Preliminary Design Review Presentation

University of Louisville
River City Rocketry
November 20, 2015

AGSE

- Launch Platform
- Vehicle Actuation Device
- Payload Capture Device
- Igniter Installation Device
- Sub-Frame
- Master Controller

AGSE

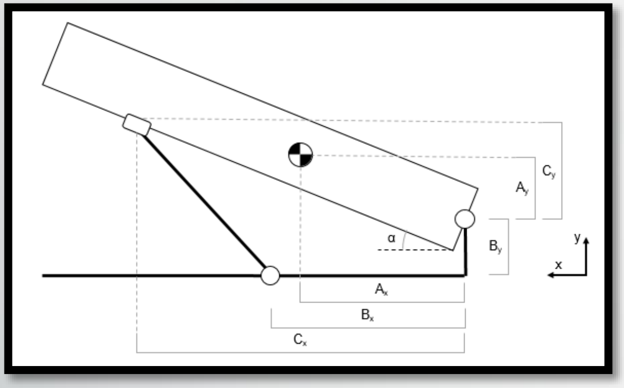
System Dimensions

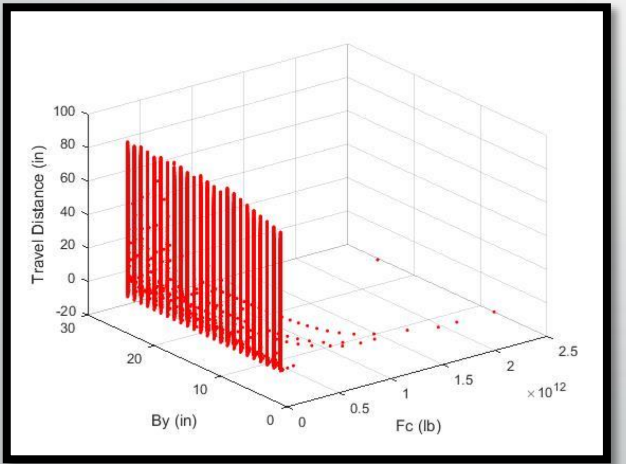
Mass (lb_m)	Width (in)	Horizontal orientation		Launch orientation	
		Height (in)	Length (in)	Height (in)	Length (in)
140.00	73.02	38.39	117.77	108.04	91.67

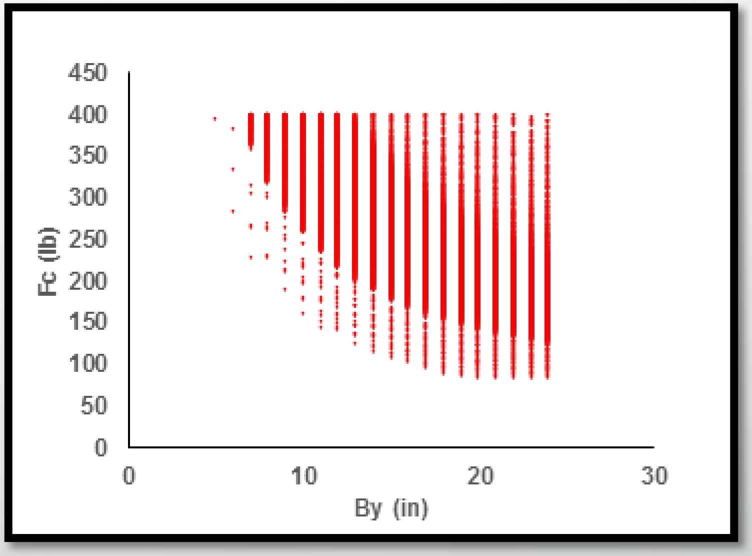
System Timeline

System	Task	Autonomous Procedure																				
		0:00	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15	4:30	4:45	5:00
Payload Capture	Pivot arm to payload location																					
	Extend arm to payload location																					
	Capture payload																					
	Retrack arm																					
	Pivot arm to vehicle insertion location																					
	Rotate wrist to insertion orientation																					
	Extend arm into vehicle																					
	Release gripper																					
	Retrack arm																					
Vehicle	Close Door																					
Vehicle Actuation	Raise Vehicle																					
Igniter Instllation	Install Igniter																					

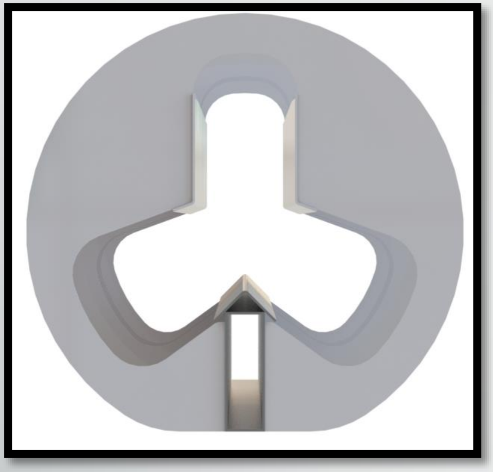
Geometry Optimization

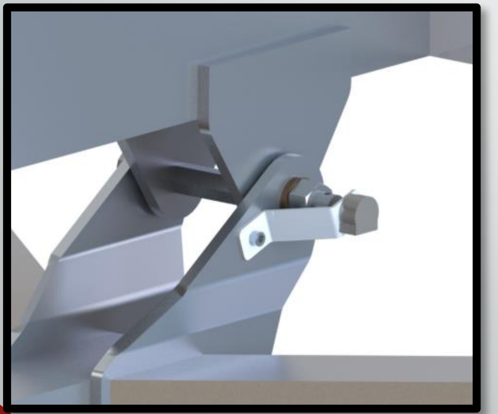


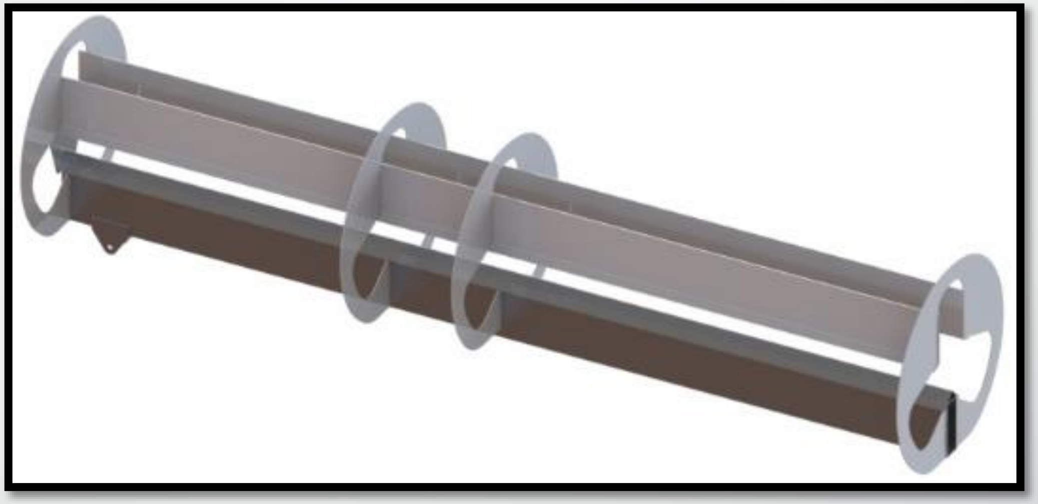




Launch Platform

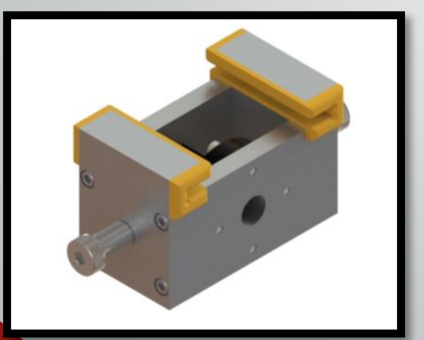






Mass (lb_m)	Width (in)	Height (in)	Length (in)
50.00	22.00	23.97	96.63

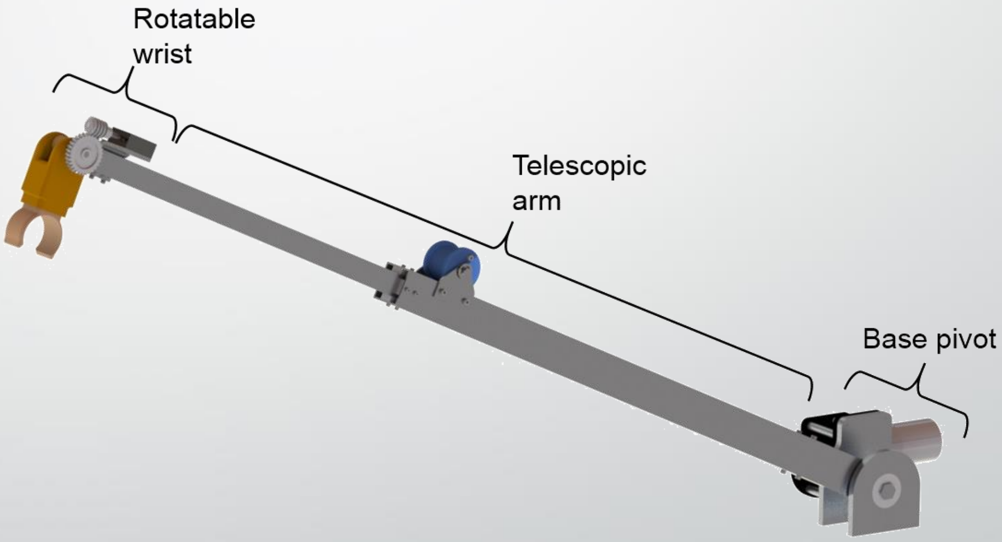
Vehicle Actuation



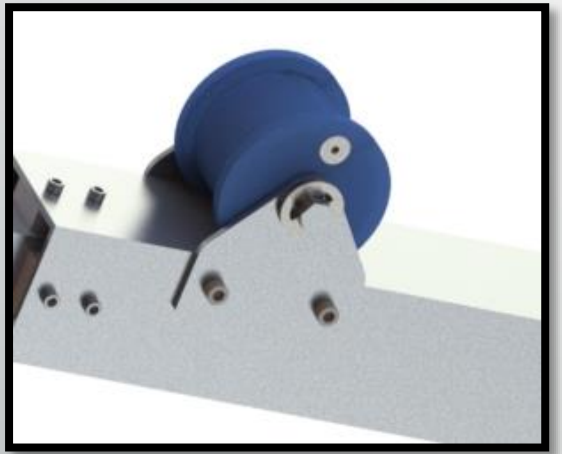
Mass (lb_m)	Width (in)	Height (in)	Length (in)
28.69	8.00	5.125	63.42

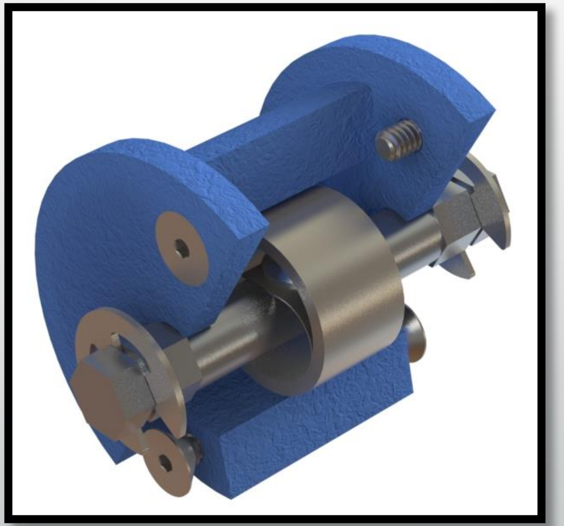
Payload Capture Device

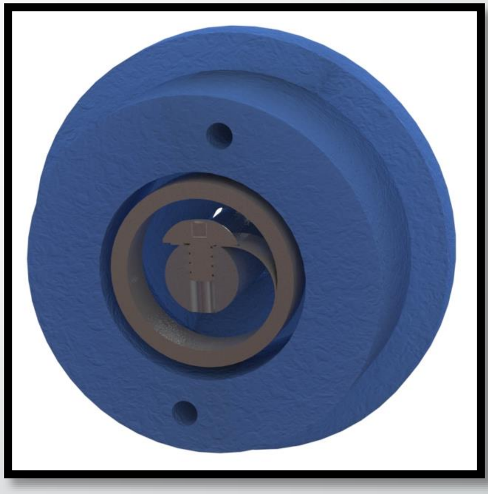
- Retrieves payload from ground and inserts into rocket
- Mounts onto base of (whatever we are calling it now)
- Max length:42.08”
- Min length: 25.49”



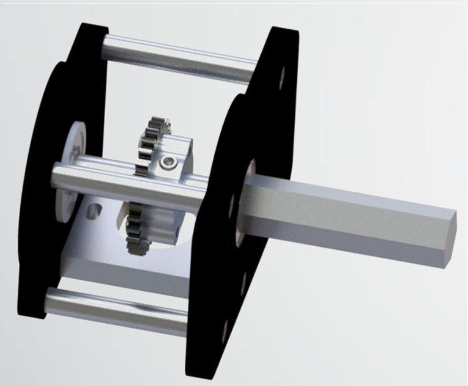
Wire Spool



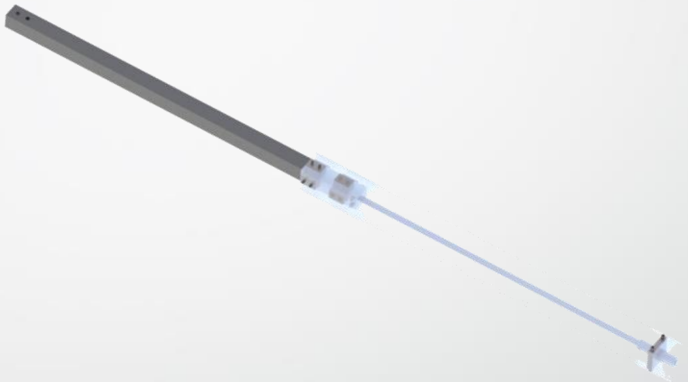




Payload Capture Mobility



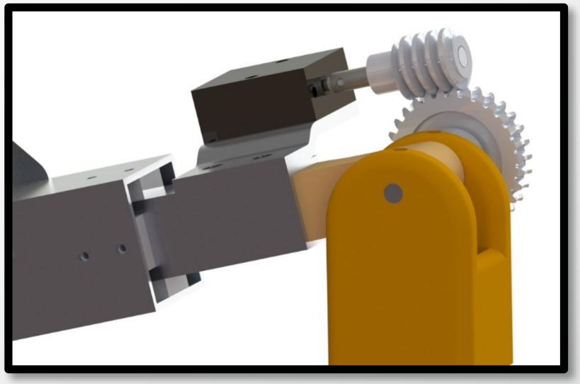
- Powered by 12 VDC motor
- Worm gear prevents stall on motor



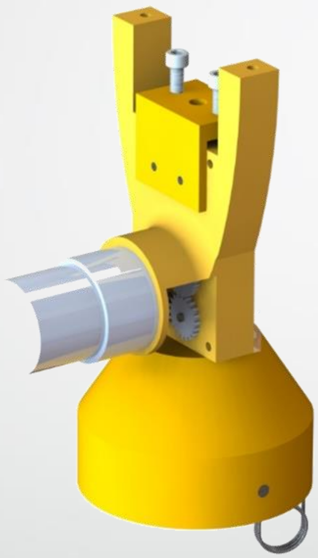
- Powered by 12 VDC motor
- Rides up and down ¼ 16" ACME Screw

Gripper Assembly

- Static compression gripper
- Gripper will stay in rocket with payload
- Gripper will be released by 4.8 VDC servo housed internally

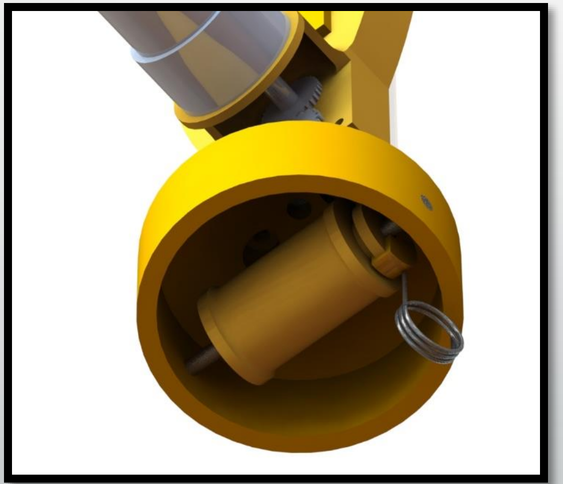


Igniter Installation

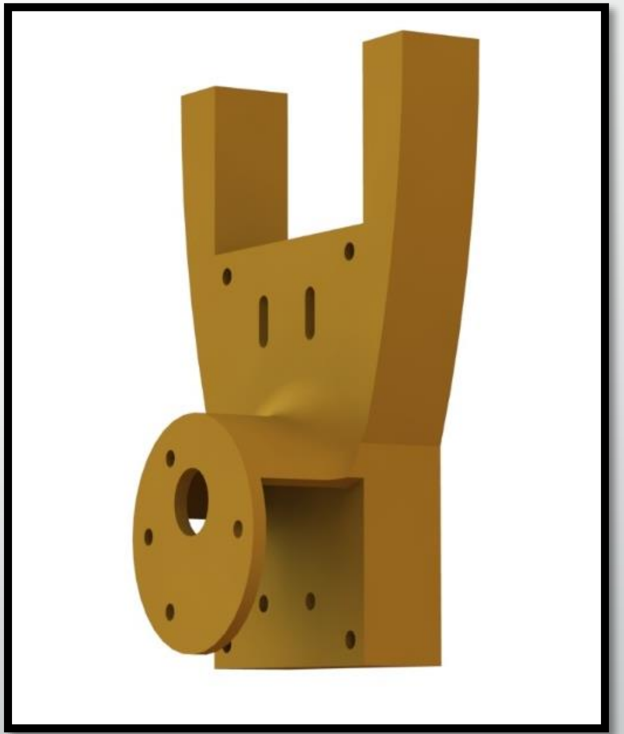


Mass (lb.)	Width (in.)	Height (in.)	Depth (in.)
3.70	3.25	6.32	3.25

Major Components

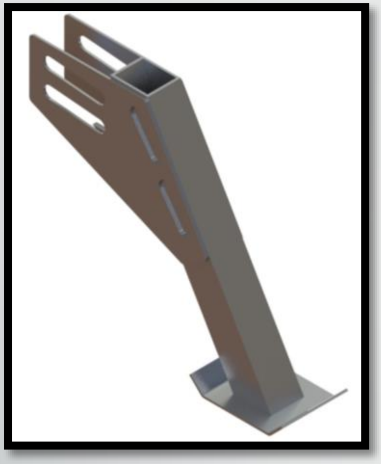


Motor Selection



- 12v DC
- 20 rpm
- Max torque 185 oz-in.

Sub-frame

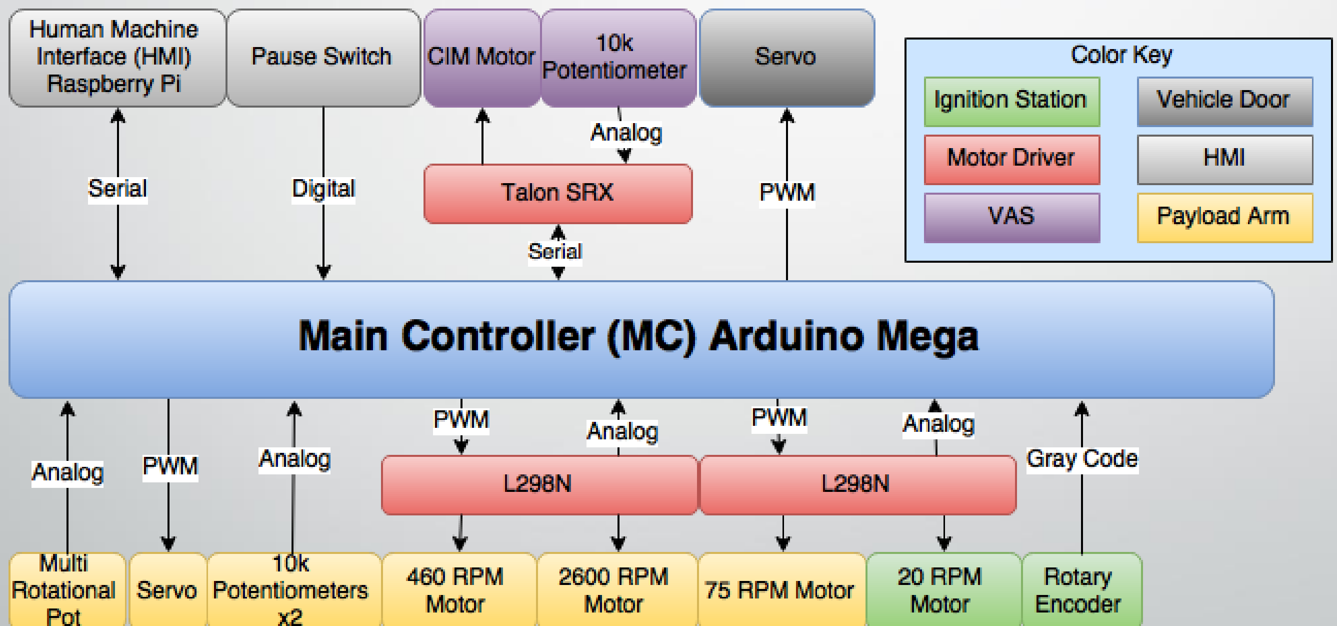


Mass (lb_m)	Width (in)	Height (in)	Length (in)
30.85	73.02	17.01	91.67

System Controls and Integration

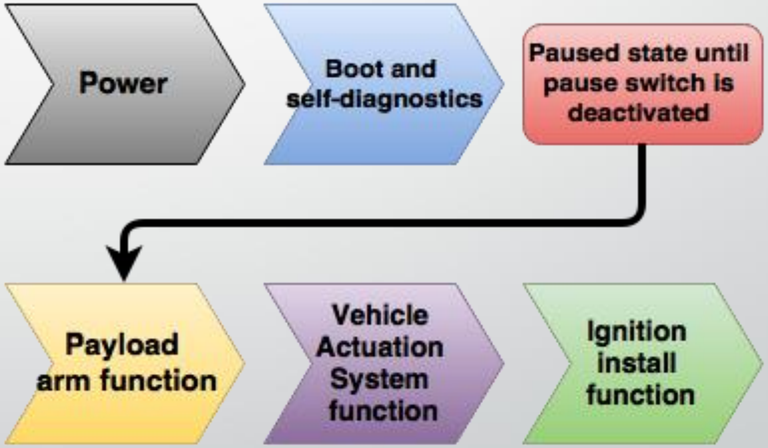
- Initiate startup
- Sub-system cooperation
- Distribute power
- Provide user interface

Electrical Systems Relationships

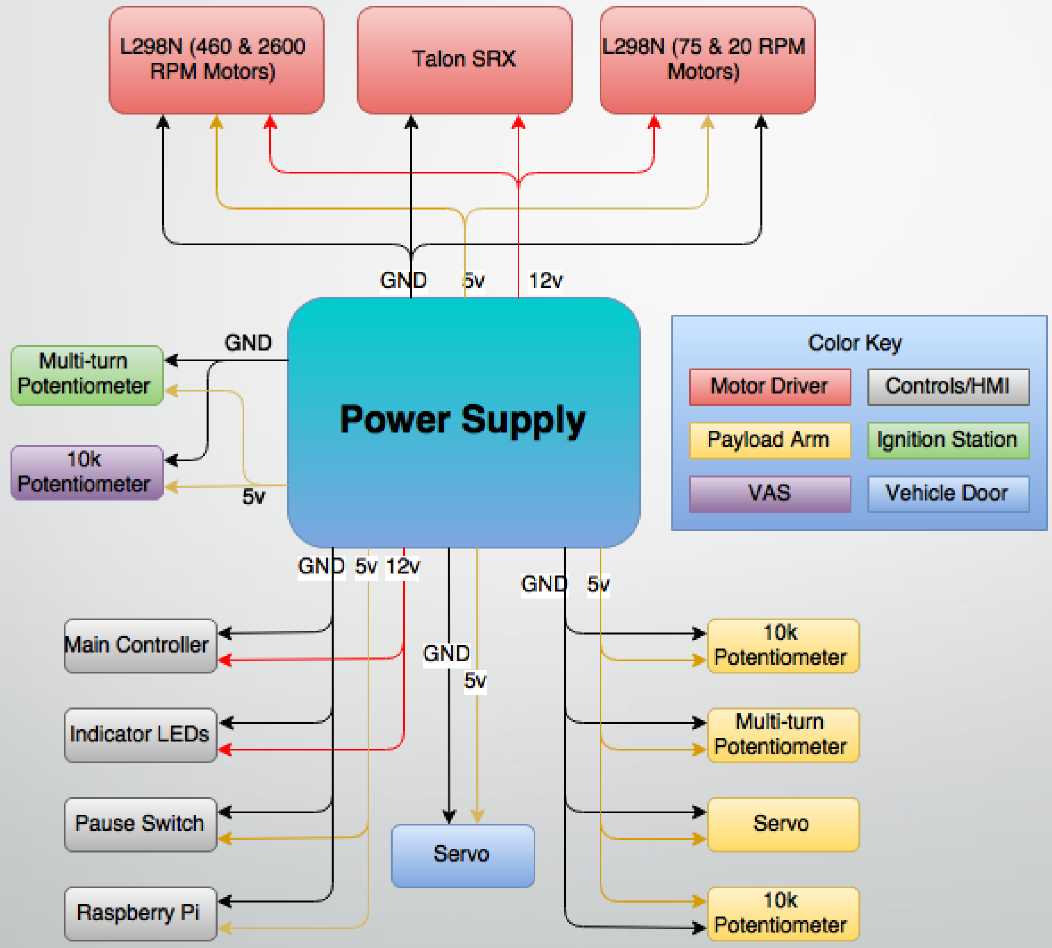


Sequence of Functions

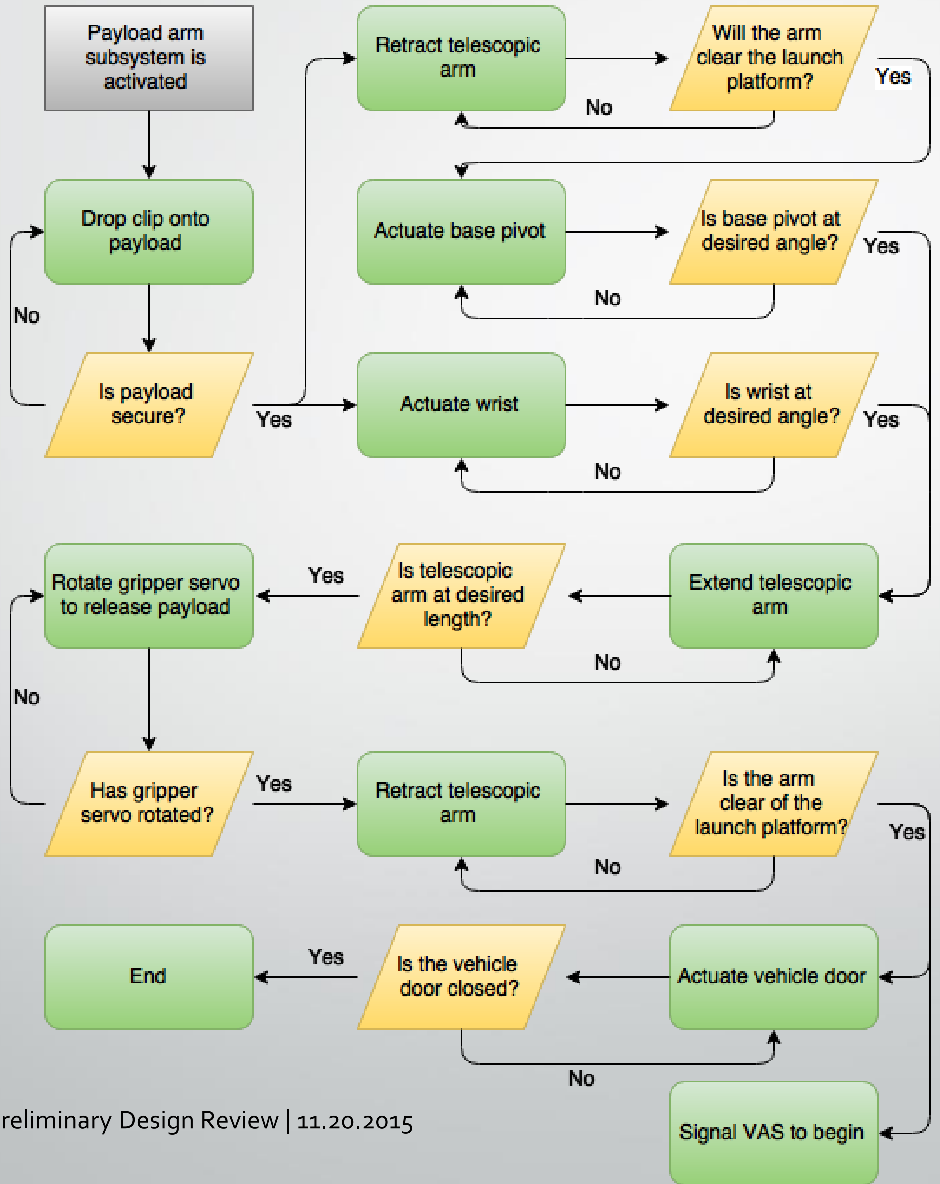
- Master power switch on
- Set to default position
- Waits for pause deactivation
- Begins 3 main functions
- Pause switch can halt sequence at any time



Power Distribution

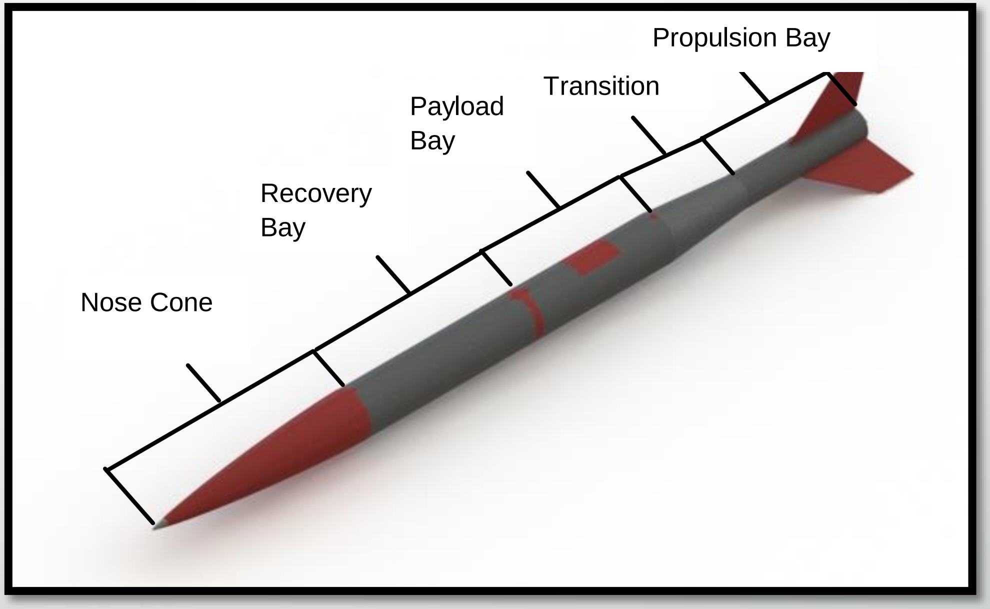


Payload Arm Flowchart



Overall Vehicle Design

- 6" Diameter Carbon Fiber Launch Vehicle
- 6" Diameter to 4" Diameter Carbon Fiber Transition
- Adjustable Ballast System
- Removable Fin System
- Retractable Door Assembly



Overall Vehicle Design (cont.)

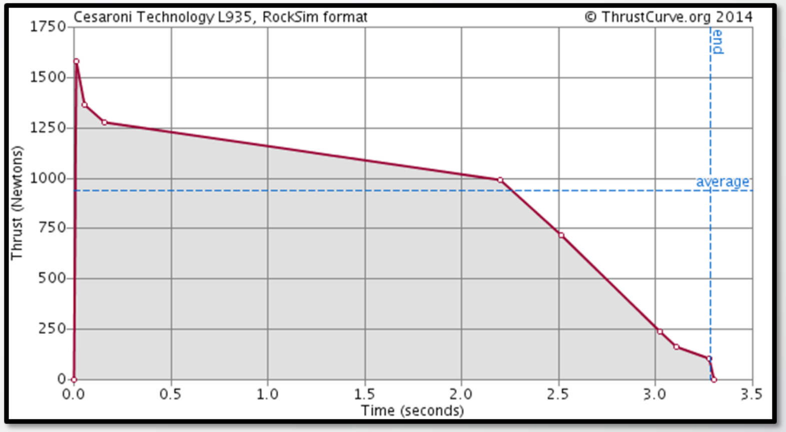
Primary Component Materials

- **Carbon fiber**
- **Fiberglass**
- **Aluminum**
- **Stainless Steel**
- **ABS Plastic**
- **Plywood**

Section of launch vehicle	Length of section (in)	Mass (lbs)
Nose cone	30	6.40
Recovery bay	26	4.83
Payload bay	20	8.32
Transition	12	0.98
Propulsion bay	20	3.70
Motor	N/A	5.61
	Total mass	29.84

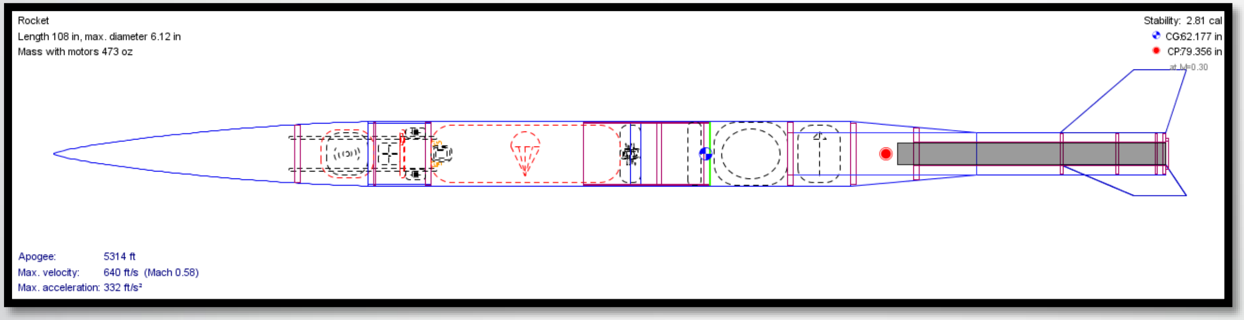
Vehicle Motor Selection

- Cesaroni L935-IM
- Obtained motor selection through various OpenRocket simulations trials



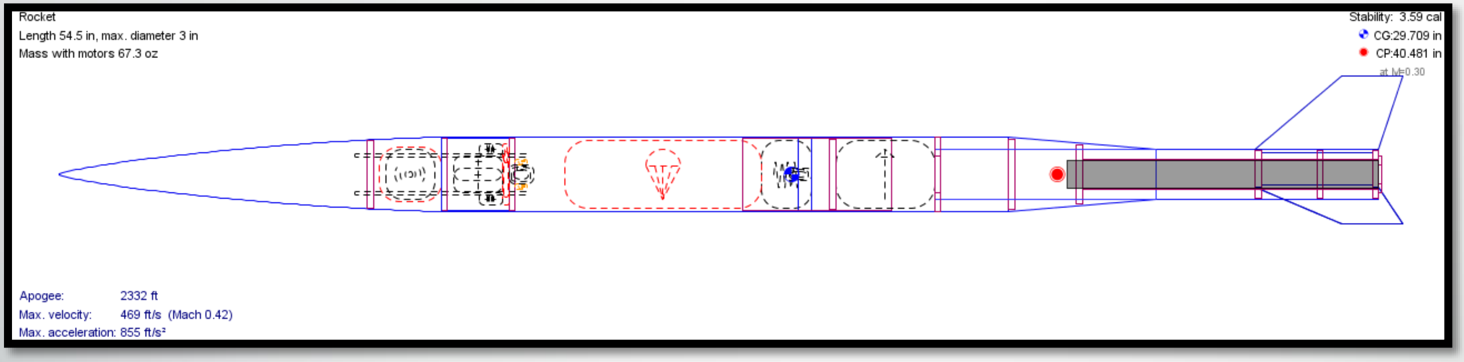
Thrust-to-weight ratio	12.06
Rail exit velocity	60.9 ft/s
Project altitude	5287 ft
Maximum acceleration	345 ft/s2
Motor burn time	3.4 sec
Maximum motor thrust	1585.6 N
Average motor thrust	933.8 N
Total motor impulse	3146.8 N-sec

Stability Margin



- Overall Length: 108 in
- Overall Diameter: 6.12”
- Overall Mass: 29.56 lbs
- Stability Margin: 2.81
- CG Location (from tip): 62.18 in
- CP Location (from tip): 79.36 in

Subscale Verification

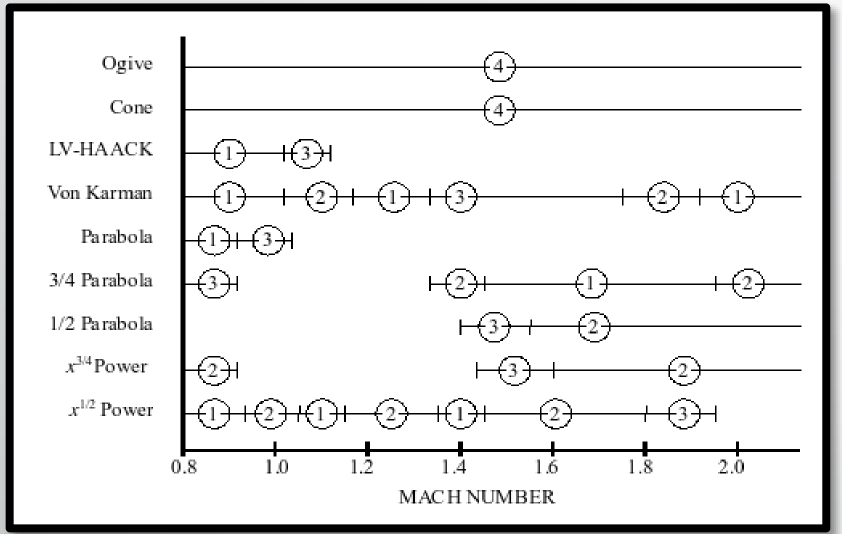


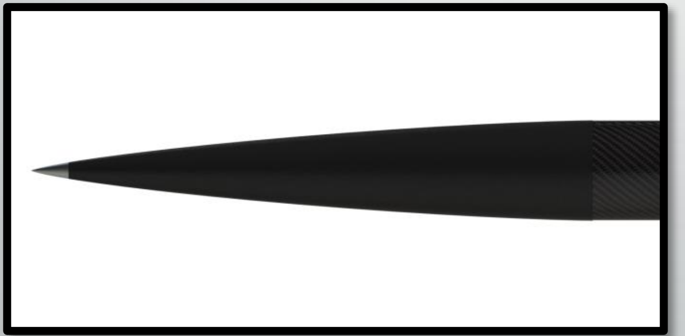
- A half scale model will be launched to verify aerodynamic properties of the rockets design.
- Will verify:
  - Aerodynamic properties and stability of the launch vehicle.
  - Custom reefing deployment parachute system and custom parachute design

Subscale Verification (cont.)

Property	Full scale	Subscale
Diameter (in)	6	4
Length (in)	108	54.5
Empty mass (in)	383	56.9
Motor selection	CTI 3147-L935-IM-P	CTI 217-H170-BS
Stability caliber	2.81	3.71
Rail exit velocity (ft/s)	60.9	66
Maximum velocity (ft/s)	640	342
Maximum acceleration (ft/s^2)	345	342

Nose Cone Design

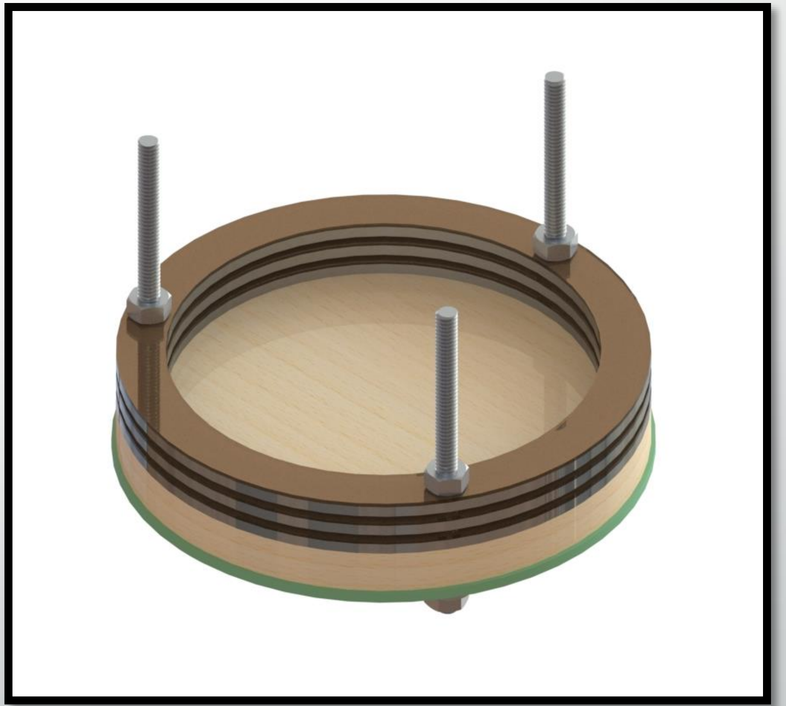




- The equation used to model the nose cone was the Von Karman equation, otherwise known as the LD-Haack.
- Optimal usage in ranges of Mach 0.8-1.2.
- $y = \frac{R}{\sqrt{\pi}}\sqrt{\theta - \frac{\sin(2\theta)}{2} + Csin^3\theta}$
- $C = 0\ for\ LD - Haack$

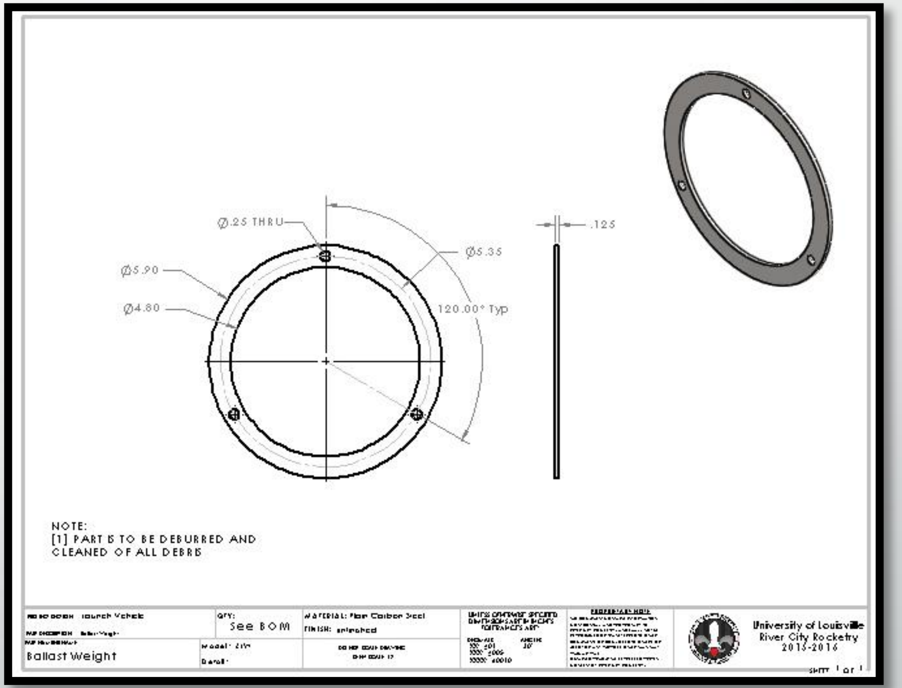
Adjustable Ballast System

- Designed to not interfere payload bay
- Adjustability of 0.33 lb increments



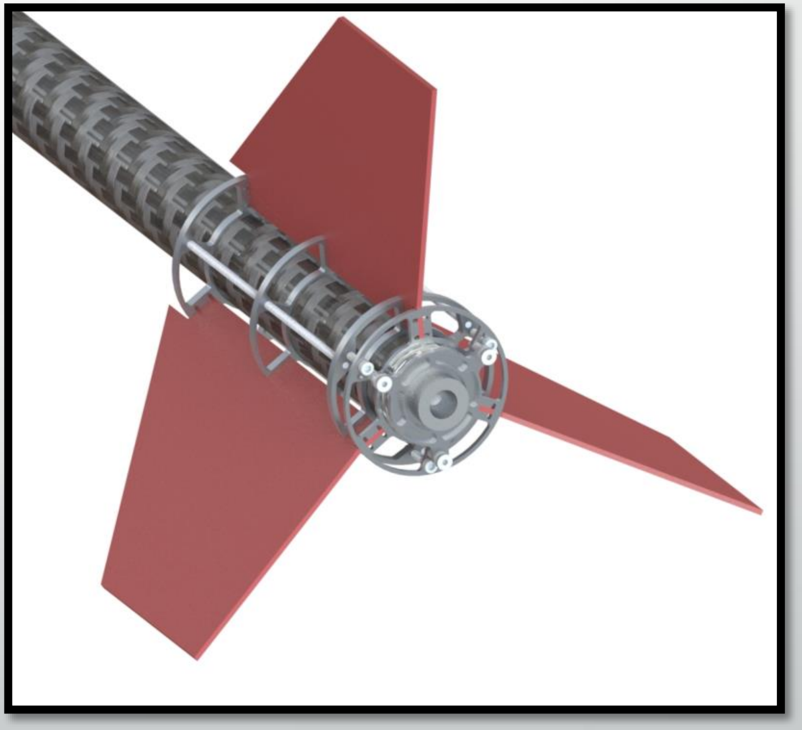
Adjustable Ballast System (cont.)

- AISI 1080 low carbon steel ballast
- 0.05" thick silicone spacer to reduce vibration during flight
- Allows for versatile manipulation of CG



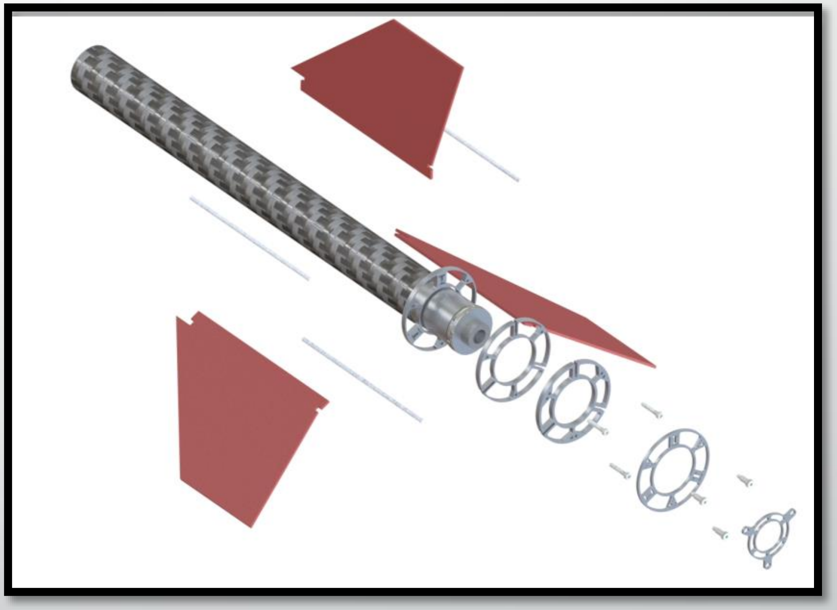
Removable Fin System

- Designed for quick and easy removal and installation of fins
- Advantages:
  - Fins are immediately replaceable in the event of breakage
  - Accurate mounting allows for predictably stable flight
  - Test various fin designs
  - Easier transportation

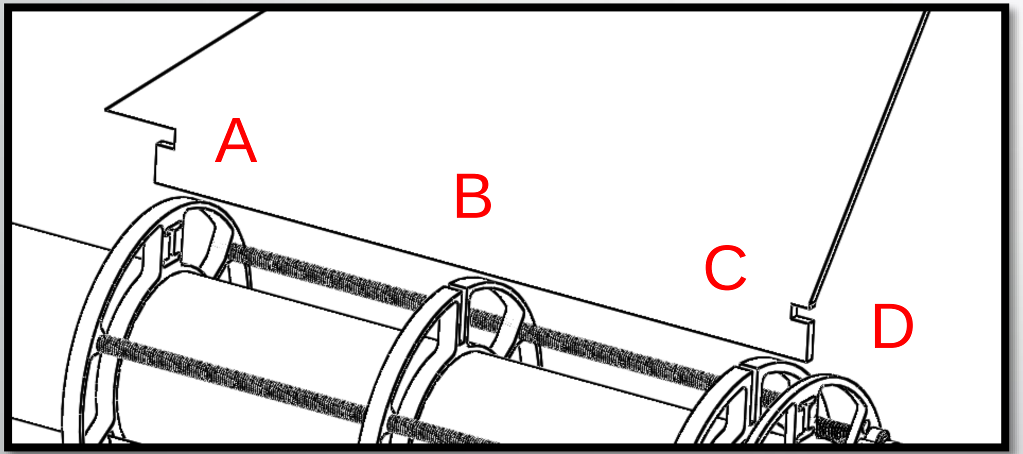


Removable Fin System (cont.)

- Components:
  - Fore, middle, and aft fin centering rings
  - Fin retainer
  - Motor Retainer
- All components machined from 6061-T6-Aluminum
- Centering rings are epoxied in place

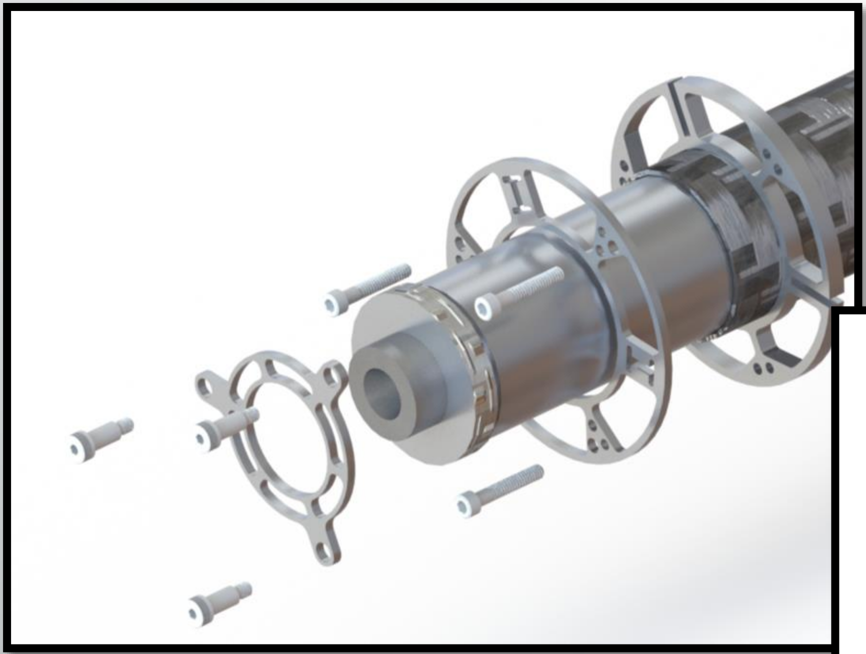


Removable Fin System (cont.)

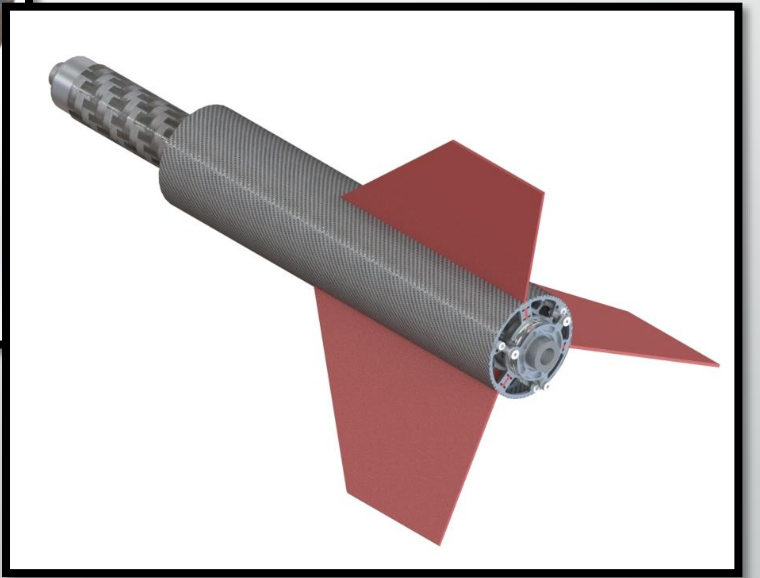


- Fin is inserted through airframe into slots at B and C
- Fin tab is pushed forward through slot A
- Rear fin retainer is installed onto aft fin centering ring (see next slide)

Removable Fin System (cont.)



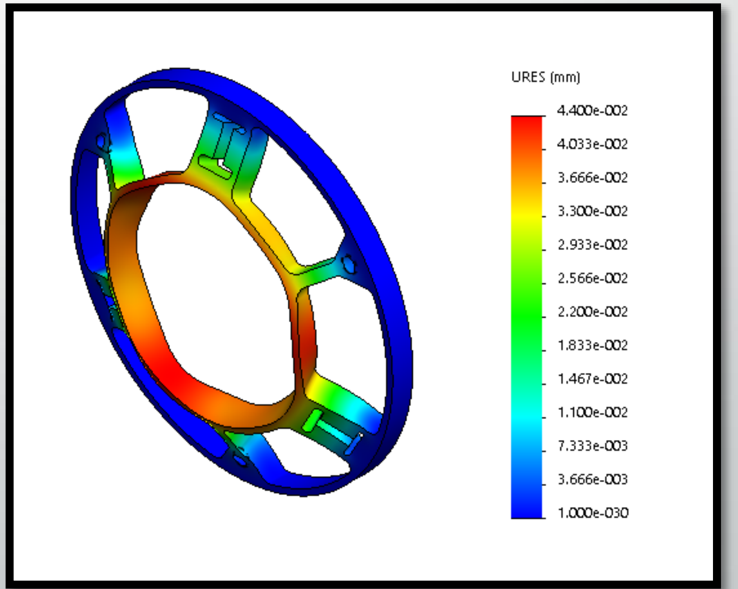
- Motor casing is installed into the motor tube
- Motor casing retainer is installed onto the rear fin retainer



Centering Ring Optimization

Component	Load applied	% of Motor force
Fore centering ring	567 N	33%
Mid centering ring	567 N	33%
Aft centering ring	1701 N	100%

- Optimized to reduce centering ring weight
- Minimum factor of safety of 2.0 for each centering ring

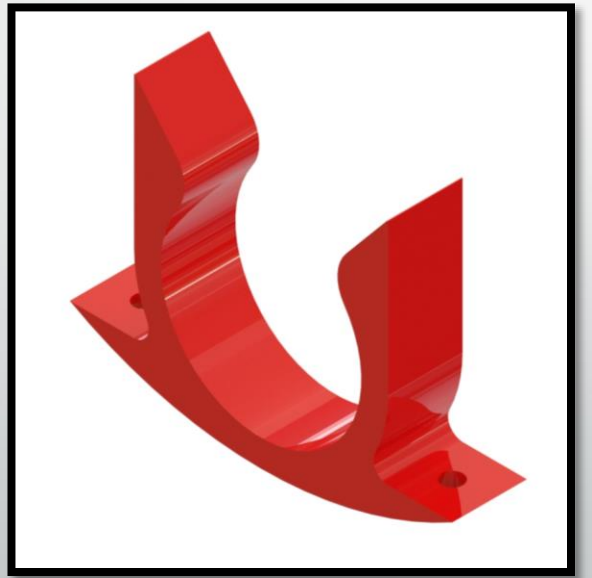


Centering Ring Optimization Results

	Maximum stress (Mpa)	Maximum displacement (mm)	Minimum factor of safety
Fore centering ring	103.5	0.044	2.65
Mid centering ring	101.1	0.056	2.85
Aft centering ring	112.1	0.074	2.45

Payload Containment

- Payload inserted into payload bay via payload capture device
- 3D printed clips retain cache payload



Retractable Door Assembly

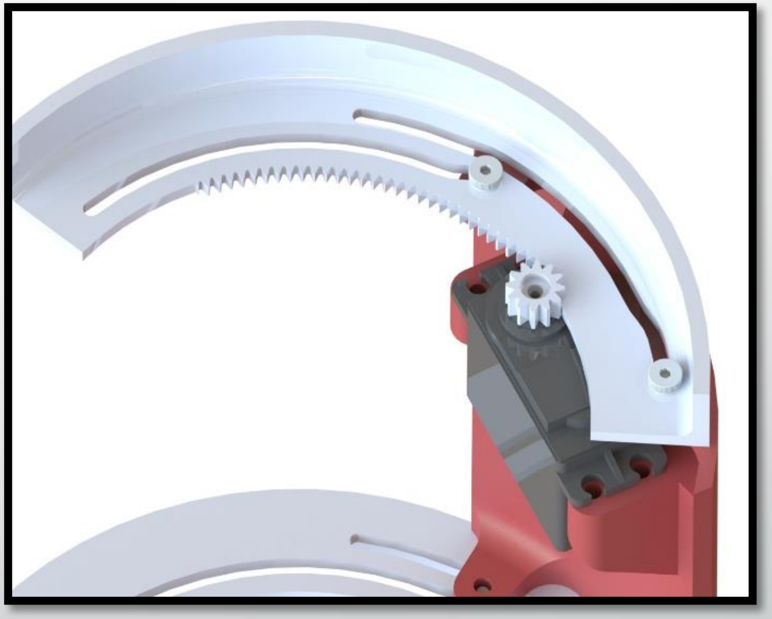
- A rotating 3D printed door was designed to allow for access to load payload into payload bay
- Door has the same outer radii in order to form a near seamless two piece assembly

Retractable Door Assembly (cont.)

- Rotational movement eliminates wasted space from linear movement
- Door is driven by a servo motor connected to a rack and pinion gear system

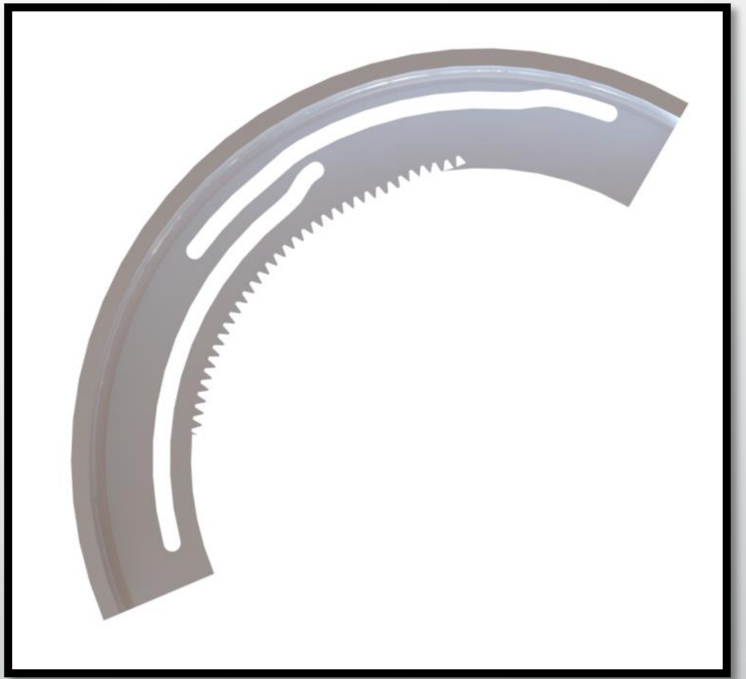
Retractable Door Assembly (cont.)

- Steel should screws attach door to guide tracks
- Servo motor will compensate for any frictional issues associated with steel on plastic contact



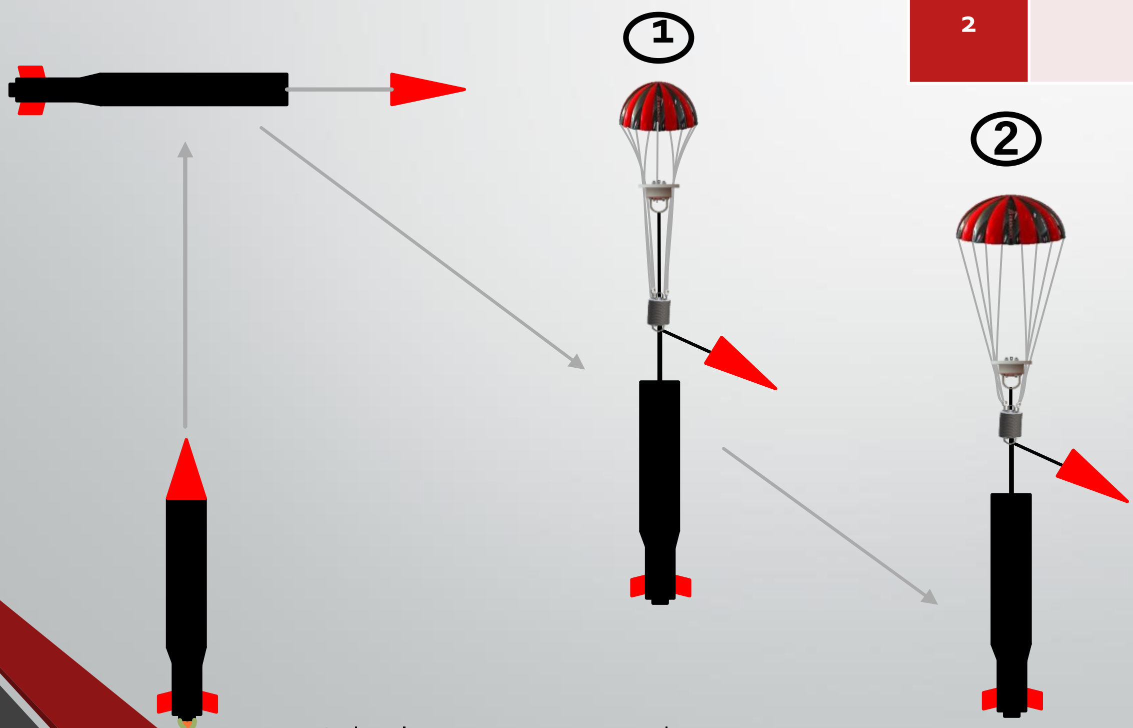
Retractable Door Assembly (cont.)

- Two separate paths for track guides
- Upper guide acts as the rack for pinion to run against

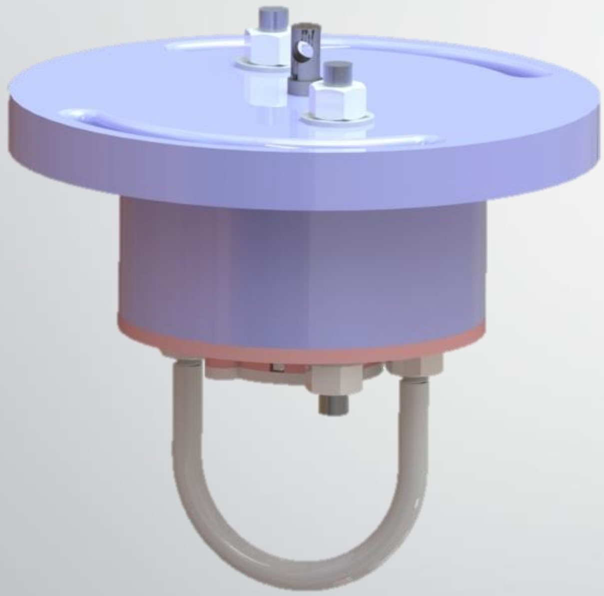


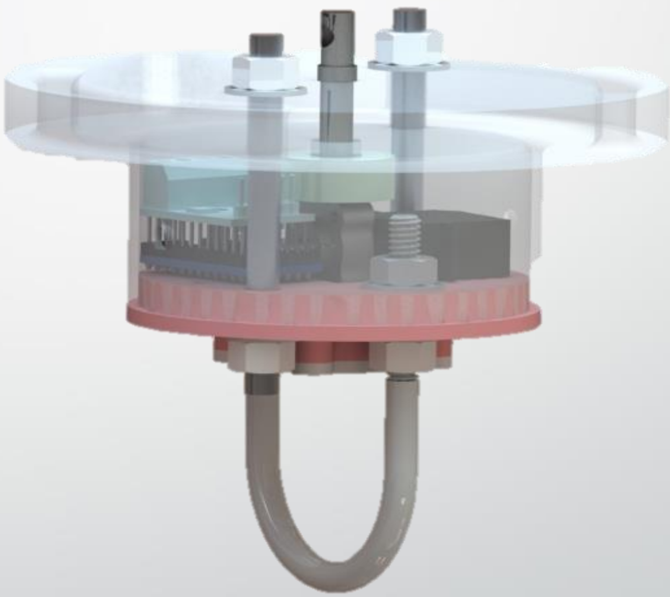
Vehicle Flight Path

Event	Altitude (ft.)	Description
1	5,280	Apogee. Upper stage of the rocket separates from propulsion bay. Reefed main parachute to act like a drogue.
2	800	The act of de-reefing allows main parachute to fully open.

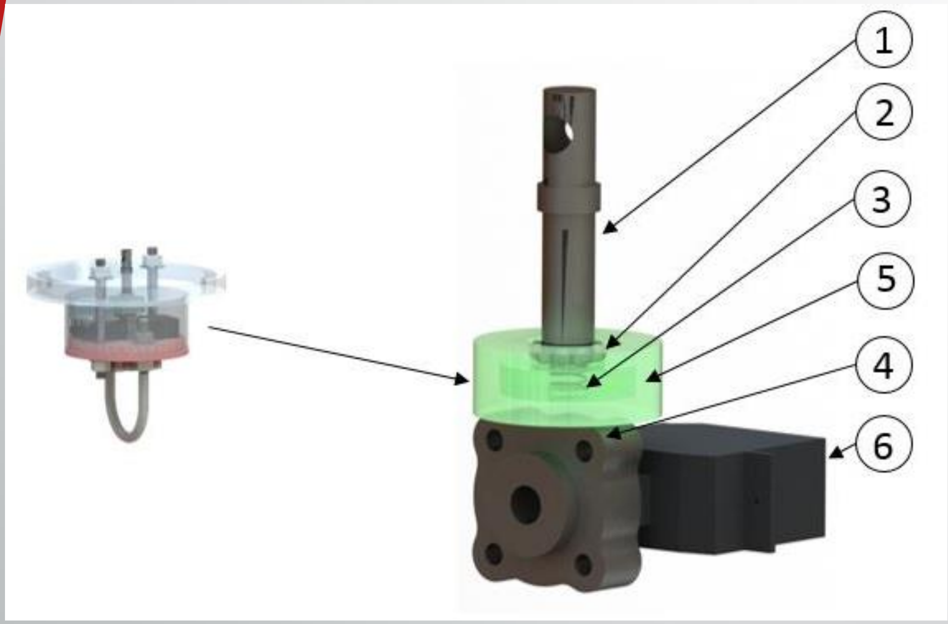


Reefing System





Reefing System Continued…



Item Number	Description	Quantity
1	Ejection Pin	1
2	3/32 ball bearings	9
3	0.187 inch by 0.125 inch compression spring	1
4	Ball bearing retainer	1
5	Servo hub	1
6	Micro servo 9g A0090	1

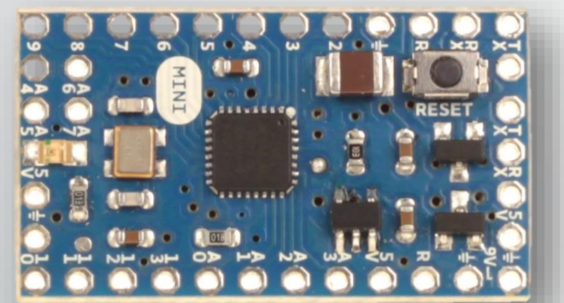
Reefing System Continued…

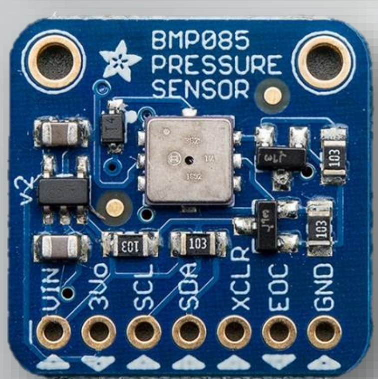
- Secondary Reefing Bay
- Central tie off point that connect the launch vehicle to the recovery system.

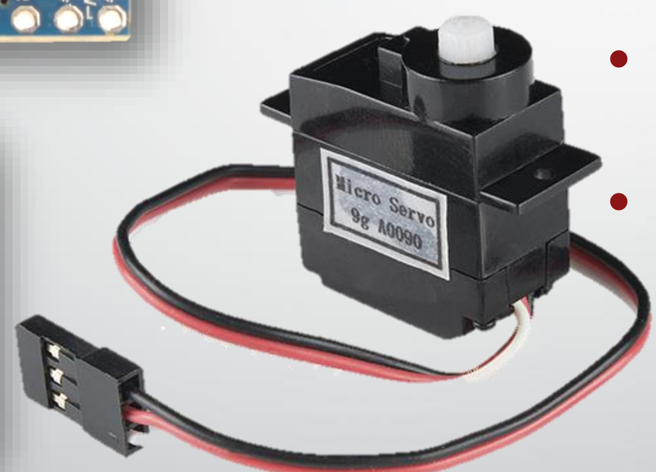
Avionics

- Two PerfectFlight StratoLoggers placed in nose cone
- Garmin Astro DC40 dog tracker

Reefing Electronics







- Arduino Mini
- Adafruit BMPO85 barometric pressure sensor
- Micro Servo 9g A0090

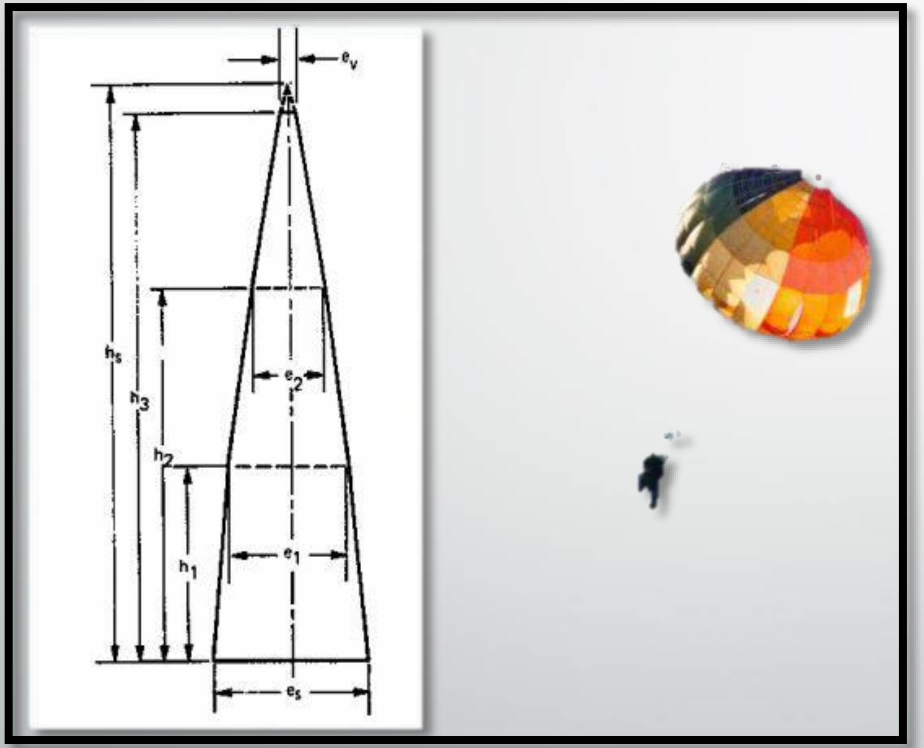
Kinetic Energy and Drift Calculations

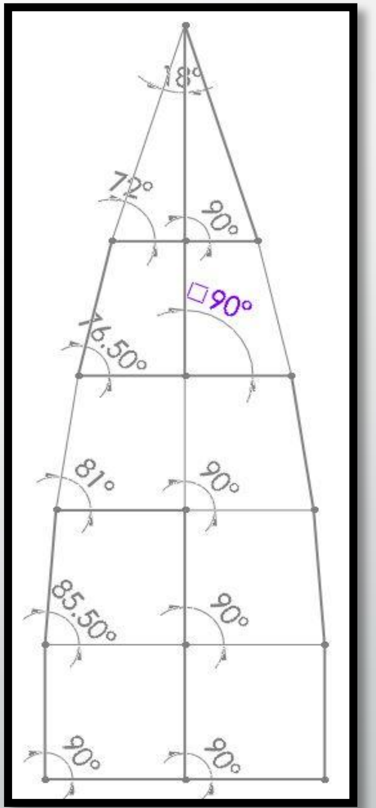
Section	Mass (lbs)	KE (ft-lb$_f$)
Nose Cone	4.89	12.29
Booster (rest of rocket)	19.00	47.71

C_D (worst case)	0.75
Mass (lbs)	23.89
Area(ft^2)	169.33
Diameter (ft)	14.68
Velocity (ft/sec)	12.71

Wind speed	Drift (ft)
0	0
5	109.11
10	218.20
15	327.31
20	436.41

Polyconical Schematic and Layout





Safety Features

Safety Manual

- Lab workshop safety
- Launch safety
- EE safety
- MSDS
- Energetics safety

Risk Assessment Matrix				
Probability Value	Severity Value			
	Catastrophic-(1)	Critical-(2)	Marginal-(3)	Negligible-(4)
Almost Certain- (1)	2-High	3-High	4-Moderate	5-Moderate
Likely-(2)	3-High	4-Moderate	5-Moderate	6-Low
Moderate-(3)	4-Moderate	5-Moderate	6-Low	7-Low
Unlikely-(4)	5-Moderate	6-Low	7-Low	8-Low
Improbable-(5)	6-Low	7-Low	8-Low	9-Low

Table 3: Risk Assessment Matrix

Comprehensive launch procedure:

- Required tools
- Assembly instructions
- PPE
- Warning, Caution and Danger icons

Risk Assessment Matrix:

- Lab and machine shop
- AGSE
- Electronics
- Recovery
- Vehicle
- Environmental

Educational Engagement

- MathMovesU
- Robotics
- Programming through games
- Electronics Satellites E-Expo
- Paper rockets
- Water rocket competition

2015-2016 Overall Budget

Overall Tentative Budget	
Budget	**Total Cost**
Full Scale Vehicle	$1,822.49
AGSE	$821.40
Recovery	$1,346.88
Subscale Vehicle	$962.30
Educational Engagement	$1,163.42
Travel	$5,750.00
Promotional Materials	$3,012.50
Safety and Misc	$4,866.07
Overall Cost	**$19,745.06**