Critical Design Review

Texas Tech University - Space Raiders

Our Team

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

Rocket and Payload Dimensions

Rocket Dimensions

- Height: 114.57 in
- Body Inner Diameter: 5.98 in
- Body Outer Diameter: 6.37 in
- Mass on Pad: 42.82 lbs
- Dead Mass: 37.61 lbs
- Mass Margin: 42.8-47.3 lbs

Rover Dimensions

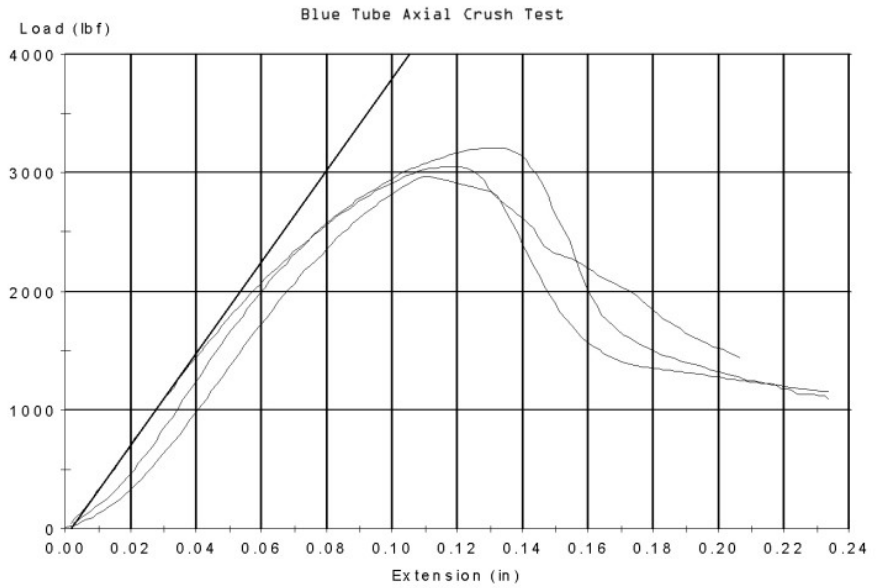
- Chasis Length: 4.25 in
- Chasis Width: 2.9 in
- Chasis Height: 2.13 in
- Payload Section Length: 7.55 in
- Bearing Inner Diameter: 4.92 in
- Bearing Outer Diameter: 5.79 in

Vehicle Design

Final Vehicle Material and Design

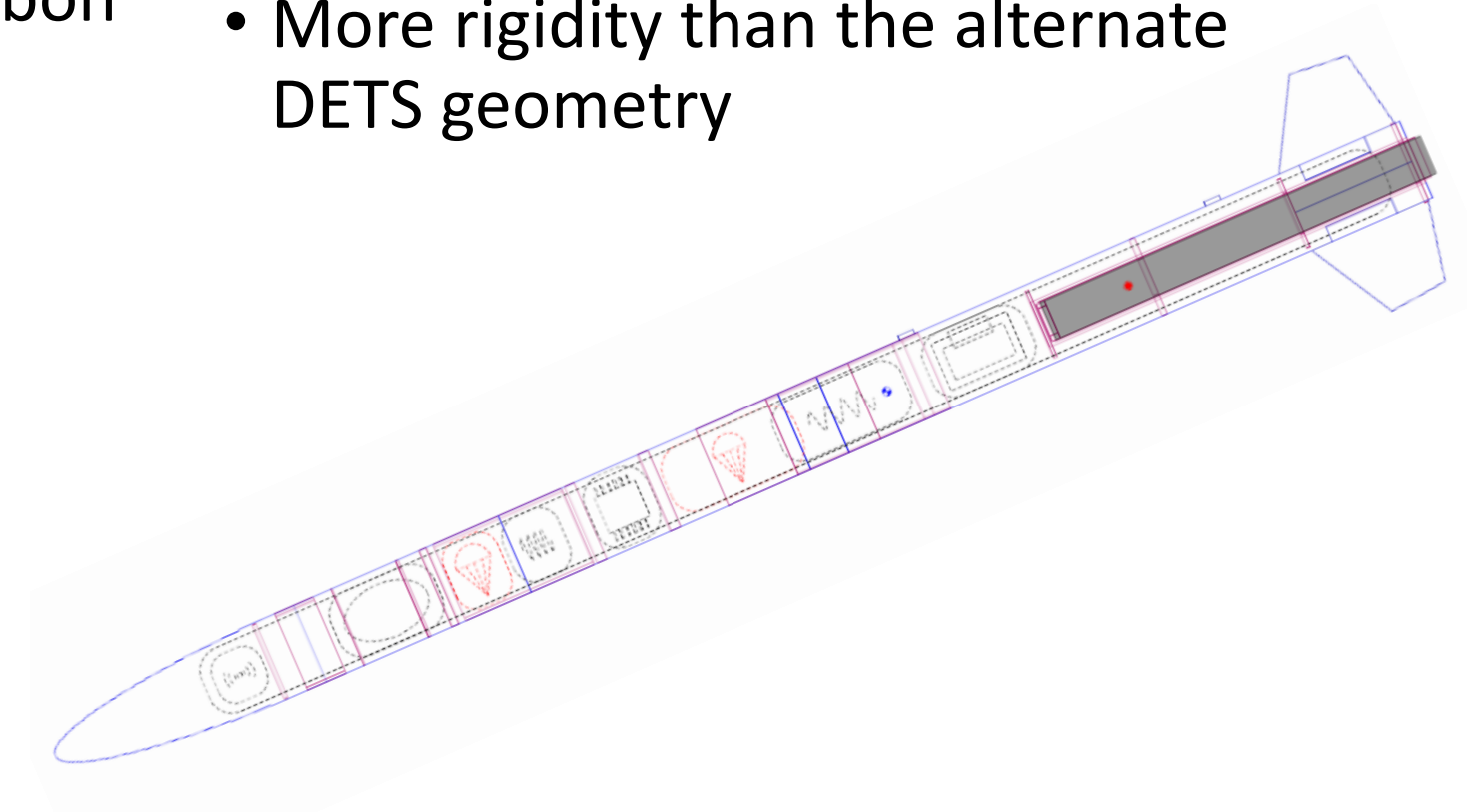
6 inch Blue Tube 2.0

- Superior strength to phenolic tubing
- More cost effective than carbon
- Standardized sizes



Constant Diameter Rocket Body Design

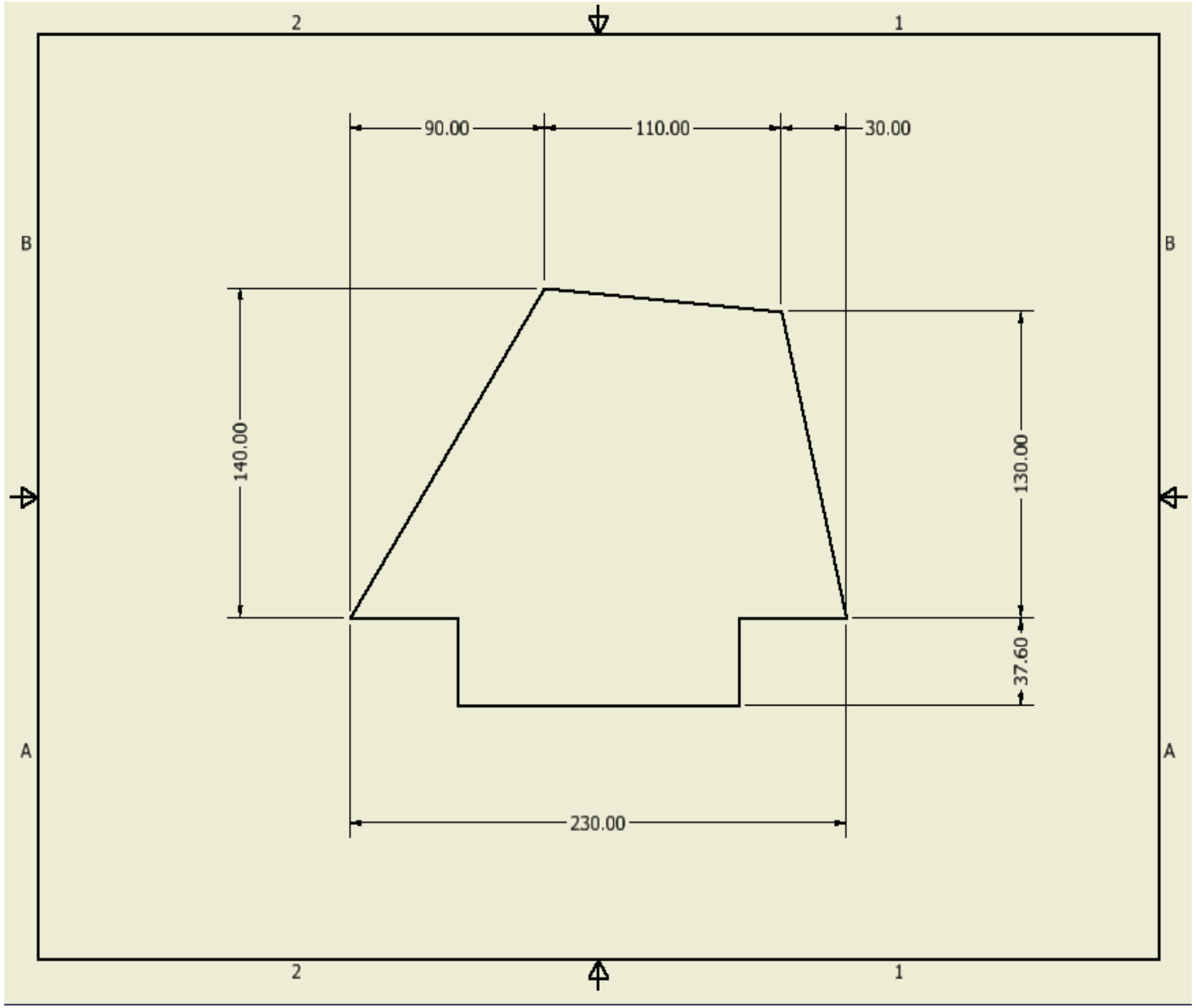
- Cost effective
- Less complex
- More rigidity than the alternate DETS geometry



Final Fin Design

G10 Fiber Glass

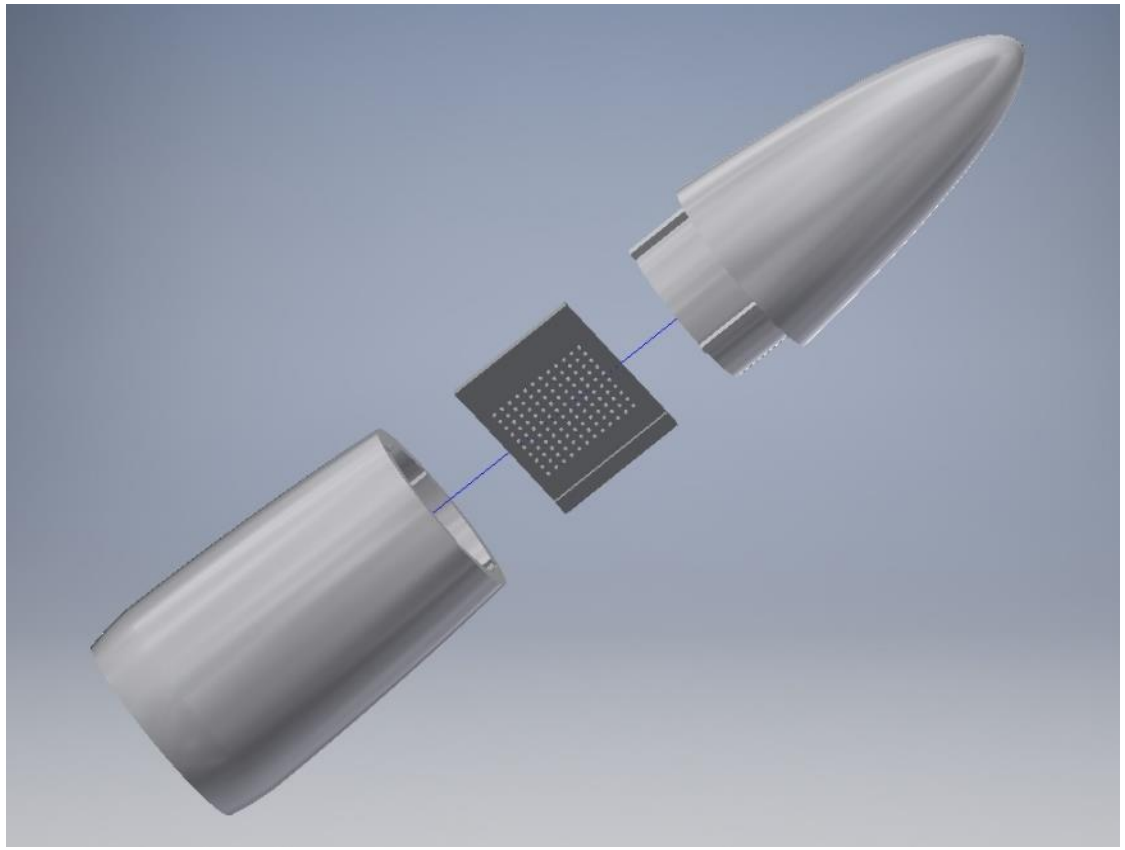
- Heat resistant properties
- High tensile strength
- Experience with G10 handling
- Available in 3/16 inch
- Easily sanded using wet sanding technique



Final Nose Cone Design

3D Printed ABS – Long Elliptical Shape

- High Density (60%)
- Ability to hold part sled for electronics mounting
- Low drag due to long elliptical shape
- Affordable and customizable



Rail Button Selection

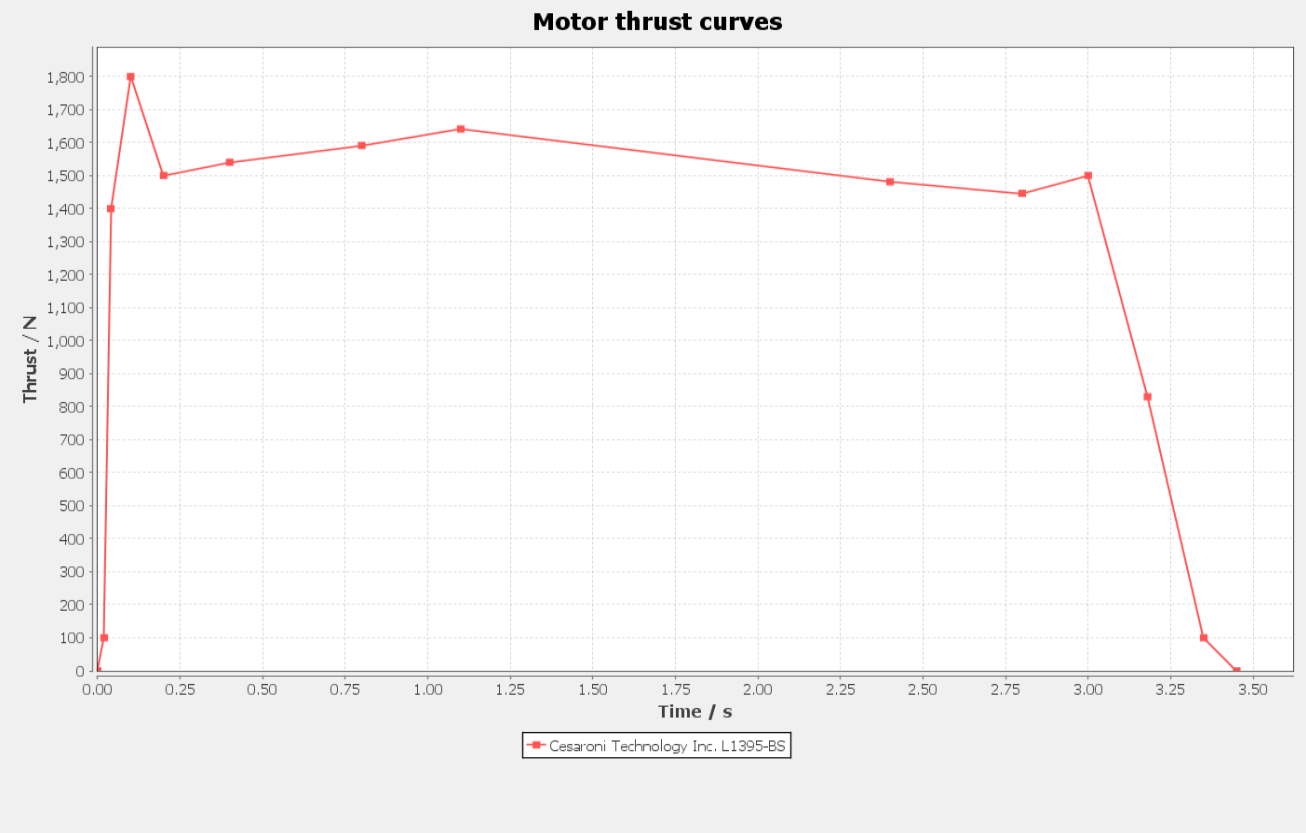
Derlin 1515 Rail Buttons

- Rail buttons are commercial manufactured to ensure functionality
- Going with metal rail buttons rather than plastic (especially low density ABS) will increase shear strength of the rail buttons

Final Motor Selection

Cesaroni L1395 – BS (Blue Streak)

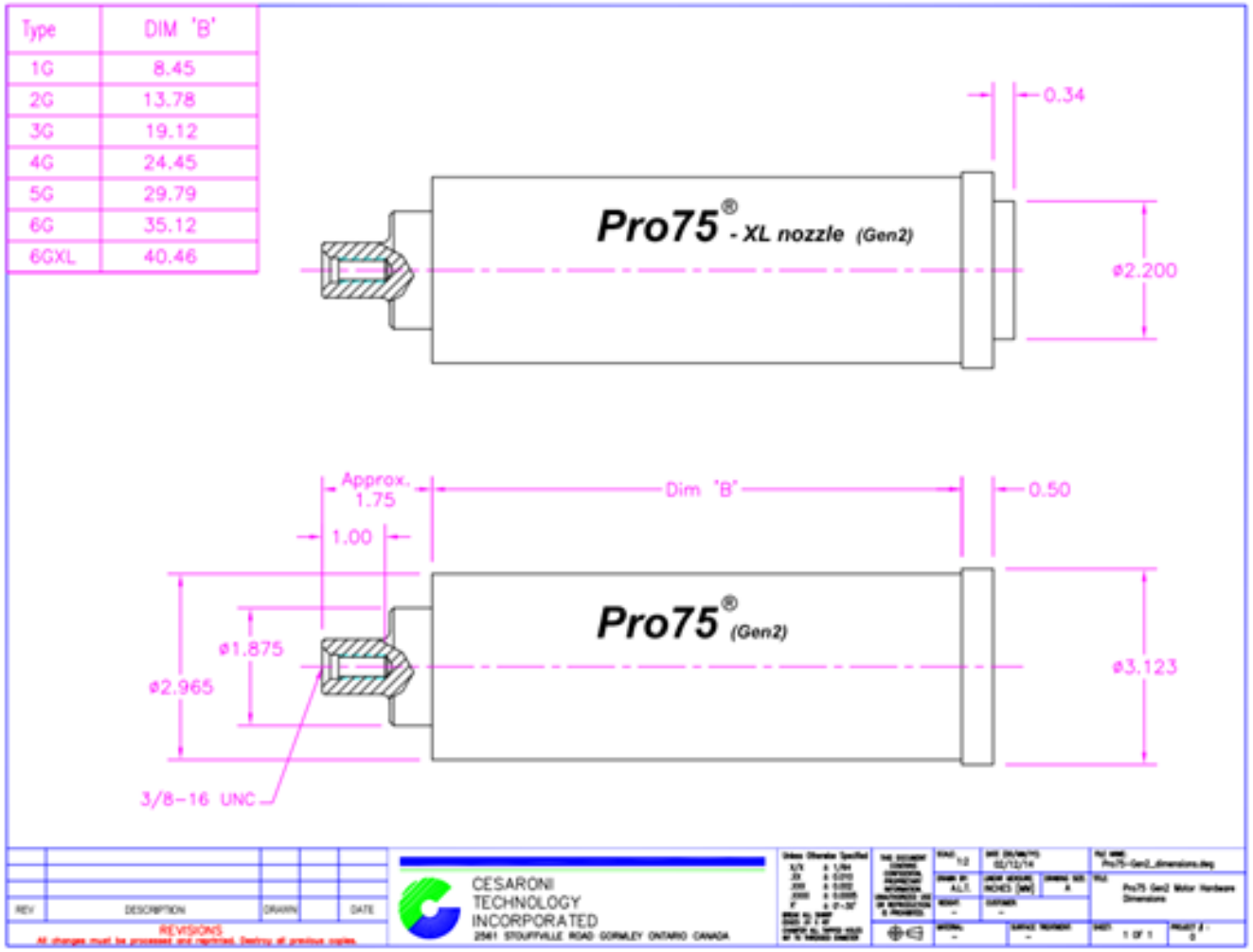
- 75mm, 4 Grain
- Average Thrust: 328.895 lbf
- Max Thrust: 404.656 lbf
- Total Impulse: 1100.439 lbf-s
- Burn Time: 3.45s
- Launch Mass: 9.531 lbm
- Dead Mass: 4.074 lbm



Motor Hardware

Cesaroni 75mm Casing

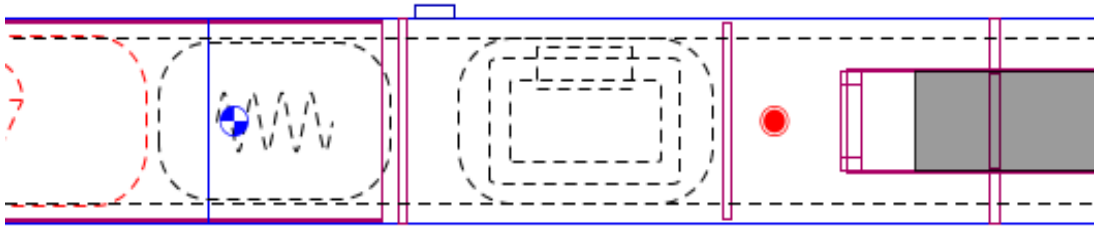
- Cesaroni manufactures casings for thier motors therefore they are directly compatible with any of their motors
- CNC machined 6061 – T6 anodized aluminum



Stability and Thrust to Weight Ratio

Factor of Stability: 2.52 cal

- Stability Factor Equation:
- $\frac{(CP-CG)}{d} = Stability\ Factor$



Stability:2.52 cal
CG: 175 cm
CP: 218 cm
at M=0.30

Thrust to Weight Ratio: 7.66

- Thrust to Weight Ratio Equation:
- $\frac{Average\ Thrust}{Weight} = Thrust\ to\ weight\ ratio$

Apogee: 1816 m
Max. velocity: 216 m/s (Mach 0.64)
Max. acceleration: 81.5 m/s²

Rocket
Length 291 cm, max. diameter 17.1 cm
Mass with motors 19425 g

Recovery

- Parachute sizes
- Recovery Harness Type
- Size
- Length
- Descent Rates

Separation Charges

Charge Sizes			
	Compartment Volume (in^3)	Charge Size (oz)	Charge Size (g)
Drogue Charge	278.2907 in^3	0.1520 oz	4.3088 g
Main Charge	500.9222 in^3	0.2736 oz	7.7559 g
Nose-Cone Charge	200.2676 in^3	0.1094 oz	3.1008 g

Landing Kinetic Energy

Kinetic Energy			
Drogue Deployment			
	Section 1 (Forward)	Section 2 (Aft)	
Mass (g)	4804.000 g	13483.700 g	
Mass (lbm)	10.591 lb	29.726 lb	
Velocity (m/s)	36.641 m/s	36.641 m/s	
Velocity (ft/s)	120.-213 ft/s--	120.213 ft/s	
Kinetic Energy (J)	3224.836 J	9051.358 J	
Kinetic Energy (ft·lb)	2378.517 ft·lb	6675.939 ft·lb	
Main Deployment			
	Section 1 (Forward)	Section 2 (E-Bay)	Section 2 (Middle)
Mass (g)	4804 g	2385.700 g	9821 g
Mass (lbm)	10.591 lb	5.260 lb	21.652 lb
Velocity (m/s)	3.9762 m/s	3.9762 m/s	3.9762 m/s
Velocity (ft/s)	13.045 ft/s	13.045 ft/s	13.045 ft/s
Kinetic Energy (J)	37.976 J	18.859 J	77.636 J
Kinetic Energy (ft·lb)	28.010 ft·lb	13.910 ft·lb	57.261 ft·lb

Nominal Drift Calculations

Drift assuming normal deployment of parachutes

Nominal Drift (2 ft drogue and 16 ft main)					
Wind Speeds					
Wind Speed (mph)	0 mph	5 mph	10 mph	15 mph	20 mph
Wind Speed (ft/s)	0 ft/s	7.33333 ft/s	14.6667 ft/s	22 ft/s	29.3333 ft/s
Wind Speed (m/s)	0 ft/s	2.2352 m/s	4.4704 m/s	6.7056 m/s	8.9408 m/s
Drogue Drift					
Drift (ft)	0 ft	261.9374 ft	523.8747 ft	785.8123 ft	1047.7497 ft
Drift (m)	0 m	79.8385 m	159.677 m	239.5156 m	319.3541 m
Main Drift					
Drift (ft)	0 ft	95.1755 ft	190.3510 ft	285.5266 ft	380.7021 ft
Drift (m)	0 m	29.0095 m	58.0190 m	87.0285 m	116.0380 m
Total Drift (ft)	0 ft	357.1129 ft	714.2260 ft	1071.339 ft	1428.4518 ft
Total Drift (m)	0 m	108.8480 m	217.6961 m	326.5441 m	435.3921 m

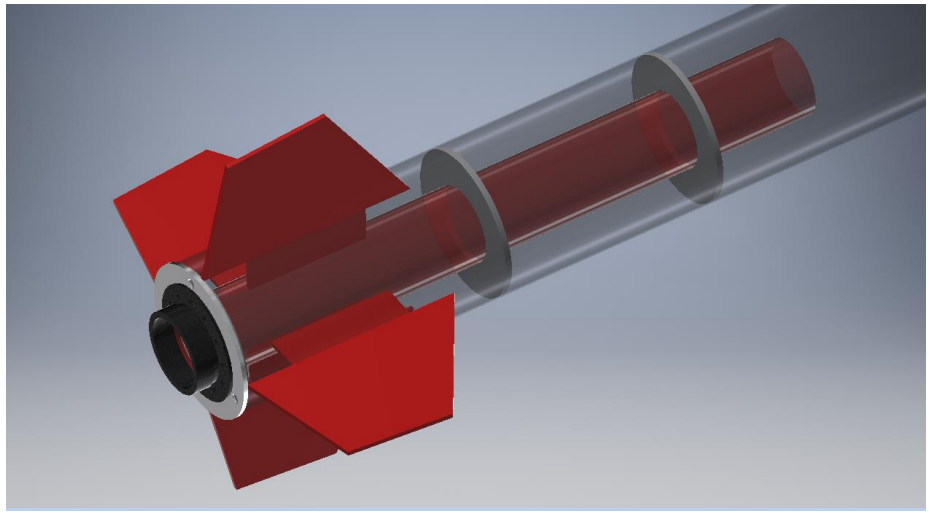
Immediate Inflation Drift Calculation

Assuming immediate inflation of parachute & deceleration

Immediate Inflation Drift (2 ft drogue and 16 ft main)					
Wind Speeds					
Wind Speed (mph)	0 mph	5 mph	10 mph	15 mph	20 mph
Wind Speed (ft/s)	0 ft/s	7.33333 ft/s	14.6667 ft/s	22 ft/s	29.3333 ft/s
Wind Speed (m/s)	0 ft/s	2.2352 m/s	4.4704 m/s	6.7056 m/s	8.9408 m/s
Drogue Drift					
Drift (ft)	0 ft	219.3635 ft	438.7270 ft	658.0906 ft	877.4541 ft
Drift (m)	0 m	66.8620 m	133.7240 m	200.5860 m	267.4480 m
Main Drift					
Drift (ft)	0 ft	229.4475 ft	458.8950 ft	688.3425 ft	917.7900 ft
Drift (m)	0 m	69.9356 m	139.8712 m	209.8068 m	279.7424 m
Total Drift (ft)	0 ft	448.8110 ft	897.6220 ft	1346.433 ft	1795.2444 ft
Total Drift (m)	0 m	136.7976 m	273.5952 m	410.3929 m	547.1905 m

Internal Interfaces

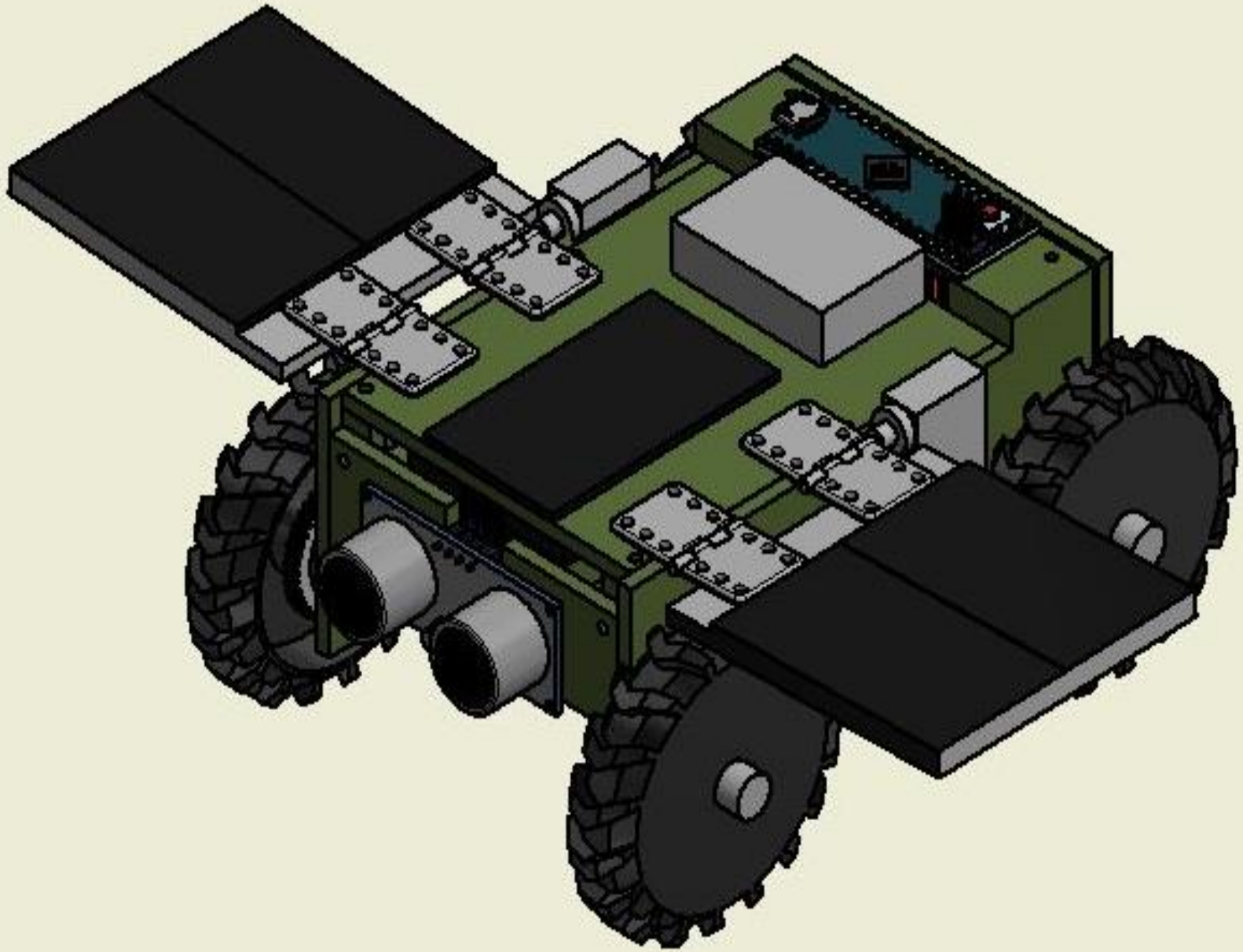
- Couplers
  - Shear Pins & Screws
- Rover Housing
  - Bear/Coupler Interface
  - Rover/Guide Rail Interface
- Motor Mount
  - Thrust Plate
  - Centering Rings
- Nose Cone



External Interfaces

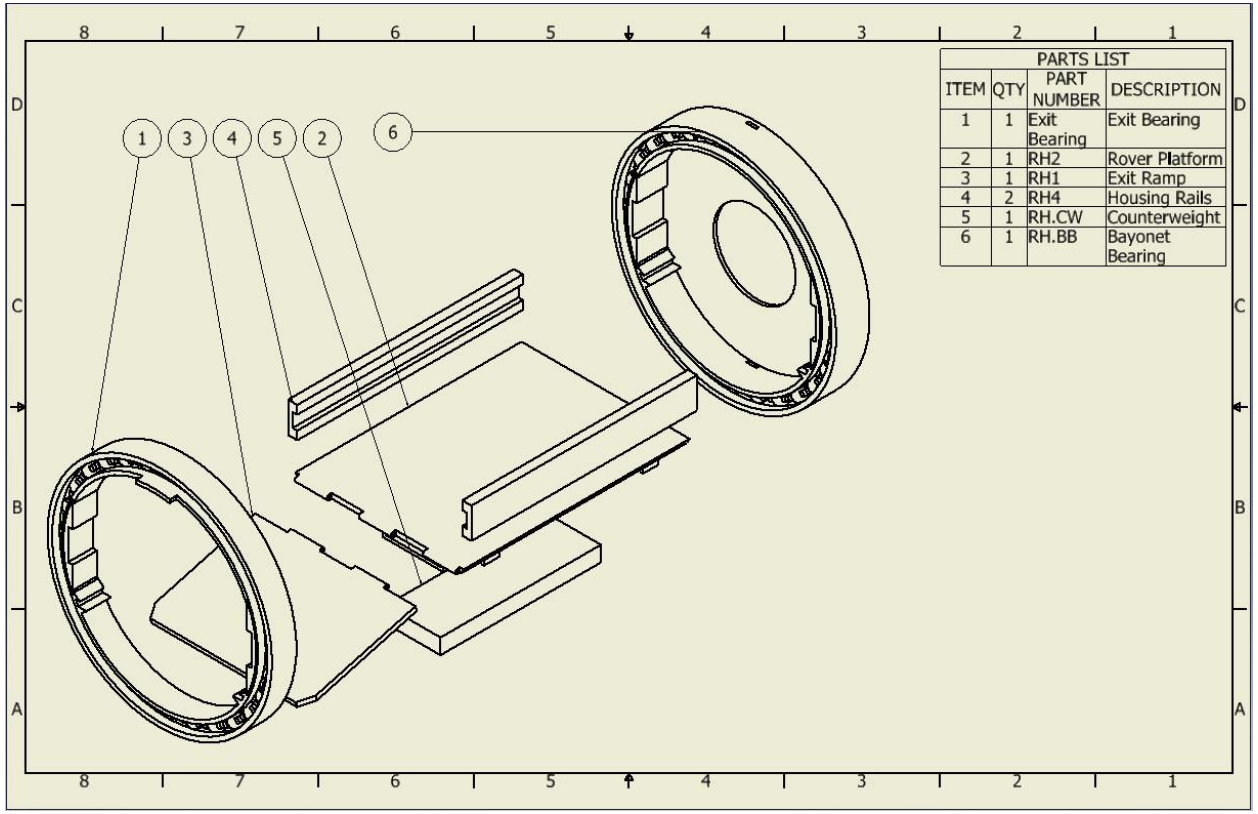
- Launch Pad
- Guide Rails
  - 1515 Rails
  - 1515 Rail Buttons

Payload Design



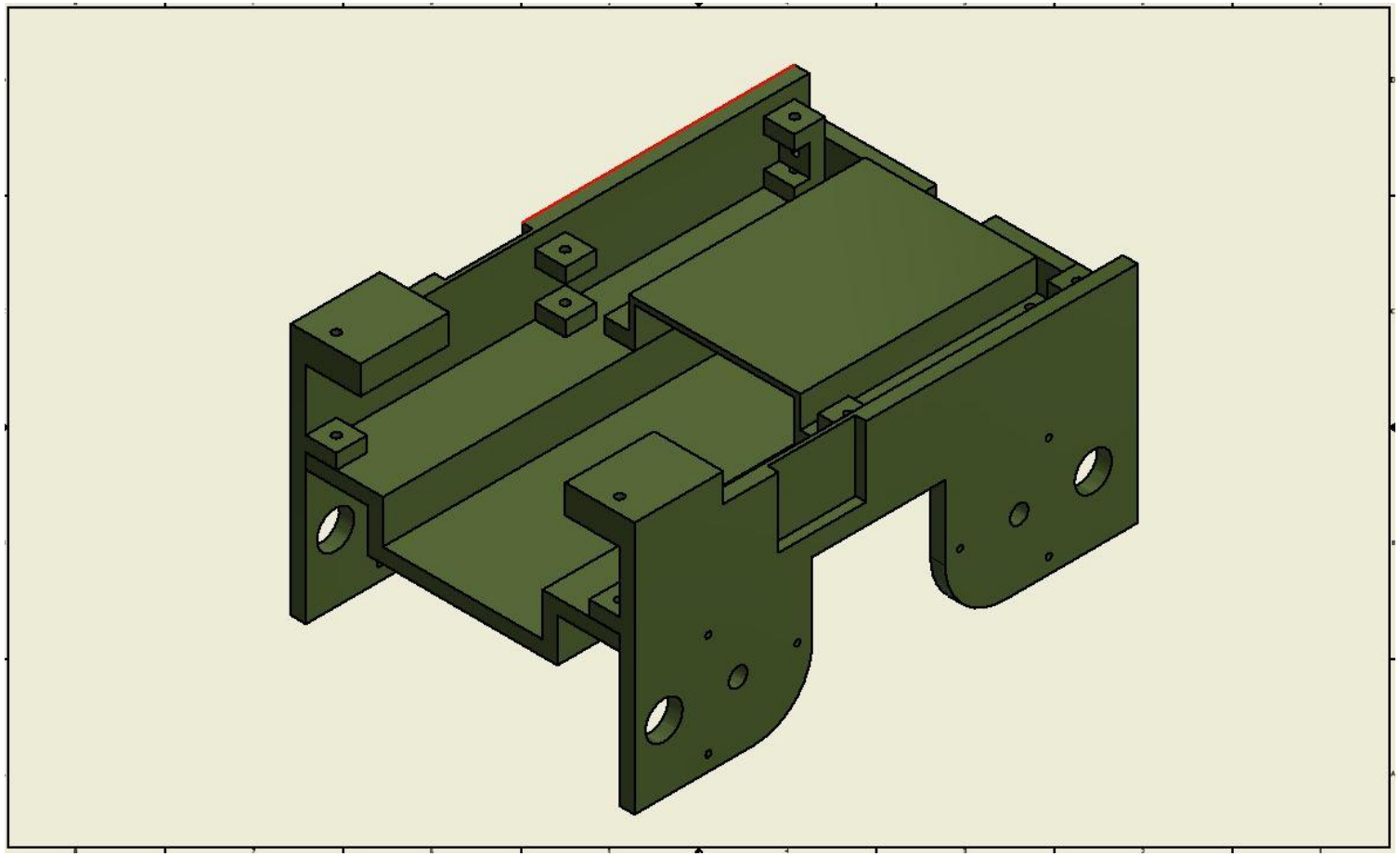
Rover Housing and Deployment

- Rover housing has 2 bearings that allow the rover to orient itself prior to deployment
- Rover will be held radially by guide rails where axle pins will be slotted
- Upon nose cone separation, rover bay door will open



Rover Chassis

- Tab System
- 3-d printed



Rover Electronics

Travel Electronics

Microcontroller: Arduino Micro

- Small and light microcontroller that will carry out tasks and experiments

Ultrasonic Sensor:

- Used for obstacle avoidance

Experiments

Altimeter Sensor:
MPL3115A2 Sensor Board

- Pressure/altitude/temperature sensor all in one saves space

Atmospheric Sensor:
Adafruit Si7021

- Takes humidity and temperature readings after landing

Batteries and Motors

Rover Battery: Turnigy Nano-Tech receiver pack

- Mass/Dimensions: 98g/(87 x 34 x 17)mm
- Voltage/Capacity: 7.4V/2000 mAh

Rover Motors (x4): C2024 Micro Brushless Outrunner

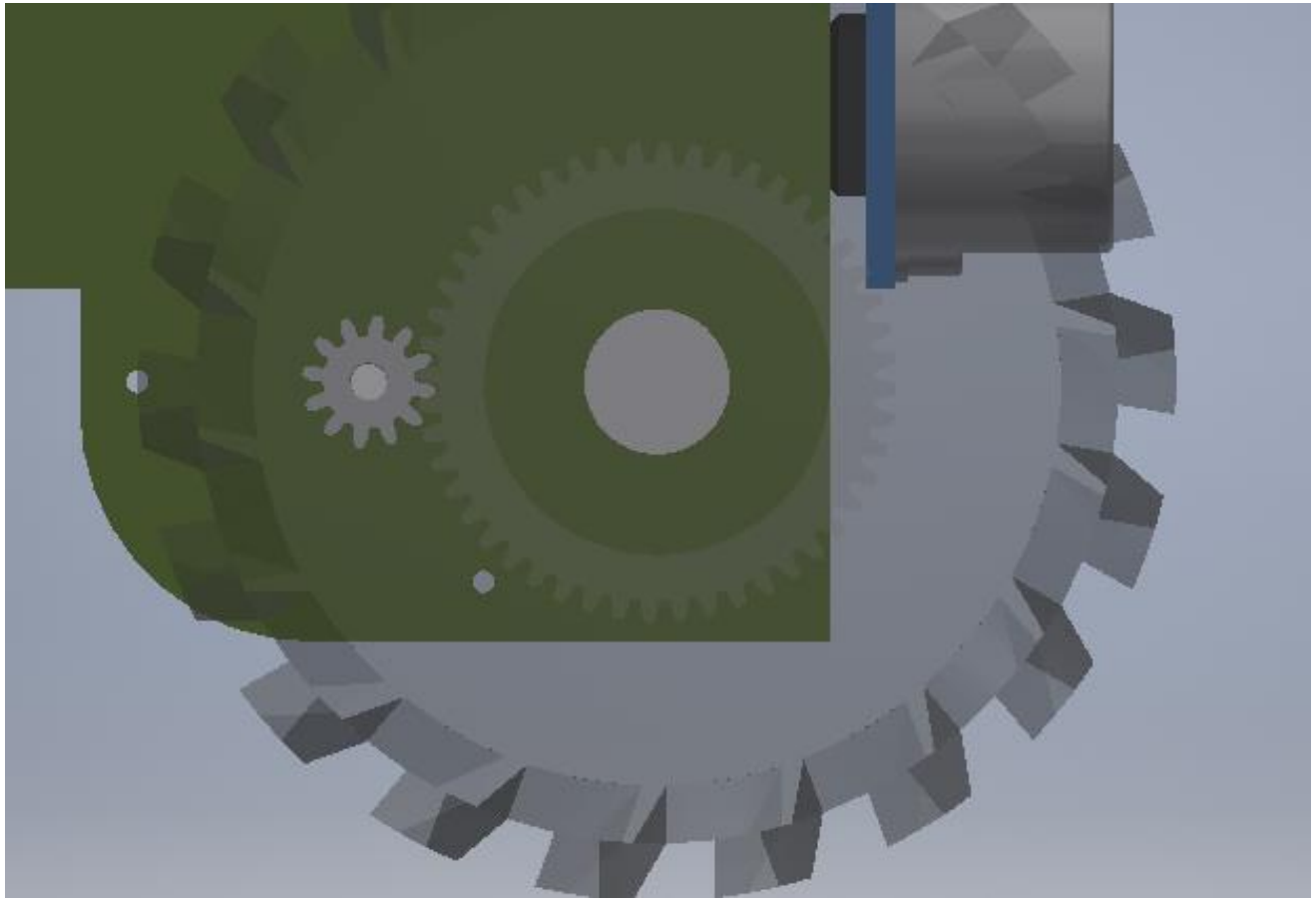
- Diameter/Length: 20.2mm/24mm
- Mass/Kv Value: 17g/1600(rpm/v)

ESC

- Operating Current
- Bullet Y-Connectors

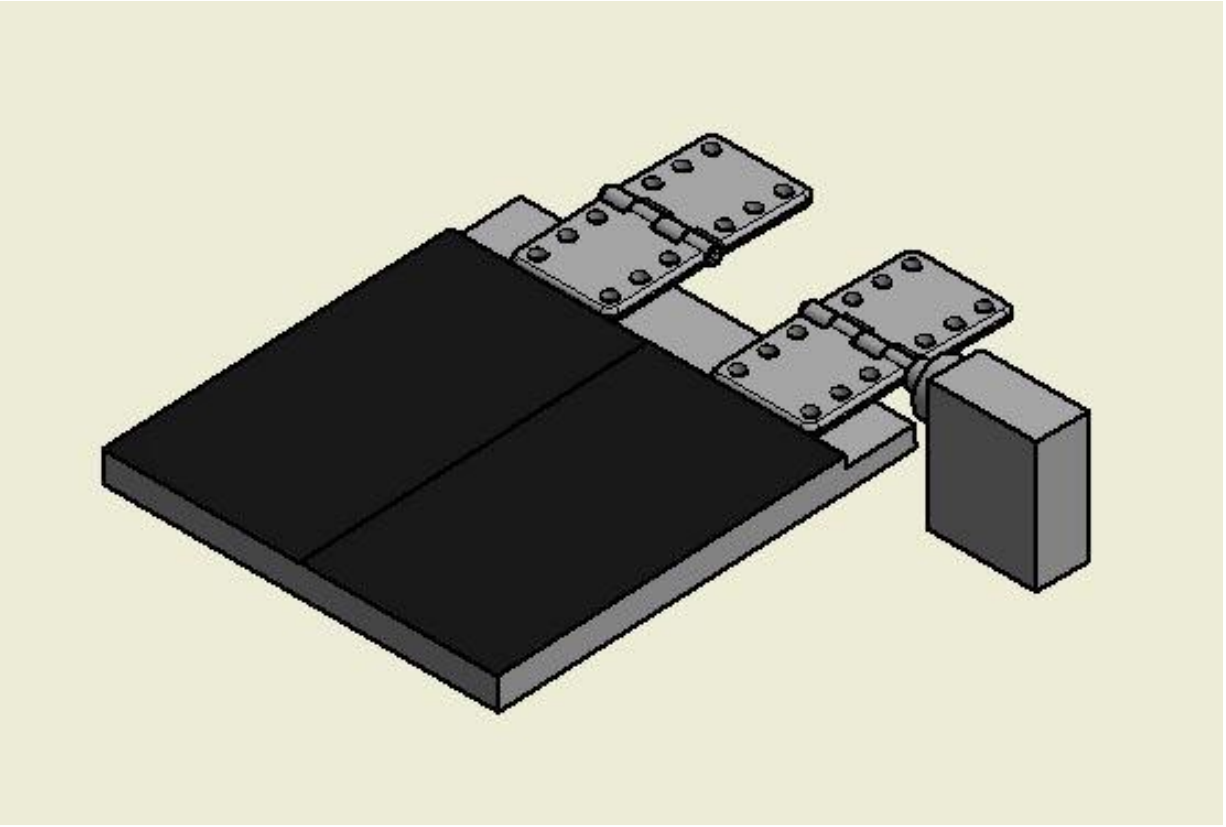
Drive Train system

- Indvidual wheel motors
- Internal gear housing
- Spur and Pinion Gears



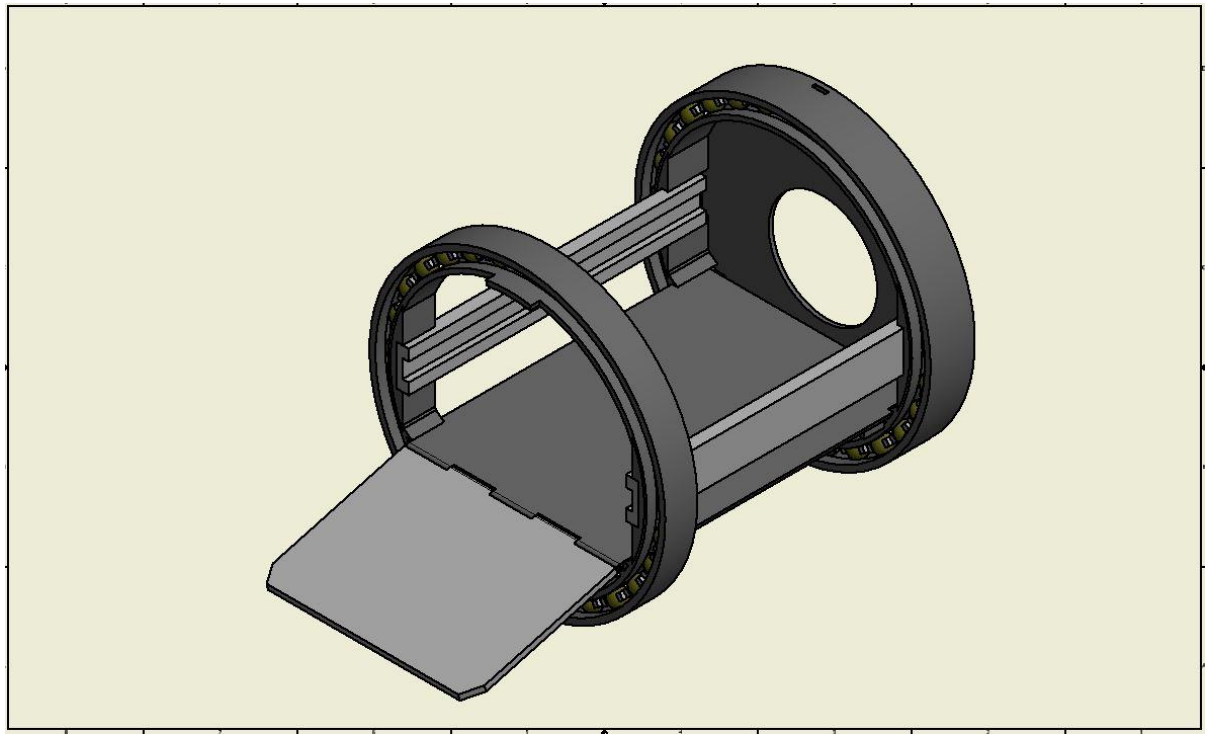
Solar Panel Deployment

- System will use a set of servos to rotate the solar panels to the open position
- Servos offer a considerable weight reduction from conventional motors
- Offers ease of control
- Hinge system



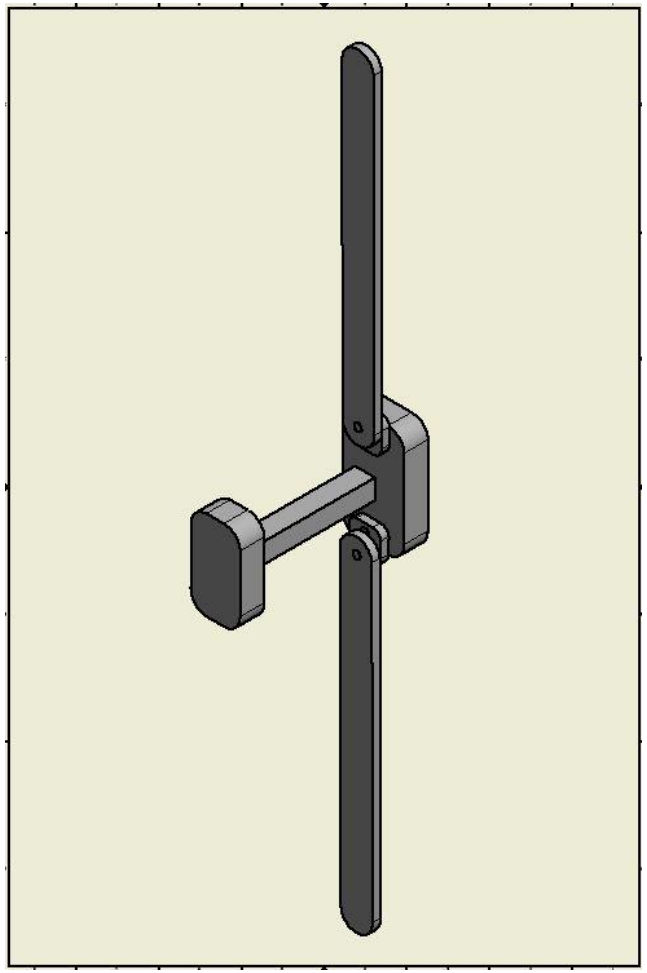
Payload Mounting and Integration

- Mounted within a coupler tube
- Self-Orienting Housing
- Supporting wheel rail system



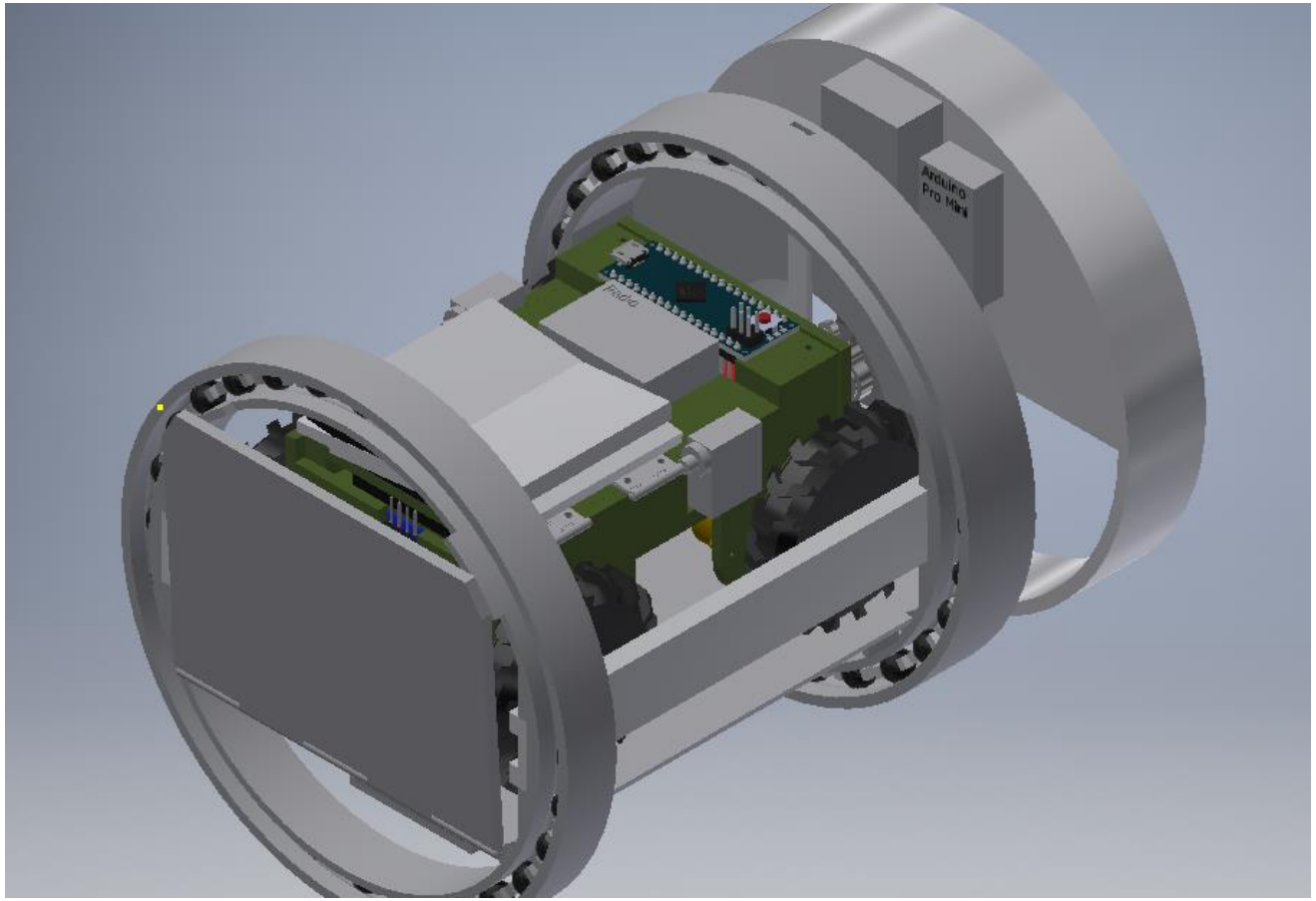
Bayonet Fitting

- Two Locking pins
- Independent servo control



Final Rover Design

- Rover Chassis
- Rover Housing
- Bayonet Fitting
- Payload Sensors
- In Wheel drive train
- Ultrasonic Steering
- Hinged Solar Deployment



Test Plans and Procedures

Vehicle Testing

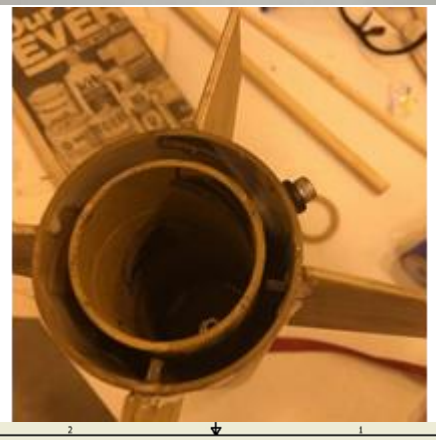
- DACS
- Aerodynamic Drag
- DACS Control Arm
- Separation Charge
- Shock Cord Bundle

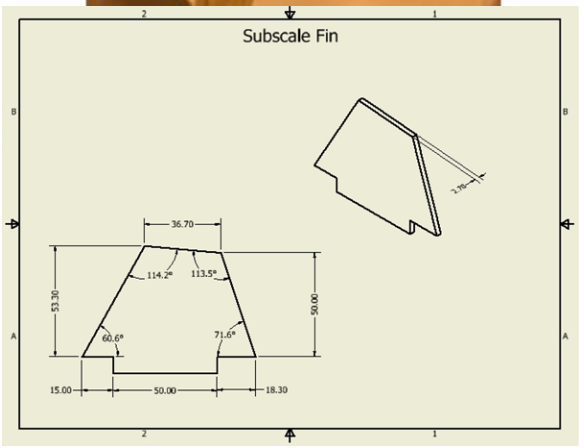
Payload Testing

- Rover Housing
- Payload Interface
- Electrical Systems
- Drivetrain and Steering
- Solar Panel

Sub-Scale Flight Build

- 3-D Printed Nose Cone
- 3-D Printed fin guide
- Foam Filler/Epoxy
- CNC routed fins





Sub-Scale Flight Test

- Predicted Altitude: 2549 feet
- Actual Altitude: 2495 feet
- 2% error
- Date: 1/8/18
- Motor: H283ST-15A
- 1/3 Scale

Recovery System Testing

- Main parachute ejection charge testing
- Drogue parachute ejection charge testing
- Shock cord bundle testing

Requirements Verification

Vehicle & Recovery

- Apogee of 5280 ft
- Altimeters
- Exit Rail Velocity of 52 fps
- Rocket has max of 4 sections
- Main and Drogue Chute
- Nose Cone Ejection
- Parachute Entanglement

Payload & Safety

- Correct Rover Deployment
- Remote Activation of Rover
- Rover must travel 5 ft
- Rover Will Deploy Solar Panels
- Safe Launch Set Up
- Emergency Safety Equipment
- Behavior and Conduct

Community Outreach

Projects

- Balloon Rocket Propulsion
- Drag Device
- STEM Career BINGO

Current Opportunities

- Dream Big Engineering Fair

Potential Opportunoties

- Boy's Ranch
- Amarillo College