Flight Readiness Review Presentation

AIAA OC Section

Vehicle Design

Launch Vehicle Design and Dimensions

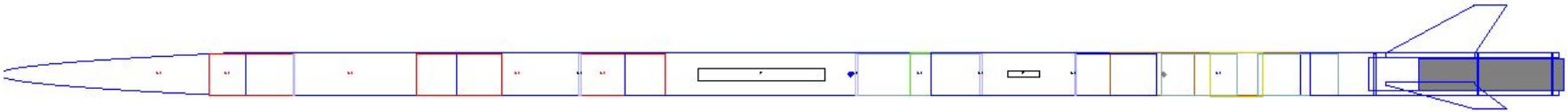
Length:

Diameter: 4 inches

Semi-Span of Fins: 3.25 in

Total Mass:

Motor Choice: Cesaroni K1085WT



Key Features of Launch Vehicle

- Avionics
  - Redundant Dual Deploy System
- Payload
- Air Brakes

Motor Description

Motor:	Cesaroni K1085
Contributor:	John Coker
Submitted:	Apr 3, 2009
Last Updated:	Apr 3, 2009
Data Format:	RockSim
Data Source:	User-Created
License:	Unknown

Statistics	*Declared*	*Calculated*	*Official*
Diameter (mm):	75.0	n/a	75.0
Length (cm):	35.0	n/a	35.0
Prop. Weight (g):	1,199.0	n/a	1,199.0
Total Weight (g):	2,430.0	n/a	2,430.0
Avg. Thrust (N):	1,042.8	1,054.3	1,113.0
Max. Thrust (N):	1,174.5	1,174.5	1,204.0
Tot. Impulse (Ns):	2,378.7	2,378.7	2,412.0
Burn Time (s):	2.3	2.3	2.1

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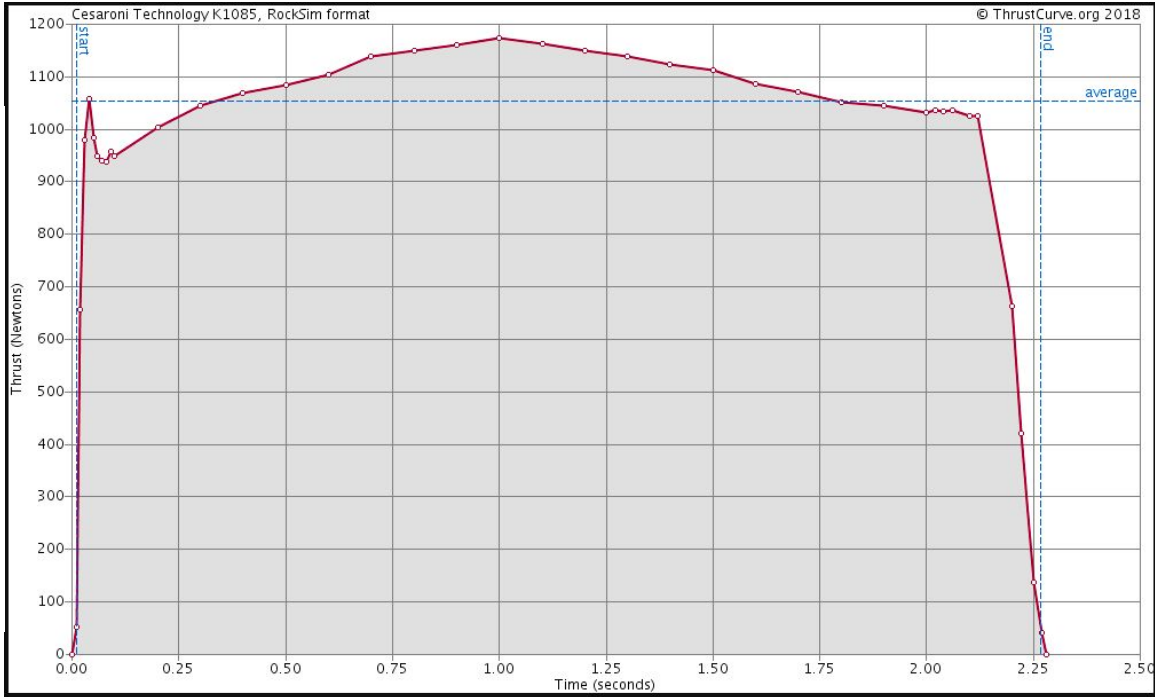
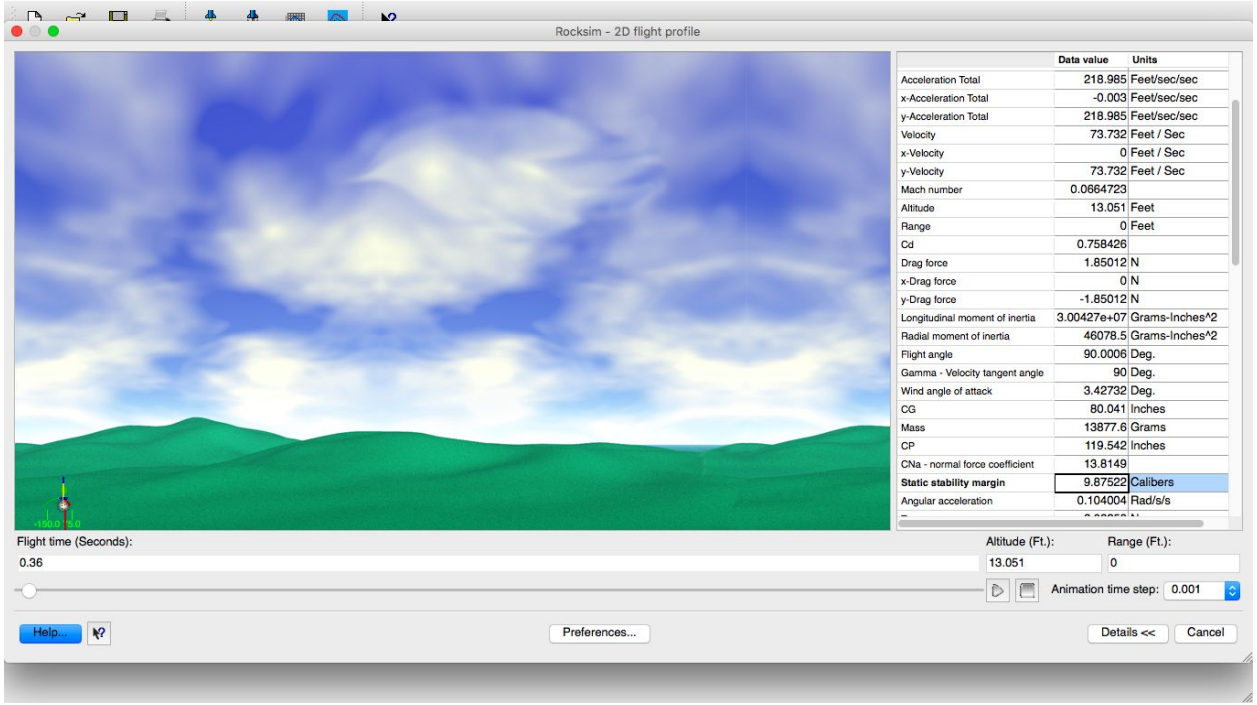


Flight Stability in Static Margin Diagram



Static Stability Margin at Rail Exit: 9.875 Calibers

Rail Exit Velocity: 73.732 ft/s

Thrust-to-Weight Ratio and Rail Exit Velocity

Thrust:Weight = 1:8.162460145

Rail Exit Velocity = 73.732 ft/s

Recovery Design

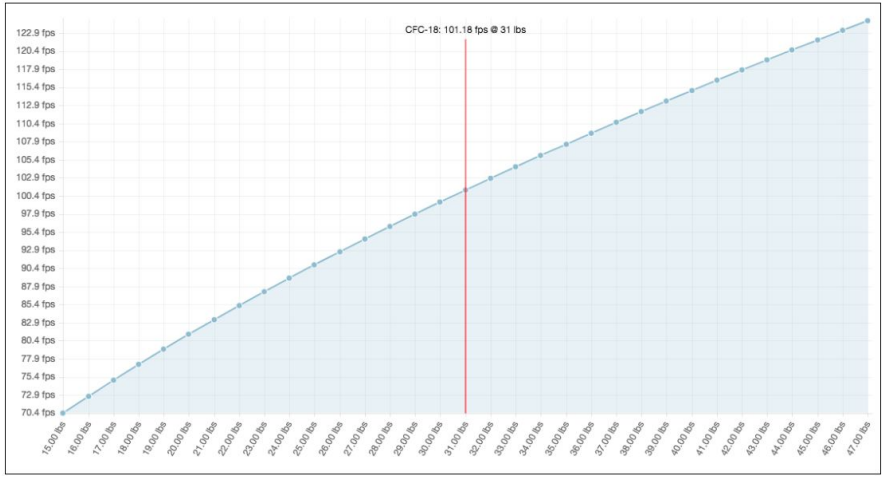
Chute Size and Descent Rate

Drogue chute: 18 inches

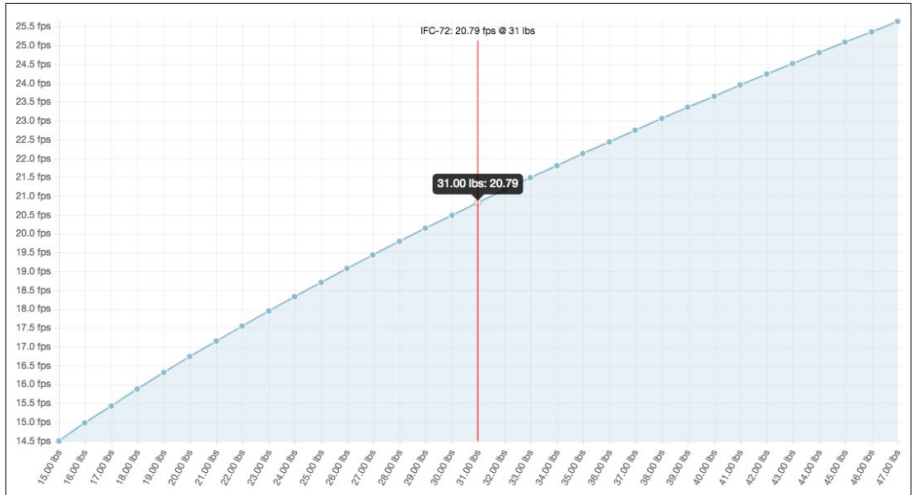
Main chute: 72 inches

Descent Rate

Descent Rate vs Weight



Descent Rate vs Weight



At 31 lbs, the descent rate of the rocket on the drogue chute is 101.18 ft/s and the descent rate on the main parachute is 20.79 ft/s.

Calculations

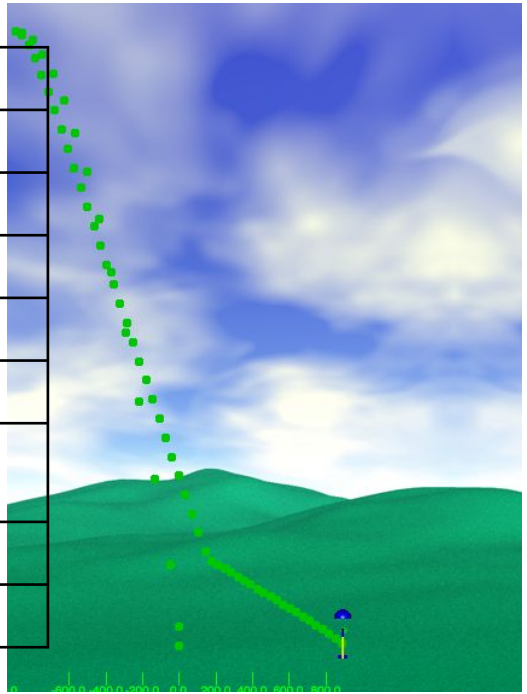
Kinetic Energy at Key Phases

Kinetic Energy of Each Section (Ft-lbs) at Landing with Main Chute	Section 1	Section 2	Section 3
	64.839	47.621	74.991

Predicted Altitude of Launch Vehicle

The target height of the vehicle is 4700 ft.

Max Data Values	
Vertical Acceleration	694.829 ft/s^2
Horizontal Acceleration	3.979 ft/s^2
Acceleration Magnitude	694.829 ft/s^2
Vertical Velocity	479.1291 ft/s
Horizontal Velocity	35.2 ft/s
Velocity Magnitude	489.1196 ft/s
Range from Launch Site	948.08321 ft
Altitude	3356.22071 ft



Predicted Drift of Launch Vehicle

3.3.6.3.1 0 MPH Wind

[(1 second101.18 feet)(4700-600 ft)+(1 second20.79 feet)(600 ft)] (0 miles1 hour)(5280 feet1 mile)(1hour3600 seconds) =0 ft

3.3.6.3.2 5 MPH Wind

[(1 second101.18 feet)(4700-600 ft)+(1 second20.79 feet)(600 ft)] (5 miles1 hour)(5280 feet1 mile)(1hour3600 seconds) =508.8003882 ft

3.3.6.3.3 10 MPH Wind

[(1 second101.18 feet)(4700-600 ft)+(1 second20.79 feet)(600 ft)] (10 miles1 hour)(5280 feet1 mile)(1hour3600 seconds) =1017.600776 ft

3.3.6.3.4 15 MPH Wind

[(1 second101.18 feet)(4700-600 ft)+(1 second20.79 feet)(600 ft)] (15 miles1 hour)(5280 feet1 mile)(1hour3600 seconds) =1526.401165 ft

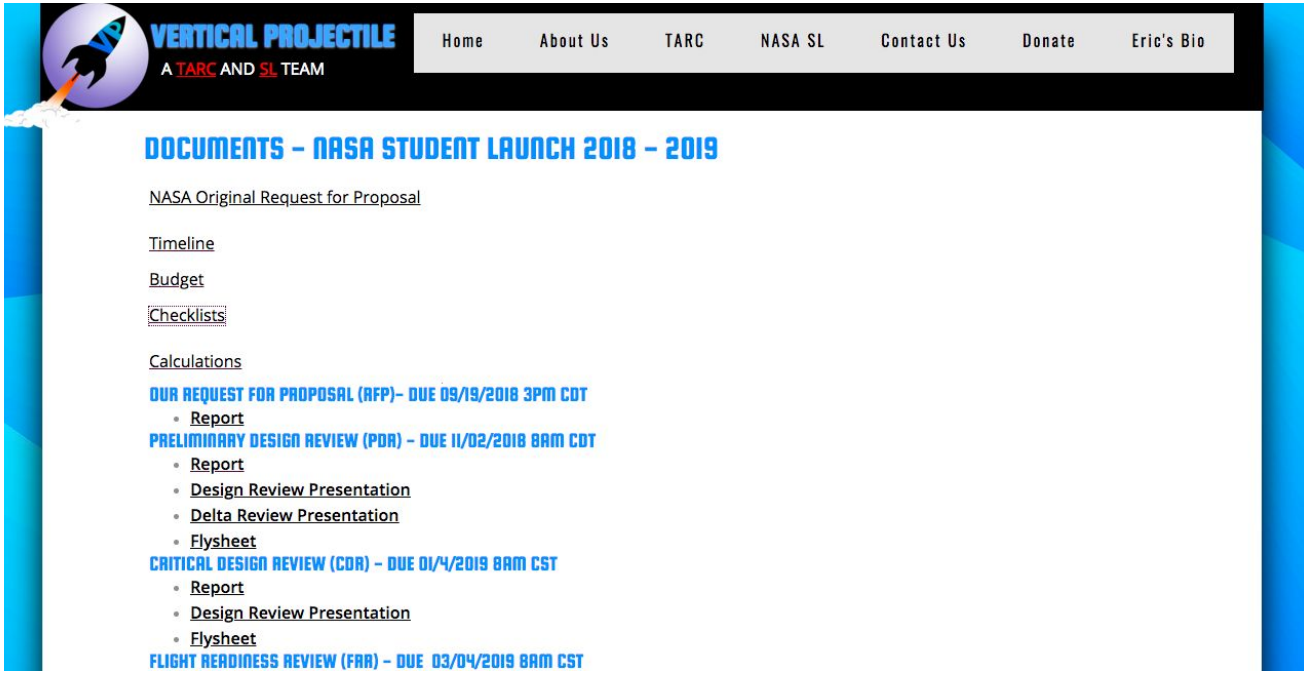
3.3.6.3.5 20 MPH Wind

[(1 second101.18 feet)(4700-600 ft)+(1 second20.79 feet)(600 ft)] (20 miles1 hour)(5280 feet1 mile)(1hour3600 seconds) =2035.201553 ft

Test Plans and Procedures

Test Plans and Procedures

All test plans and procedures and checklists are available on the website under the documents tab.



Vehicle Demonstration Flight

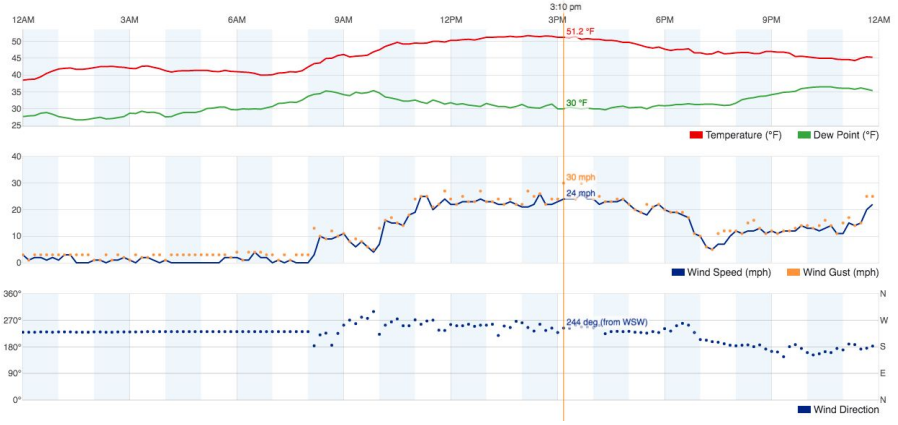
Flights on February 16, 2019

Successful Launches: One Full Scale, One Subscale

Launch Day Conditions

	High	Low	Average
Temperature	51.7º F	38.5º F	45.1º F
Dew Point	36.5 º F	26.7º F	31.2º F
Humidity	72%	44%	57%
Precipitation	0 in	-	-
Wind Speed	26 mph	-	11 mph
Wind Gust	30 mph	-	-
Wind Direction	-	-	SW
Pressure	29.98 in	29.9 in	-

Weather Conditions at FAR on 2/16/2019

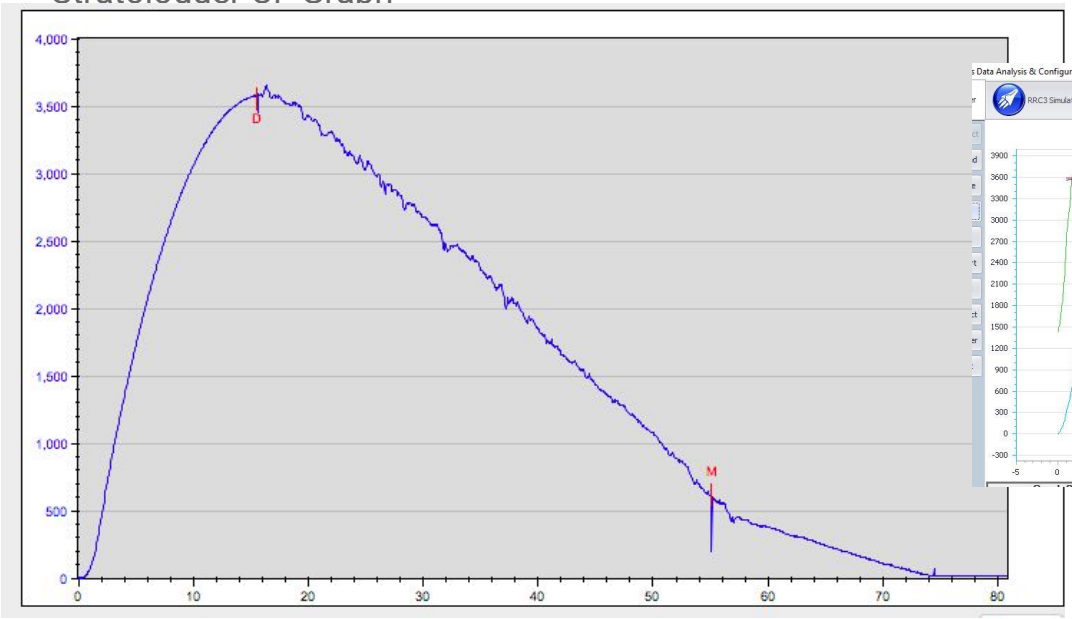


Full Scale Flight with Test of Release Mechanism

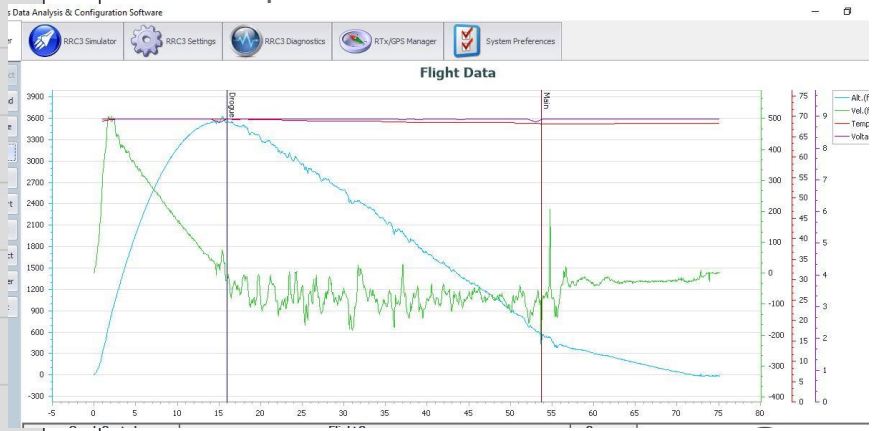
The rover release mechanism, controlled with the callsign KM6AJD, was tested and verified on 2/16/2019

Flight Data

Stratologger CF Graph

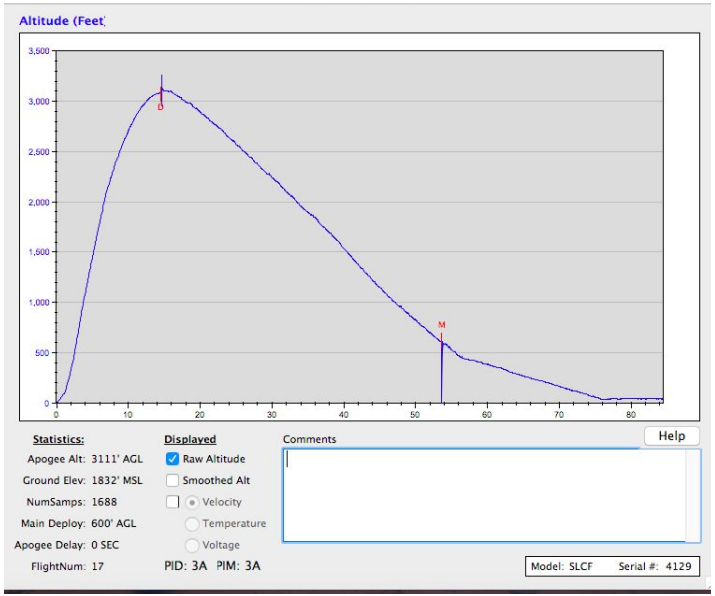


RRC3 Graph



Subscale Flight with Air Brakes

On 2/16/2019, along with the first full scale flight, we flew our second subscale launch with active air brakes



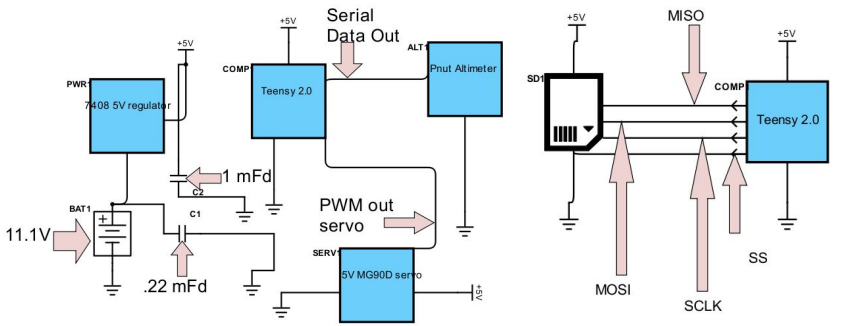
Air Brake Flight Data

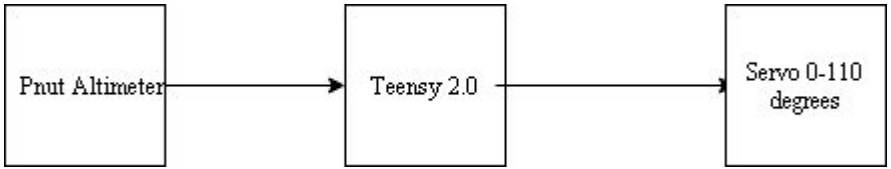
---------- Pnut Altitude: 1698
>>>>> elapsed time:5.12
++++ ApogeeDetectFlag:0
%%%%%% Airbrake Servo Control: projectedAltitude= 3228.71
%%%%% inside AirbrakeServoCtrl Coarse Tune, keep open for ms: 500
This is the line number:1

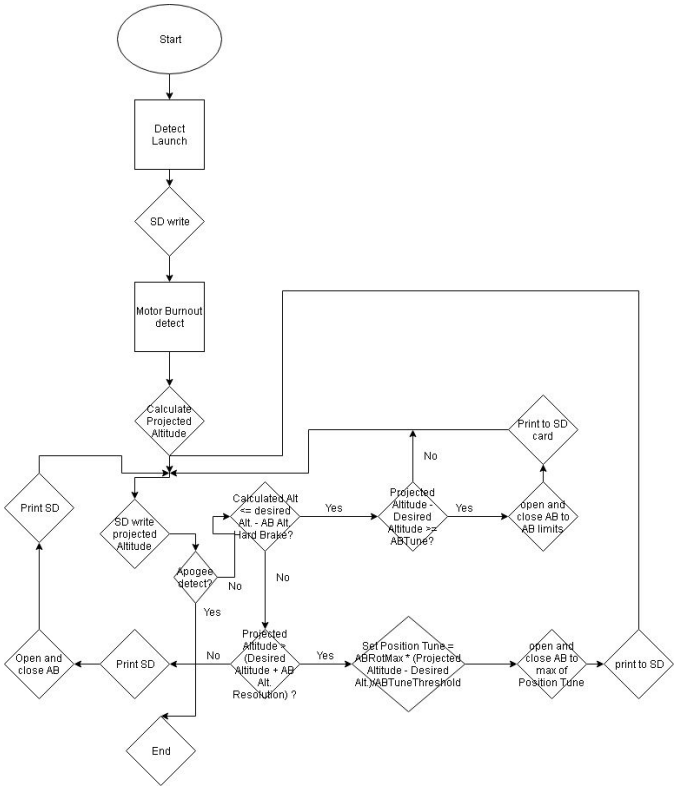
---------- Pnut Altitude: 2778
>>>>> elapsed time:21.93
++++ ApogeeDetectFlag:1
&&&& Parachute Deployed !! &&&&
This is the line number:13

The two blocks of text above indicate the first and last calculations done by the electronics on the air brakes.

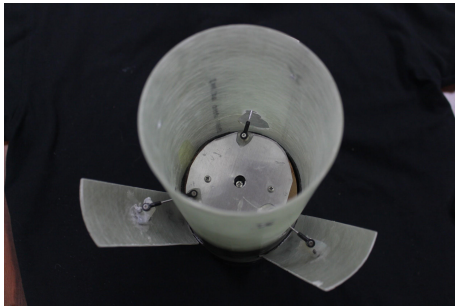
Air Brake Diagrams

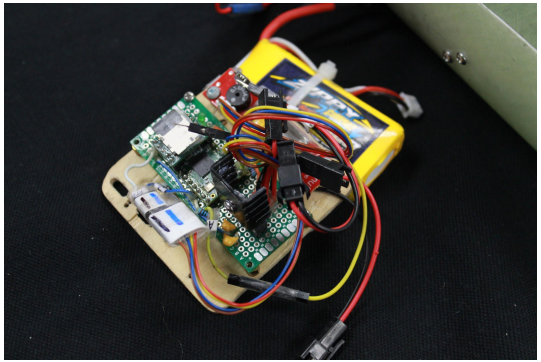


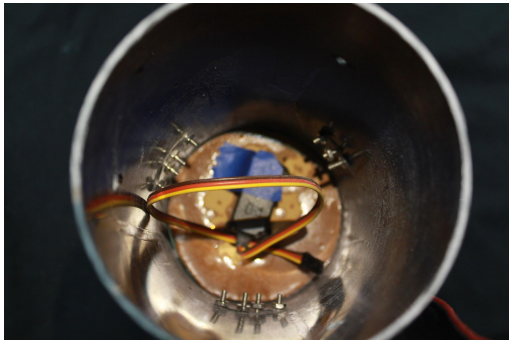




Air Brake Pictures







Recovery System Tests

Black Powder Testing of Full Scale Rocket

Successful!

Ground Testing the Dual Deployment

Ground testing with a pickle jar and a hand pump.

Avionics has christmas light bulbs attached for continuity and to show when the parachutes deploy

Requirements Verification of Launch Vehicle

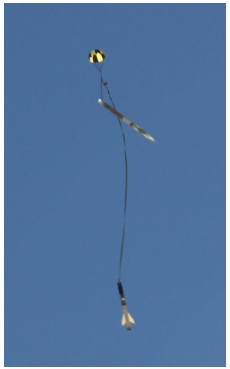
Vehicle Verification

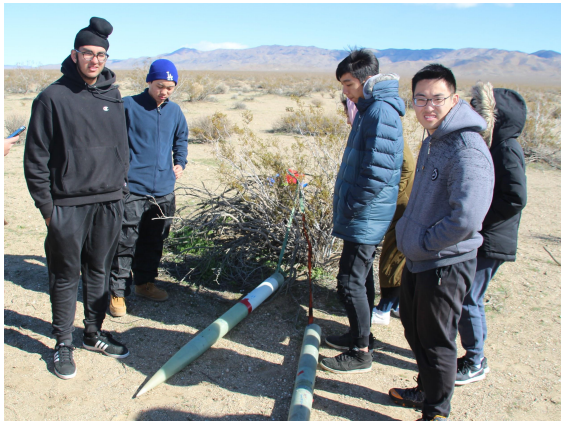
6.2.1.3.1 Testing

Verification was done on February 16th launch, at the Friends of Amateur Rocketry launch site.

6.2.1.3.2 Analysis

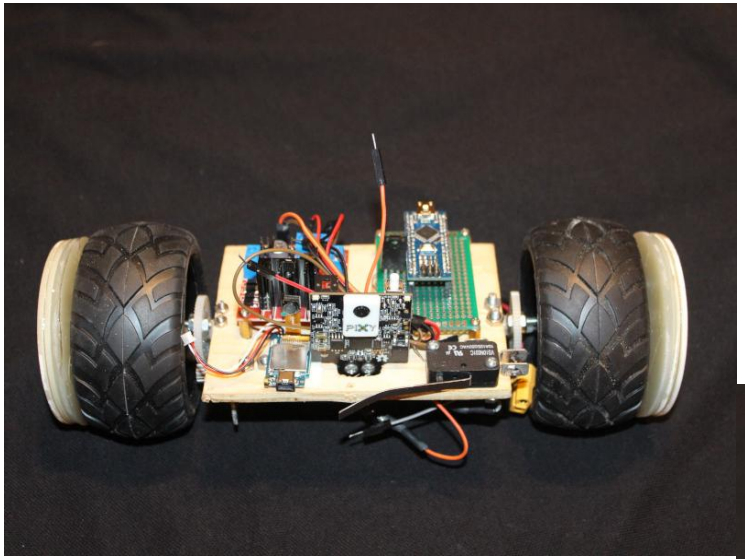
Our original goal for out rocket was to reach a height of 4700 feet; during the testing, the rocket reached a height of 3628, which is severely below our goal.

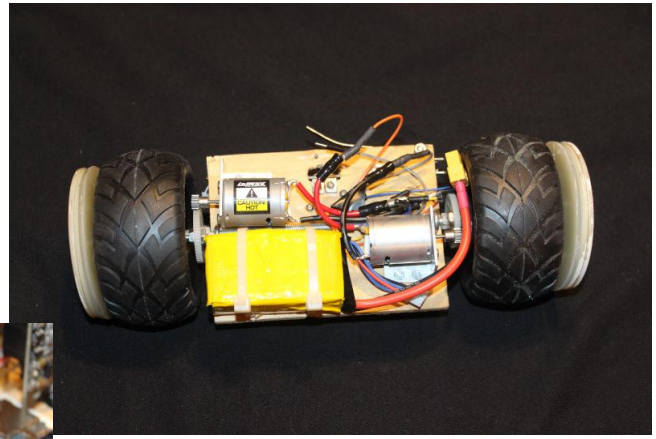




Payload

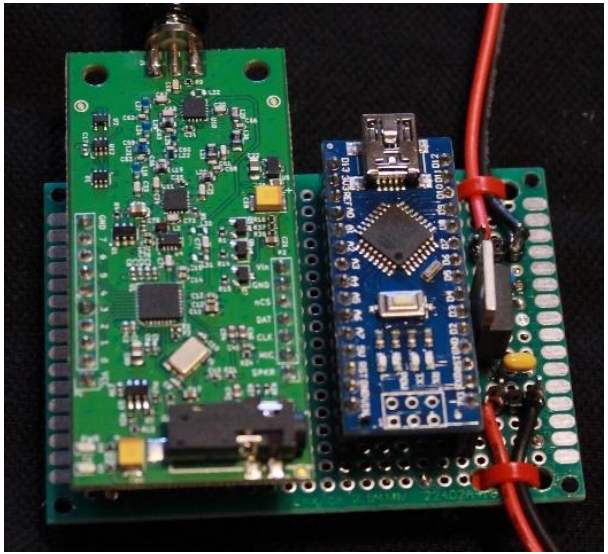
Rover as of 3/4/2019 (Not flown)

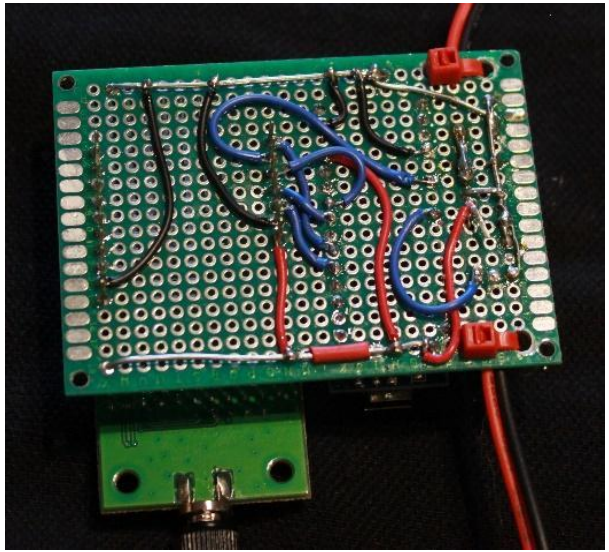




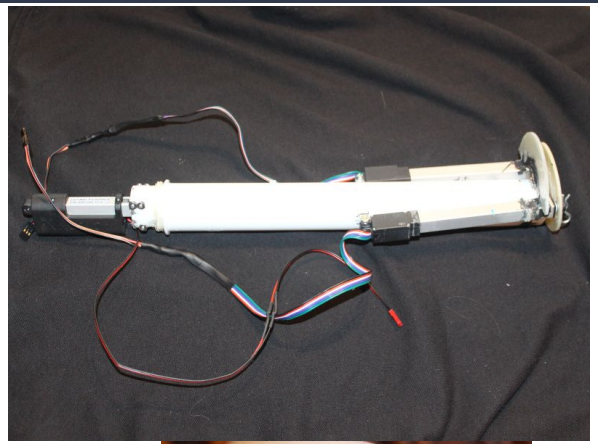
Release System

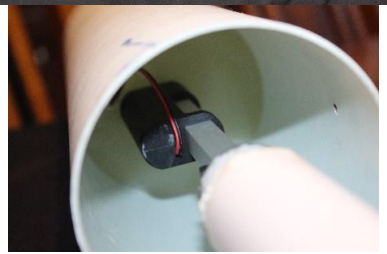
Arduino Nano & Hamshield Transceiver

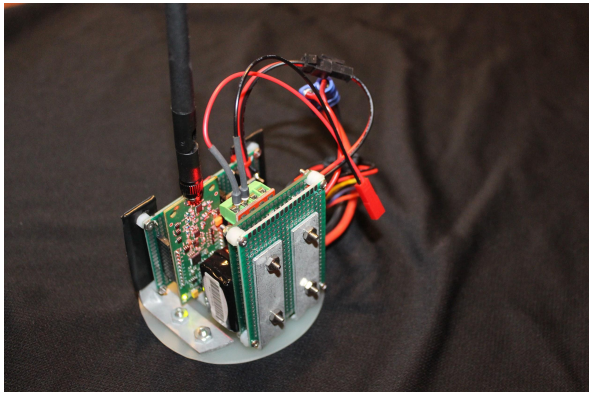


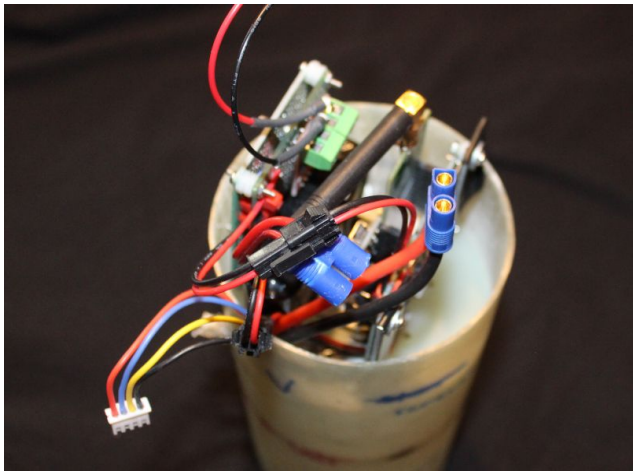


Release Mechanism (Flown)

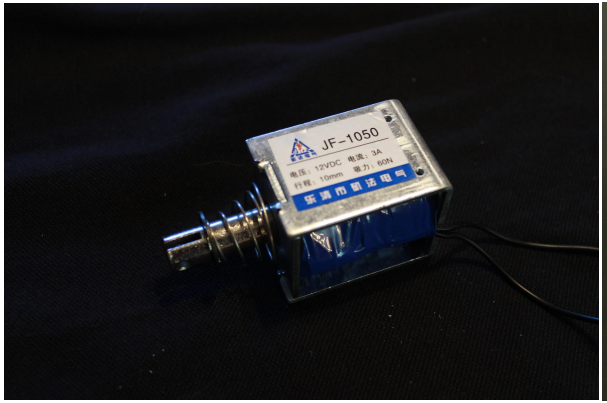


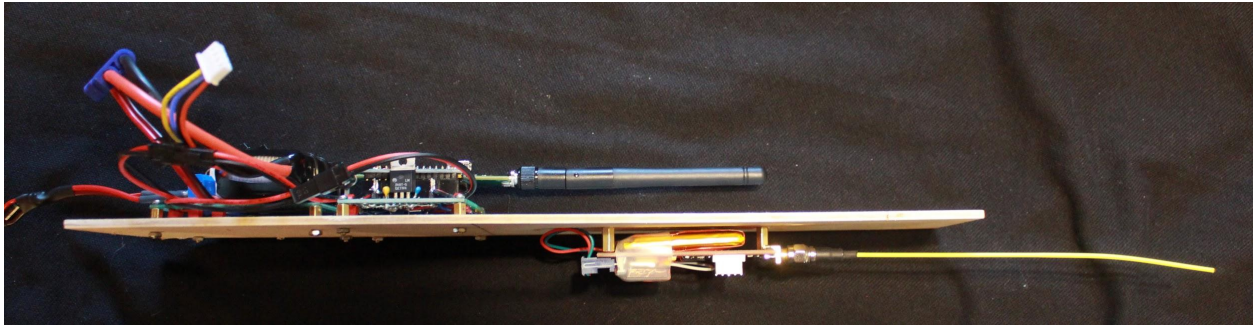






Active Retention System





Commands to Control Release

“*1” starts the solenoid to release the nose cone. The solenoid remains activated for 10 seconds. “R 1 KM6AJD” is sent via Morse Code upon receipt of the command, and “SK 1 KM6AJD” when the 10 seconds has elapsed and the solenoid is no longer energized

“*2” starts the linear actuator to push the rover out. This takes approximately 80 seconds. Limit switches on the Linear Actuator assure that the software stops the linear actuator if it has reached the end, even if it is within 80 seconds. Since this command takes so long to execute, the system sends the elapsed time every 20 seconds. For example, at 20 seconds the system sends a “20” in Morse Code, and “40” at 40 seconds, and “60” at 60 seconds. At the completion of 80 seconds, the system sends “SK 2 KM6AJD” in Morse Code

“*3” is identical to “*2” except the linear actuator is retracted and the acknowledgements return “3” for the command instead of “2”

“*9” sends out a command to stop any action in progress and acknowledge with the string “SK 9 KM6AJD” and the firmware begins looking for commands again

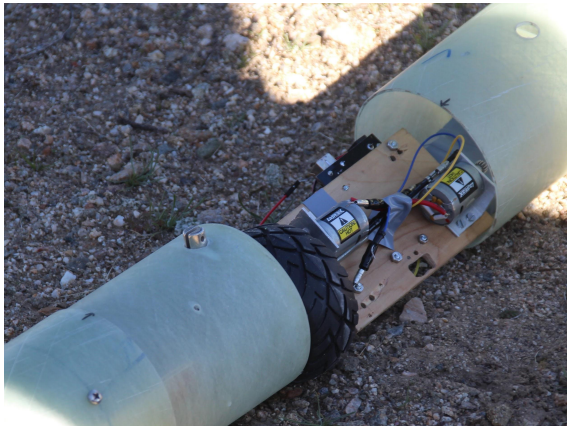
Requirements Verification of Payload

Payload Verification

5.1.7.2 Success Criteria

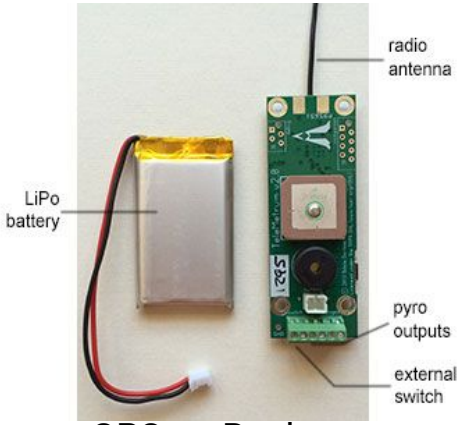
The retention system is deemed successful if the rover is proven to not be at risk of being released mid flight and is able to allow the deployment of the rover once the rocket has safely and securely landed on the ground. The deployment system is deemed successful if the rover is able to be safely and securely deployed on the ground without damaging the actuator, rover, solenoid, or rocket body upon release. Lastly, the autonomous rover is deemed successful if it is able to detect when it has been completely released from the system, activate the electronics, move a few feet away from the rocket and determine where the colored band on the rocket is.

Parts 1 and 2 of the Success Criteria were proven to hold true on the test flight at FAR on 2/16/2019
Deployed using the callsign KM6AJD on a Baofeng radio



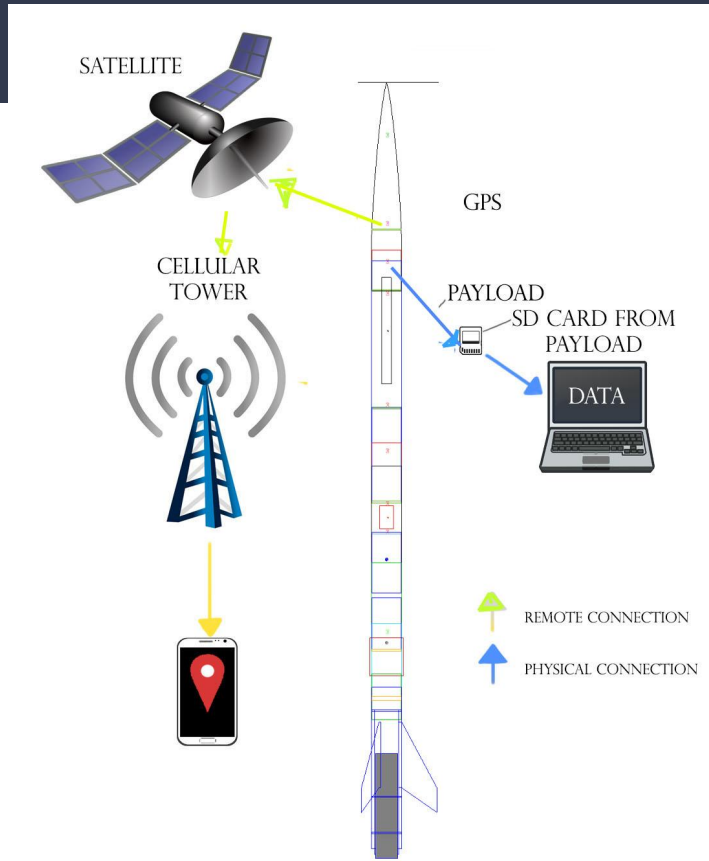
Interfaces with Ground Systems

GPS Interface



GPS on Rocket

Ground Station (Non-Apple Phone, Handheld radio, Mobilinked TNC

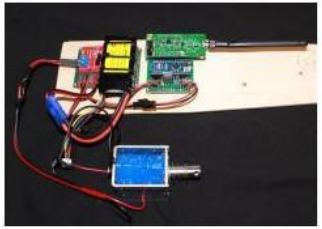


Release Mechanism Interface

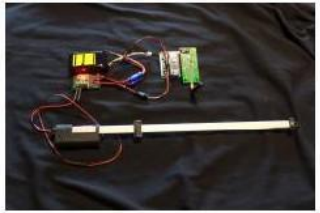
System Block Diagram – Rover Release Mechanism

Baofeng Transceiver
Generates DTMF tones
On 70 cm (420 - 450 MHz)

70cm RF link



Arduino Nano and Hamshield Transceiver
Interpret DTMF commands and activate
Solenoid to release Nose Cone



2nd Arduino Nano and Hamshield
Transcever Interpret DTMF commands
and activate Linear Actuator to push
out Rover through Nose Cone end

Thank You