Critical Design Review

University of South Florida

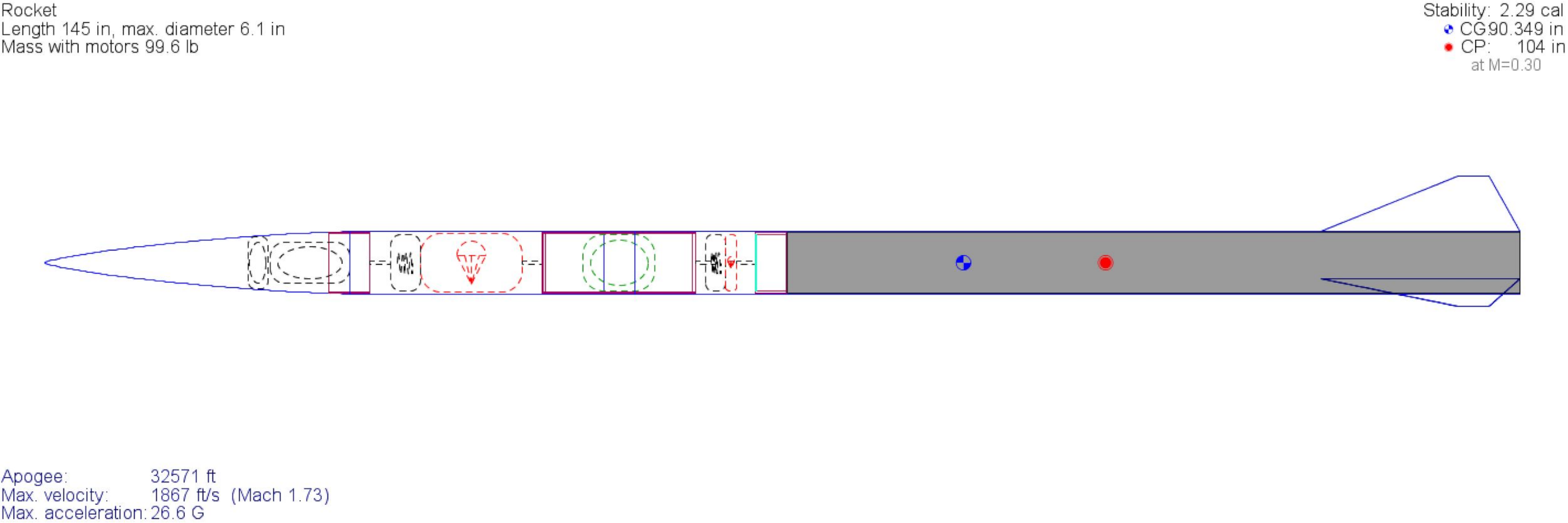
Society of Aeronautics and Rocketry

Spaceport America Cup 2020

Agenda

1. **Vehicle Summary**
2. Recovery
3. Ground Systems & Launch Procedures
4. Avionics & Payload
5. Future Plans & Deadlines

Vehicle



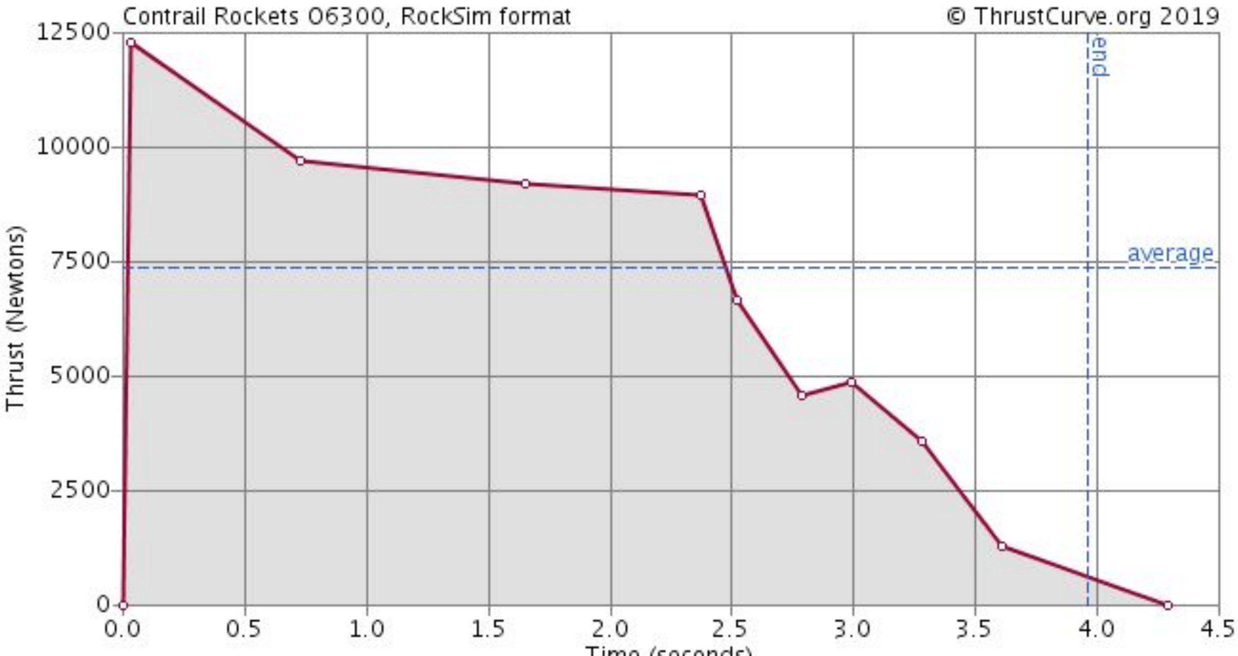
Fuel Weight: 11.1 lbs

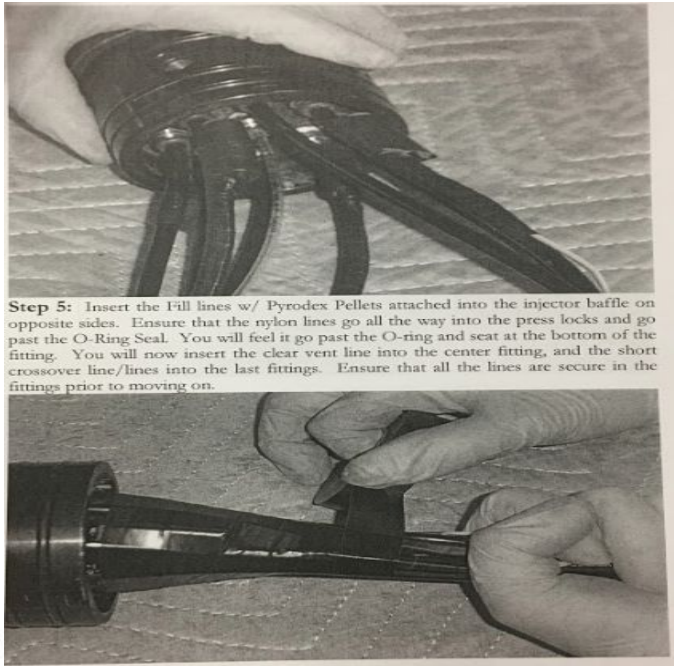
Payload Weight: 8.8 lbs

Materials: Fiberglass body and carbon fiber fins

Motor: Contrail O6300

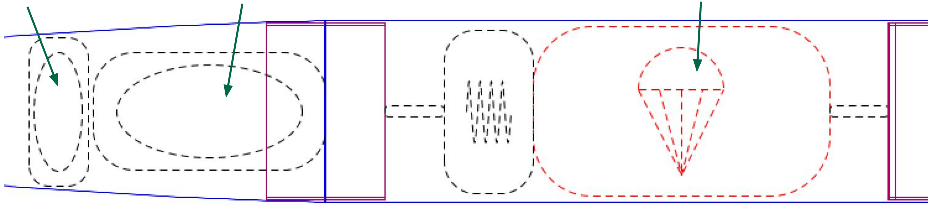
Statistics	Declared	Calculated	Official
Diameter (mm):	152.0	n/a	152.0
Length (cm):	182.9	n/a	182.9
Prop. Weight (g):	3,175.0	n/a	5,216.0
Total Weight (g):	28,576.0	n/a	28,576.0
Avg. Thrust (N):	6,803.0	7,366.2	6,353.6
Max. Thrust (N):	12,271.0	12,271.0	12,732.1
Tot. Impulse (Ns):	29,184.8	29,184.8	27,244.0
Burn Time (s):	4.3	4.0	4.3



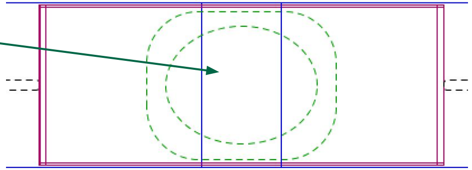


Sections

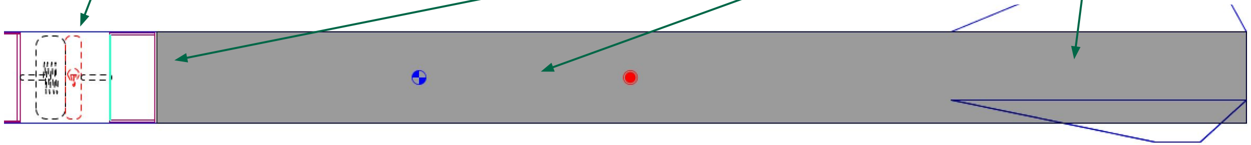
Upper Airframe: ABS Payload Main Parachute



Coupler: Avionics Bay / Switchband

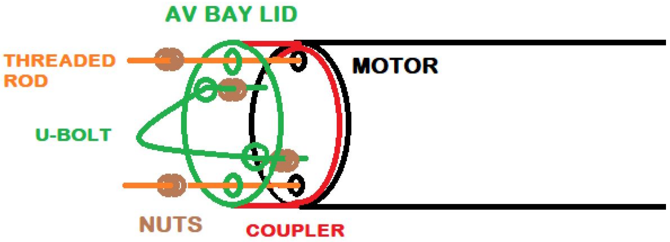


Lower Airframe: Drogue Motor Retention / Tank Fuel Casing

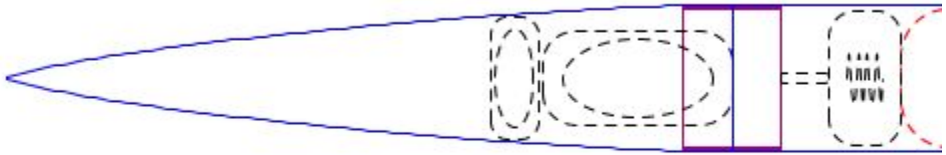


Key Design Features

Motor Retention System:
Our motor will be retained as if it were min-Dia. This requires a specially designed retention system.



Nosecone Integrated Payload:
By putting the payload in the nose cone, we save space in the rocket and push the center of gravity higher.



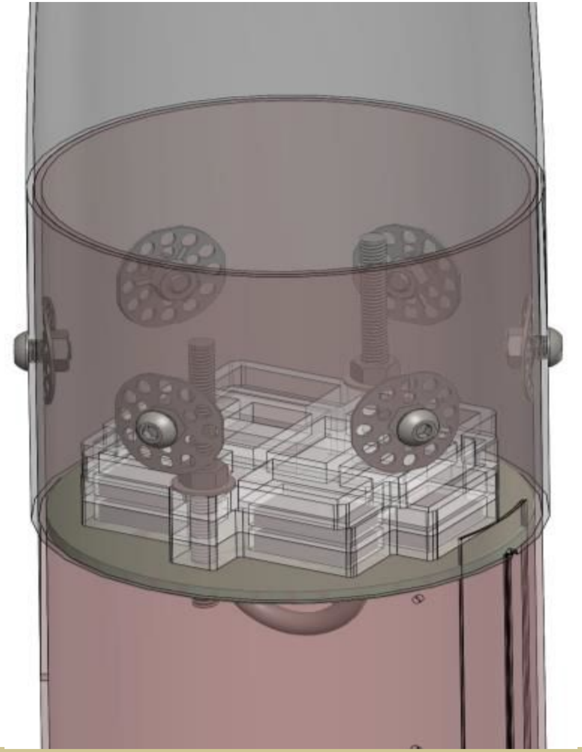
Tip To Tip Fins: By tip to tipping the fins, we drastically reduce the chances of a in flight shred. Being tested on Apis II subscale

Adjustable Ballast System

An adjustable ballast system is simply a device we can add or remove weights from to change our CG and improve stability.

This design has been used heavily in our past NSL rockets.

As part of the rules for the payload in IREC, we have to have a payload of 8.8lbs (33% of which can be dead weight) and we don't expect to need a large ABS as the payload is so heavy.



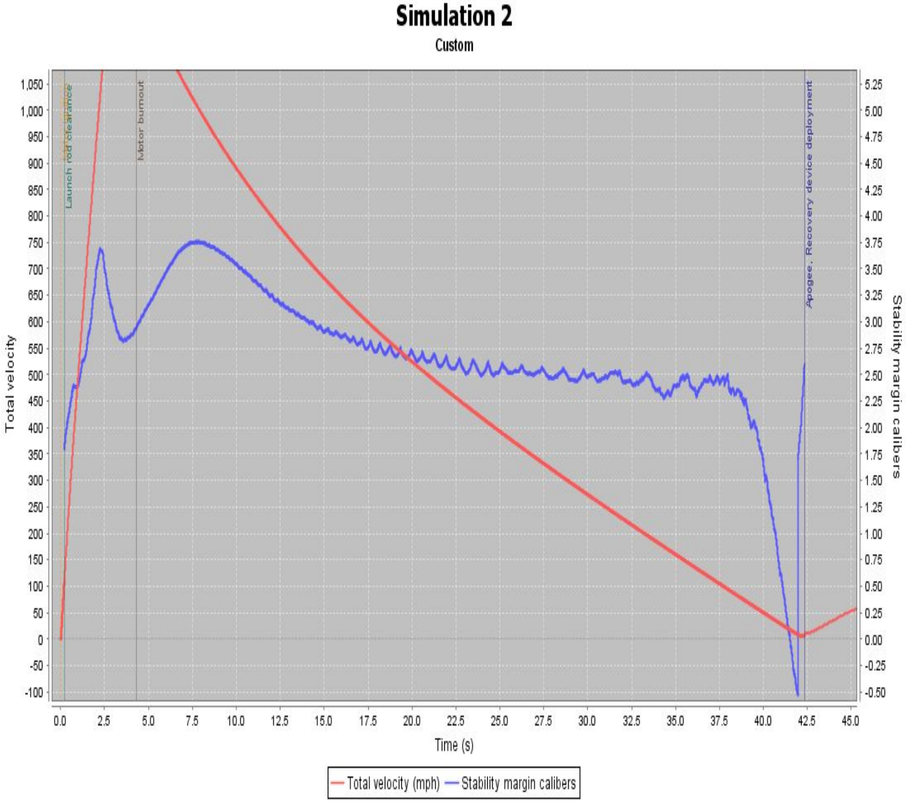
Fin Size Selection

Fin Height (in)	Stability (cals)	Altitude (ft)	Comments
5	1.67	32,886	Max alt
5.25	1.99	32,726	Lowest acceptable Stability Margin
5.5	2.29	32,574	Best mix
6	2.81	32,253	Max stability

Rocket Flight Stability

Assuming we utilize 5.5” fins, we can expect our static stability to be 2.29 cal.

At rod clearance, we are at our lowest stability of 1.625. This will increase to 2.0 in under 0.2 seconds.
At Mach 1 we will hit 2.9 cal.
Our max stability is 3.69 at Mach 1.3
We drop to 2.8 at Mach 1.6.
We go back to 3.6 cal and then to 2.75-2.5 cal at the cruising portion on the flight. We topple at 1 second before apogee.



Mass Statement

99.6 lbs TOTAL (w/o epoxy)
36.6 lbs (No motor)
52 lb Motor
11 lb Propellant
8.8 lb Payload
1.2 lb ABS
1 lb of cf wrap (cf and epoxy weight for 2 layers)
~1 lb epoxy used in assembly

Expected total after assembly ~105 lbs

Apogee Projections (Full Scale)

Launch Angle (degrees) @4.47 mph wind	Altitude
83	31867
84	32032
85	32172

Apogee Projections (Small Scale)

Info@contrailrockets info@contrailrockets.com via yahoo.com
to me

That is one I never tested efficiency improves the longer the motor burns both due to increase in heat and increase in surface area.
My best guess is 50 % NOS gets you 1/3 total thrust.

Have been playing with HPTV injectors and Pleated grains which act much differently in NOS utilization. Seeing a 40% bump in performance in some of my smaller motor tests.

Tom

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2. **Recovery**
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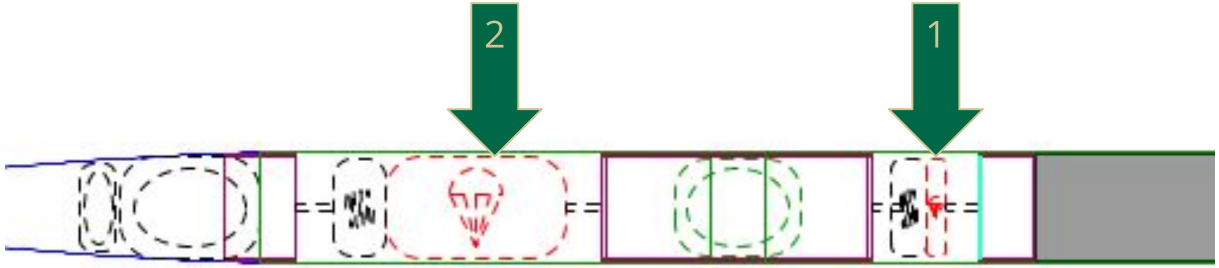
Recovery Overview

1. Drogue Parachute
   a. 4’ Rocketman Standard
   b. Shock Cord: Rocketman 2,520 lb test Braided Kevlar
2. Main Parachute
   a. 144” Rocketman High Performance CD 2.2
   b. Shock Cord: Rocketman 2,520 lb test Braided Kevlar



Recovery Concept of Operations

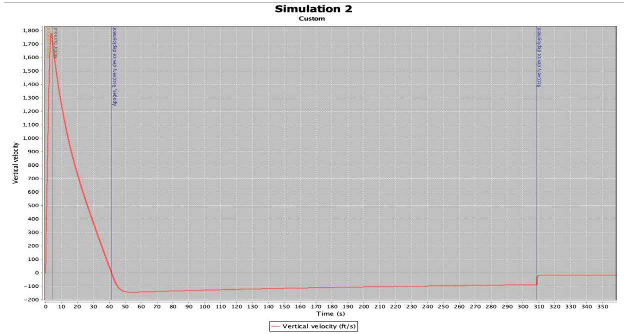
1. Recovery Devices are armed on the pad
2. Rocket launches
3. Drogue is deployed at apogee using black powder charges
4. Main parachute is deployed at 1000 Feet AGL using black powder charges
5. Rocket lands, Recovery team heads out and picks it up

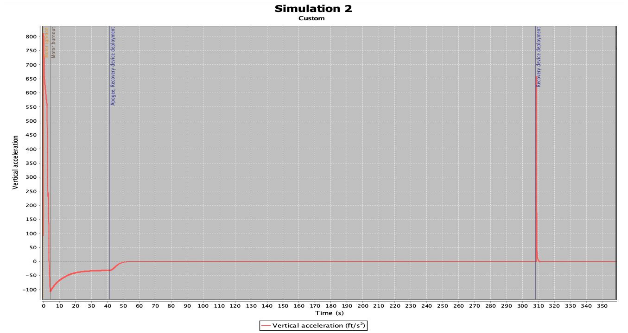
Recovery Details

	Rocketman High Performance CD 2.2 144”	Rocketman Standard
Deploy Setting	1000 Feet AGL	Apogee
Backup Deploy Setting	950 Feet AGL	Apogee +1 Second
Material	1.1 Mil-spec Ripstop Nylon	1.1 Mil-spec Ripstop Nylon
Surface Area (sq. ft.)	~113.09	~12.57
Drag Coefficient	2.2	0.97
Number of Lines	16	4
Shock Cord	50’ Rocketman 2520 lb Test Kevlar	50’ Rocketman 2520 lb Test Kevlar
Descent Rate	19 ft/s	89.5 ft/s

Recovery Predictions

	Drogue	Main
Descent Velocity (ft/s)	-144.75 ft/s decelerating to -89.5 ft/s at Main Deploy	-19 ft/s, very little variance during descent
Descent Time (s)	319 Seconds after Deployment Charge to Ground Hit	52 Seconds after Deployment Charge
Kinetic Energy at Landing	N/A	590.05 ft-lbf





Recovery Drift Predictions

Wind Speed (mph)	Drift (feet/miles)
0	125/0.02
10	1154/0.22
20	2780/0.53
30	11887/2.25
40	16567/3.13
50	22329/4.22
60	27821/5.27

Method

Used OpenRocket Parachute Simulations, and assumed average wind speeds over the entire altitude range based on measurements from the Aviation Weather Center.

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Ground Systems Overview

Current plans are for either a partial rebuild of our existing launcher to upgrade it to a wireless system or to build an entire launcher from scratch.

Launcher will include two physical lockouts that will be kept with arming personnel at all times.

Ground Systems Details

The Ground System will be capable of remote filling and purging our on-board Nitrous tank.

It also controls the launch sequence of the rocket.

It will be connected to an external Nitrous tank and a 12V battery.

The ground system is completely safe until both the ignitor wire leads and Nitrous has been loaded onboard the rocket.

This gives the maximum possible safety.

Ground Systems Safety Features

The Ground System will remain disconnected from the battery until the non-essential personnel are ready to leave.
The unit will be connected to power to ensure the battery is in working condition and then non-ess. personnel will retreat.

The ground system has an independent arming switch allowing the unit to be turned on and remain unable to fire.

The system will have a physical disconnect joint to prevent any signals from reaching it before desired.

The transmitter will also have a physical disconnect key which will be worn by Propulsions lead to ensure it is not in the firing controller and cannot be activated prematurely.

Launch Procedures

Rocket assembly procedures tbd

Procedure	To be Done By
Once the rocket is ready on the rail, all non essential personnel will evacuate the area	All members except essential
Avionics is armed and payload is turned on	Avionics Lead
Fill hose will be connected to rocket and GSE	Propulsion Lead
Ignitor will be connected to GSE	Propulsion Lead
GSE will be turned on	

Launch Procedures (cont)

Leak test will be performed	Propulsion Lead
GSE is armed. All personnel leave	Recovery Lead
Fill command is given and held to continually top off tank	Propulsion Lead
Ignition command is given.Fill command is stopped.	Propulsion Lead

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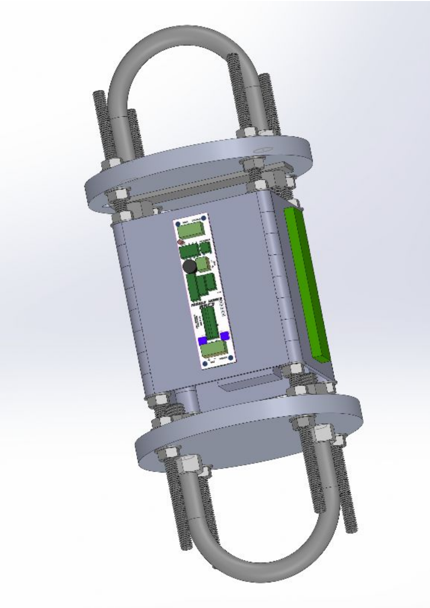
Avionics Overview

Primary Altimeter:	MissileWorks RRC3
Secondary Altimeter / GPS:	EggTimer TRS
Batteries:	3x 950 mAh 2S LiPo

1x RRC3, 1x TRS GPS, 1x TRS Deployment

Arming:	External key switches



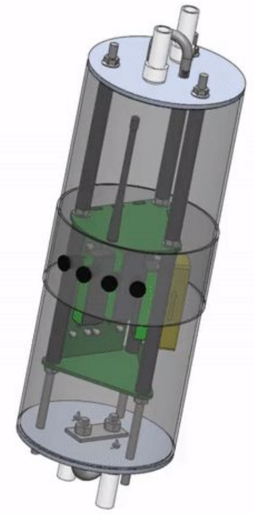
Avionics Bay Assembly

CNC milled ¼” 6061 Aluminum bulkheads

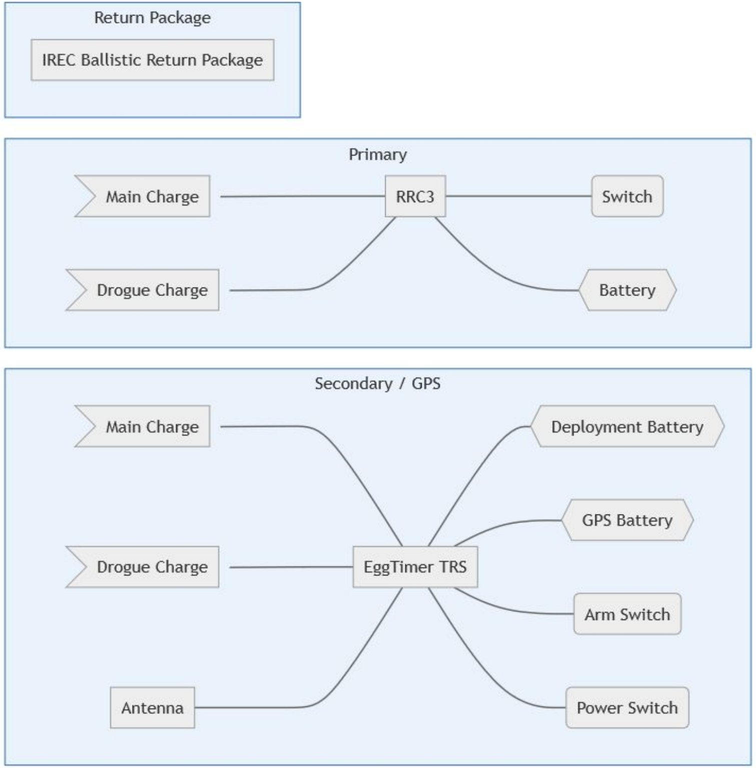
3x 5/16”-18 HSS threaded rods

Triangle sled design
- CNC milled fiberglass plates
- Batteries on interior for protection
- Boards/return pack on exterior for ease of access
- Antenna mounted near edge for GPS transmit

Shielding on threaded rods protects signal and provides structural support



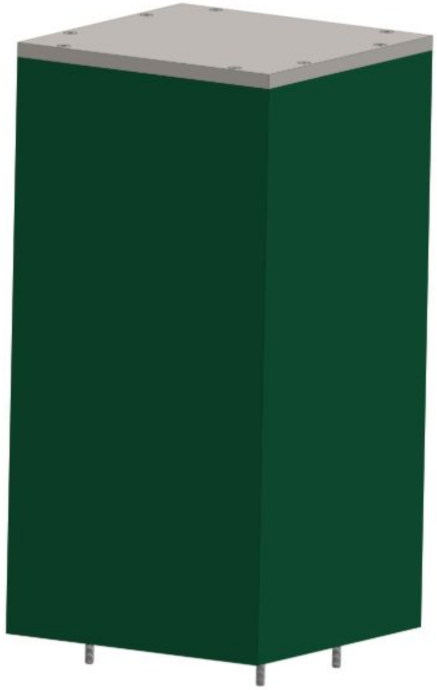
Avionics Wiring Flowchart



Payload Summary

The payload will transmit to a ground station via the RFM95W module the information collected from the ADIS16470 IMU, GPS module, and barometric sensor.

The bay will sit in the nose cone, flush to bulkhead connecting the nose cone to the rest of the rocket and attached by 4 M3x0.5 steel threaded rods



Payload Details

Outer frame made of 3D printed PLA polymer with a uniform wall thickness of 7mm

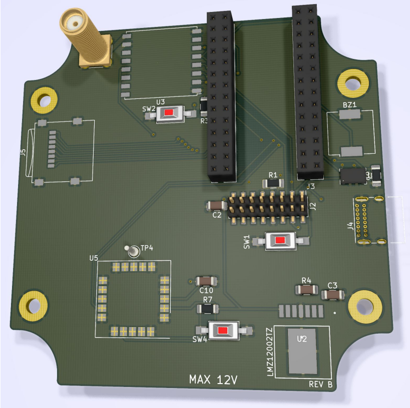
Two AISI 1020 steel plates will be attached to the bay: one inside (thickness of 2mm) 116mm from the bottom of the bay frame, separating it into two parts, and one as the cap to the entire bay (thickness 5mm). Both will be attached using low profile M3 socket head screws

Two PCBs measuring 10x10 sq.cm. spaced 9mm apart using M3 threaded Hex coupling nuts

The ADIS IMU and batteries will be placed in the upper part of the bay sitting above the steel plate

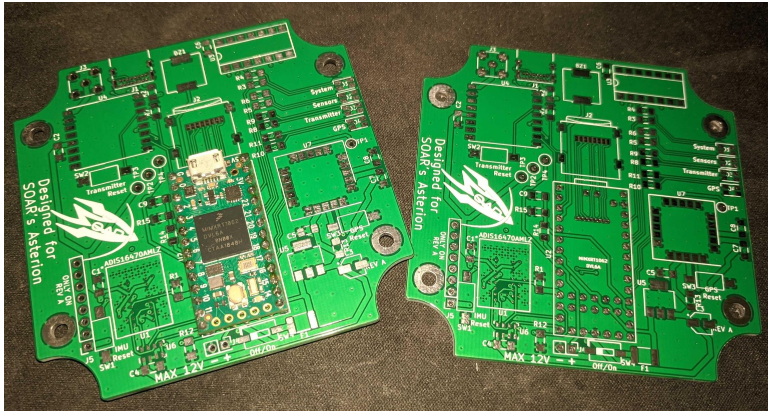
Batteries will be high capacity Lithium Ion batteries to add weight as well as to enable a long duration that the rocket might sit on the pad

PCB Status



PCB Revision A had issues that led to it not being able to properly function. This is both due to not enough review and it largely being a learning process. PCB Revision B should be getting sent to be manufactured within the week. Once we get it back we will be able to make the code for the project.

Rev B increases the modularity of the system allowing for easier swapping of parts.



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Future Project Plan

Tuesday 2/18	Inventory/Mounting hardware ordering
The next few weeks	Build Days
March 21	Rail test fit and ground testing
April 18	Launch
June	Competition