steering System
- In-Wheel Motor Steering

Stowing

- Axle Extension System
- Wheel Lift System

Drive Train

- Belt Driv en Driv etrain
- In-Wheel Motor Driv etrain

Electrical

Batteries

- Cell Voltage
- Mah
- C Value

ESC

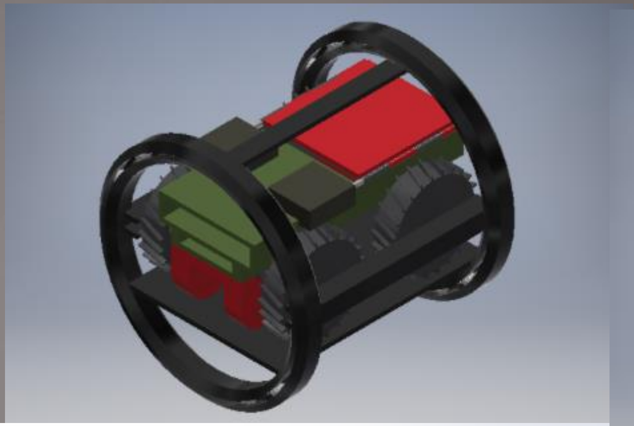
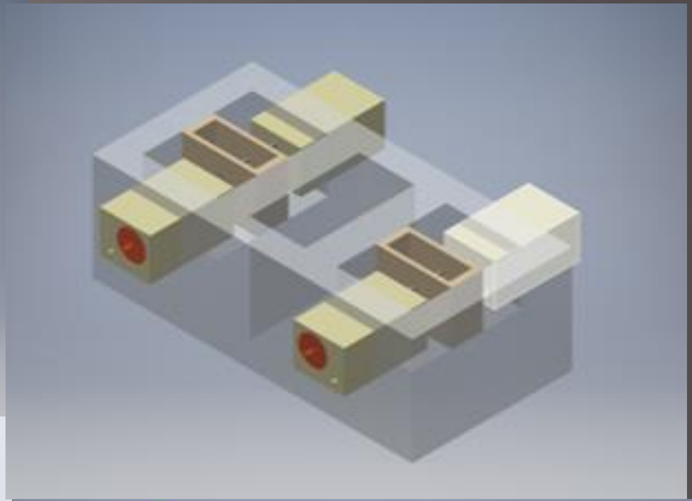
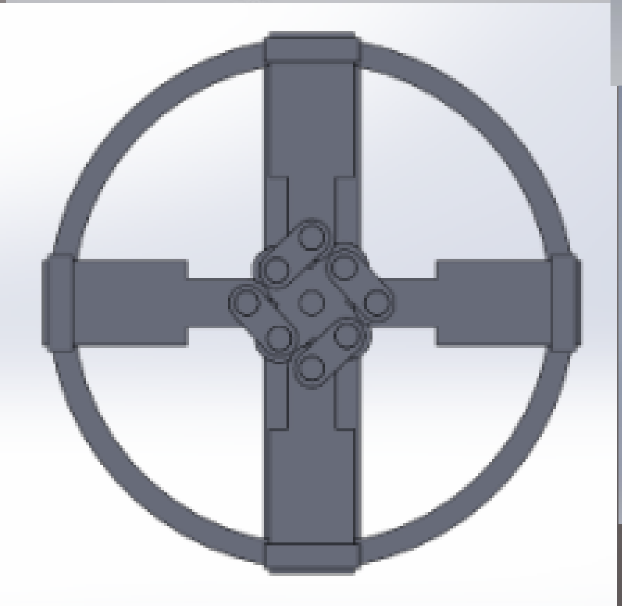
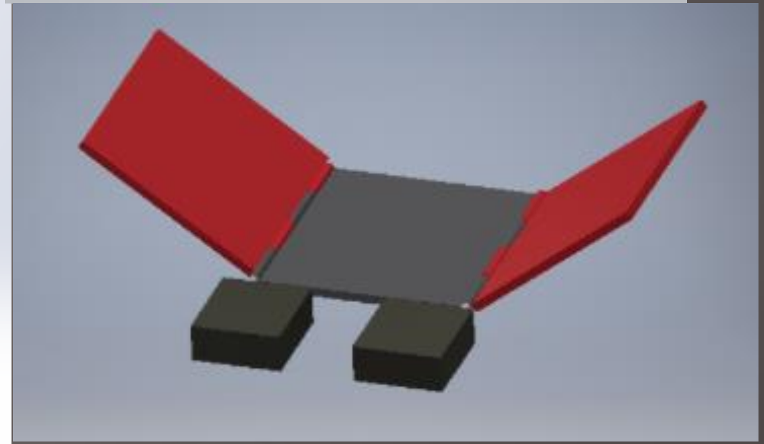
- Operating Current
- Purchase Dependent on Motor
- Bullet Y-connectors

Drive Motors

- Dependent upon KV value
- Low KV = Higher Torque
- High KV = Lower Torque
- Constant and Burst currents

Leading Rover Design

- Rotating Housing
- Bayonet Fitting
- Rasberry Pi
- 4 sensored in wheel motors
- In-wheel motor steering
- Axle Extension Stowing
- MPL3115A2 Sensor Board
- Adafruit Si7021
- Hinged Solar Deployement

General Requirements

Budget

- ➢ Member Dues
- ➢ Move-in Recycling
- ➢ Company Sponsorships
- ➢ Donations
- ➢ Top-Tier Catering

Educational engagement events

- K-12 STEM Fairs
- Catch the Engineering Bug

Safety Equipment

Safety Parts List

Equipment	Qty	Price	Total	Vendor Link
Eye Goggles	14	$1.20	$16.80	rds&id=294712
Safety Glasses	12	$1.85	$22.20	rds&id=40789
Disposable Gloves	200	$0.06	$12.00	https://www.
Disposable Coveralls	25	$1.24	$31.00	id=CjwKCAjwh
Breathing Mask	20	$0.60	$12.00	ype=pla&id=S-
Wool/Nylon Fire Blanket	1	$55.50	$55.50	VUMO3AAAAG
Poly Plastic Tarp	4	$2.80	$11.20	iwAx2nhLovM
First Aid Kit	1	$25.00	$25.00	293&gclid=Cjw
ABC Class Fire Extinguisher	1	$60.00	$60.00	=S-9873&gclid
			$245.70	

Flight Predictions and Risks

Vehicle

Predictions -

- Accurate Data supporting successful flight
- Avoidance of drag
- Proper exit velocity and apogee

Risks -

- Poorly secured motor
- Miscalculation of CP or CG
- Poorly secured Fins

Flight Predictions and Risks

Recovery

Predictions -

- Proper Electronic Connections
- Apogee Deployment
- Back up Deployment

Risks -

- Wiring Failure/disconnection
- Premature ejection charge
- Early parachute deployment
- Improper charge loading
- Over-drift
- No separation

Flight Predictions and Risks

Recovery

Predictions -

- Upon testing, confidence in rotating housing
- Well secured connections and operating electronics
- Operating sensors and navigations

Risks -

- Failure to deploy Rover
- Locking pin fails to release rotating housing
- Disconnected electronics
- Failure to deploy solar panels

Summary

- Vehicle Mission & Success
- Vehicle Design Information
- Recovery Design Information
- Payload Design Information
- General Requirements
- Safety Equipment
- Flight Predictions > Vehicle, Recovery, and Payload
- Summary

Thank You For Your Time