St Monica Rocketry Club

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Critical Design Review

2018 NASA Student Launch

January 12, 2018

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Acronym Dictionary

AGL = Above Ground Level

APCP = Ammonium Perchlorate Composite Propellant

CDR = Critical Design Review

CG = Center of Gravity

CP = Center of Pressure

EIT = Electronics and Information Technology

FAA = Federal Aviation Administration

FN = Foreign National

FPS = Feet Per Second

FRR = Flight Readiness Review

HEO = Human Exploration and Operations

LBF = Pounds of Force

LCO = Launch Control Officer

LRR = Launch Readiness Review

MAH = Millamp Hours

MSDS = Material Safety Data Sheet

MSFC = Marshall Space Flight Center

NAR = National Association of Rocketry

PDR = Preliminary Design Review

PLAR = Post Launch Assessment Review

PPE = Personal Protective Equipment

RFP = Request for Proposal

RSO = Range Safety Officer

SLI = Student Launch Initiative

SME = Subject Matter Expert

SOW = Statement of Work

STEM = Science, Technology, Engineering, and Mathematics

TRA = Tripoli Rocketry Association

I. Summary of PDR

A. Team Summary

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B. Launch Vehicle Summary

Size and Mass:

The rocket will have an outer diameter of 4 inches and has a projected mass of 23.0 lbs with the motor and case. The total length of the rocket will be 101 inches from the tip of the nose cone to the end of the tail cone

Motor Choice

Based on these simulations and considerations, we determined that an Aerotech K1275 will best satisfy the requirements, given that the Ceseroni K1200 is currently unavailable.

Recovery System

The recovery system utilizes a three-stage deployment system. At apogee, the rocket will separate into two pieces, tethered together by a shock cord and a 4 foot Rocketman ballistic drogue parachute will be deployed as a drogue bundle tied together by a zip tie connected to a cable cutter. The cable cutter will go off at 1000 feet allowing the drogue parachute to fully deploy. The 7' Fruity Chutes Iris Ultra Compact main parachute will then be deployed at 600 feet. This parachute will slow the descent enough so that the g forces sustained by the live shrimp payload during descent are less than the g forces sustained during ascent.

Rail Size

The rocket will be launched from a 1515 rail.

C. Payload Summary - Survival to Mars Experiment Summary

It takes seven years to get to Mars and a difficulty is feeding the astronauts fresh food during their journey. The Payload Experiment seeks to answer if shrimp would be able to survive the G-Forces encountered during rocket launch. The shrimp we are using are primarily used to feed other fish and creatures. This knowledge could then be applied to larger shrimp that people eat, astronauts could filter out the brine shrimp and eat them for protein or they can be used to feed other food sources being raised on-board during the journey to Mars.

II. Changes made since Preliminary Design Review

A. Changes Made to Vehicle Criteria

- Modified recovery systems to perform three deployment events instead of two to reduce the amount of g-forces exerted upon the sensitive payload.
- Changed altimeters from the PerfectFlite StratoLogger CF and EggTimer TRS to the Featherweight Raven and the MissileWorks RRC3 Sport to correspond with our three deployment events.
- Upsized drogue parachute from 2’ to 3’ to make the transition between the drogue and the main smoother.
- The recovery harness length was reduced from 75’ to 35’.
- Lengthened the aft recovery section 4” to accommodate larger parachute.
- Lengthened payload bay 6” to accommodate payload assembly.
- Motor switched to K1275 because K1200 is unobtanium.
- Fin design shape is now air foiled and vacuum sealed with a layer of carbon fiber for extra strength.
- Accelerometer on Featherweight Raven will be used instead of the Arduino to measure g-forces.
- Ballast bays were added to the booster section.

B. Changes Made to Payload Criteria

No significant changes.

C. Changes Made to Project Plan

Fundraising: No significant changes

Education: We have scheduled to present at Meadow Pond Elementary School February 16, 2018, and Mt Kiso Elementary School the end of January.

III. Vehicle Criteria

A. Design and Verification of Launch Vehicle

Unique Mission Statement

We will make a reusable launch vehicle that will achieve an altitude of 5,280ft, deploy a drogue chute bundle at apogee, and at 1000ft drogue chute fully deploys, and a main chute at a lower altitude (600ft). We will have 3 flight computers on-board the rocket, one of which will have a GPS tracking system, recording flight status. The launch vehicle will use a motor with sufficient thrust to leave the launch rail at a safe exit speed.

Component	Material	Justification
Airframe/Motor Tube/Coupler	BlueTube	Inexpensive, light weight and strong
Centering Rings/Bulk Heads	Aircraft Plywood	Strong, Easy to sand down and drill through, also inexpensive
Fins	Aircraft Plywood with a layer of carbon fiber	Reduced weight and higher strength
Nose Cone	Plastic	Inexpensive, lightweight and best option with BlueTube

Vehicle Subassemblies

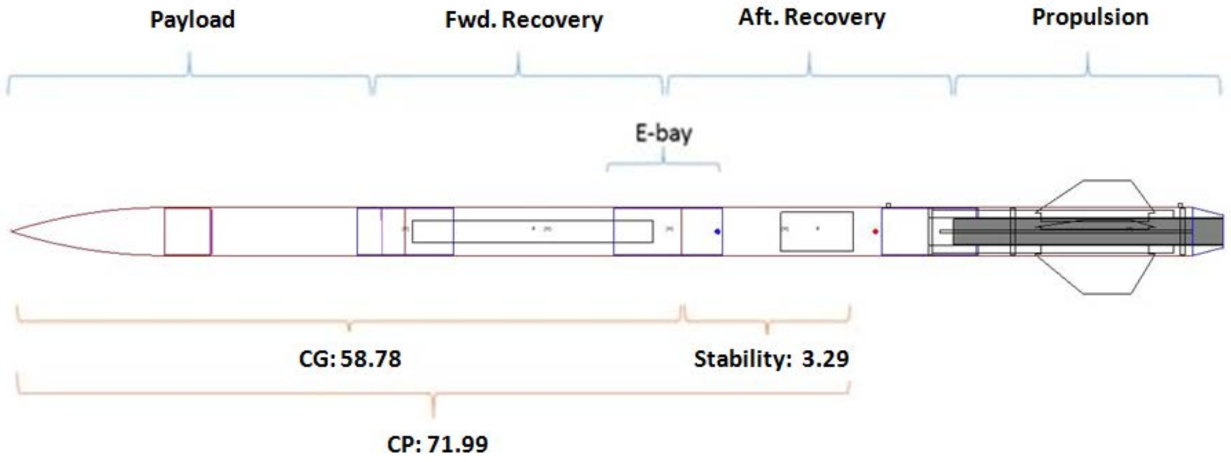


Figure 1 - Vehicle CAD Drawing

Payload: Consists of a 12.75” plastic nosecone and a 20” BlueTube body tube containing the scientific payload and cooling system. Nosecone and body tube are held together with three #6 stainless steel screws. The nosecone houses the Arduino and is sealed with a removable plywood bulkhead.

Forward Recovery: Consists of a 23” BlueTube body tube containing a 7’ Fruity Chute parachute.

E-Bay; Consists of a 9” BlueTube coupler containing the electronics sled (described below) and sealed with plywood bulkheads. Located in the interior between the Forward and Aft Recoveries. Temporarily secured with #2 nylon screws which are acting as sheer pins.

Aft Recovery: Consists of a 24.5” BlueTube body tube containing a 3’ drogue parachute. The Aft Recovery is secured to the Propulsion section with three #6 stainless steel screws.

Propulsion: Consists of an 18” BlueTube body tube containing a 24.5” 54mm BlueTube motor tube. Also contains two 3D printed centering rings and a bulkhead, which hold the ballast bays and steel threaded rods in place. Capped by a 2.5” aluminum tail cone motor retainer. Our fins are mounted to the propulsion section through the wall of the exterior body tube into the motor tube, which increases strength and rigidity.

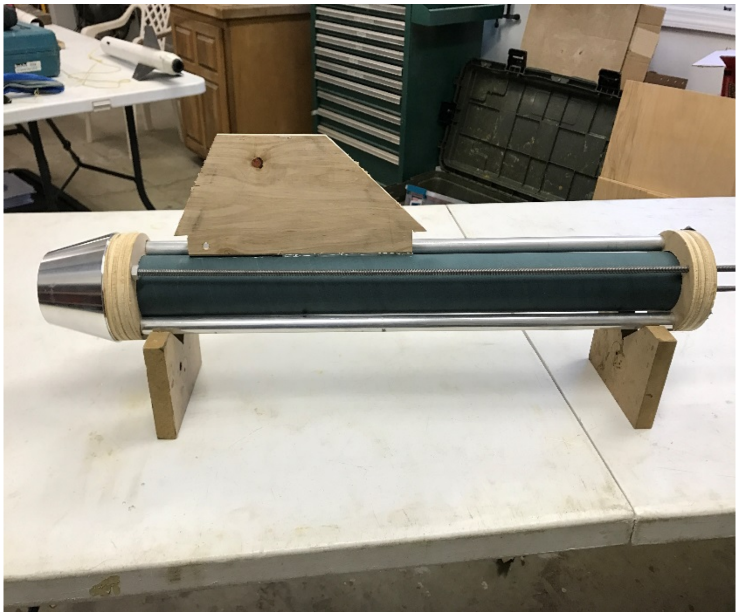


Figure 2 – Mock-up of Interior of Propulsion Section.

The root edge of fins will be attached to the motor tube.

The Propulsion section also has 2 threaded rods extended the length and connected to the centering rings, which will increase rigidity and serve as connection points for the recovery harness. The propulsion section also has 2 ballast bays, which can be accessed when the tailbone motor retainer is removed.

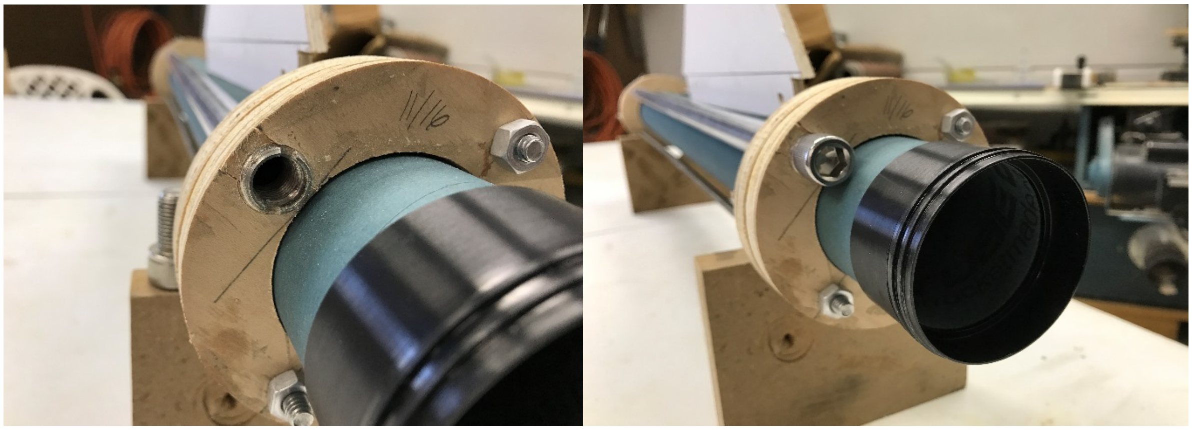


Figure 3 – Mockup of Motor Retainer, Ballets Bay and Motor Mount.

Parts Listing

FULL SCALE ROCKET AND PAYLOAD COMPONENT LISTING					
				Mass (grams)	
Totals				**8,501.13**	
Lookup Description	**Unit Mass**	**Unit**	**Quantity**	**Total Mass**	**Comment**
BOOSTER					
3.9" BlueTube Airframe	15.10	g / in	22	332.29	Booster, Exterior Body Tube
Tailcone_390 to 54mm	115.00	g	1	115.00	
2.1" BlueTube Airframe	8.54	g / in	22	187.92	54mm motor mount
3.9" BlueTube Coupler	15.00	g / in	8	120.00	Coupler between booster and aft recovery
Centering Ring 3.9" to 2.1"	25.89	g	3	77.68	centering rings for motor mount
1/4-20 stainless threaded rod	4.58	g/in	48	220.00	2 threaded rod stiffeners to go through centering rings
1/4-20 eye nut	17.58	g	2	35.15	eye nuts to attach booster to aft recovery
1/4-20 Hex Nut	3.22	g	2	6.45	
1/4" Split Lock Washer	1.00	g	4	4.00	
1/4" Washer	1.40	g	4	5.60	
1515 rail button- pair (large)	15.00	g	1	15.00	
1/4" plywood, CF Composite	72.00	g/ea	3	216.00	Fins
Aluminum Ballast Tubes	2.94	g/in	42	123.66	
7/16 Threaded Insert	8.00	g	2	16.00	
7/16 Threaded Bolt	25.50	g	2	51.00	
Paint & Glue				200.00	
				1,725.75	
LOWER RECOVERY					
3.9" BlueTube Airframe	15.10	g / in	17	256.77	
Rocketman drogue balistick 3 feet	380.00		1	380.00	
Cable Cutter	10.00	g	2	20.00	
12x12 nomax	26.00		1	26.00	
Harness: 11/16 tubular 3 loop - 35 ft long, y harness	267.00		1	267.00	
3/16" Quik Link	21.40	g	4	85.60	2 attach to booster, 2 attach to e-bay
Paint & Glue				100.00	
				1135.37	
ELECTRONICS BAY					
Raven Altimeter	17.00	g	1	17.00	
RRC3 Altimeter	17.00	g	1	17.00	
Wiring	5.00	g	6	30.00	
Screw Switch	3.69	g	2	7.37	
Charge Holder (3.0g) - pair	26.60	g	2	53.20	
2 wire Terminal Block	1.70	g	1	1.70	Required for cable cutters
1/4-20 stainless threaded rod	4.58	g/in	22	100.83	2 pieces that extend through ebay
1/4-20 eye nut	17.58	g	4	70.31	2 on each end of ebay
1/4-20 Hex Nut - aluminum	1.00	g	8	8.00	for interior of ebay to secure sled
1/4" Split Lock Washer	1.00	g	4	4.00	
1/4" Washer	1.40	g	4	5.60	
1/4" Balsa, composite lay-up	1.00	g/in^2	28	28.00	8 x 3.5 ebay sled
9V alkaline	25.00	ea	2	50.00	1 for each altimeter
3.9" Airframe Bulkhead	38.46	g	2	76.92	
3.9" Coupler Bulkhead	36.15	g	2	72.29	
3.9" BlueTube Coupler	15.00	g / in	9	135.00	
Paint & Glue				100.00	
				777.22	

Lookup Description	Unit Mass	Unit	Quantity	Total Mass	Comment
FORWARD RECOVERY					
3.9" BlueTube Airframe	15.10	g / in	22	332.29	
FruityChute Iris Ultra Compact - 84 with Spectra Lines	342.00	0	1	342.00	
4" Deployment bag - 9" long	75.00	0	1	75.00	
Harness: 11/16 tubular 2 loop - 35 ft long, y harness	267.00	0	1	267.00	
3/16" Quik Link	21.40	g	4	85.60	2 to attach to ebay and 2 to payload
Paint & Glue				100.00	
				1,201.89	
PAYLOAD					
3.9" BlueTube Airframe	15.10	g / in	14	211.46	
3.9" Nose Cone - 12.75"	200.00	g	1	200.00	LOC precision
3.9" BlueTube Coupler	15.00	g / in	8	120.00	Fwd recovery to Payload
3.9" Airframe Bulkhead	38.46	g	1	38.46	
3.9" Coupler Bulkhead	36.15	g	1	36.15	
1/4-20 eye nut	17.58	g	2	35.15	
Paint & Glue				100.00	
				741.22	
Payload Frame					
3.9" Coupler Bulkhead	36.15	g	3	108.44	
3.9" BlueTube Coupler	15.00	g / in	8	120.00	Coupler covers habitat and will serve as attachment point to airframe
1/4" Plywood - fiberglass reinforced	1.20	in ^2	48	57.60	
Carbon fiber rod - .110" ID, .156" OD	0.26	g/in	88	23.28	supports for 2/56 threaded rod
2/56 stainless steel threaded rod	0.52	g/in	88	45.47	
2/56 nut	0.20		20	4.00	
#2 washer	0.42		30	12.60	
#6 weld nuts	0.98		6	5.88	attachment point to airframe
#6 screws	1.58		6	9.48	to attach payload frame to airframe
				386.75	
Cooler Components					
8 oz habitat (with water)	293.00	g	1	293.00	recyled juice bottle
1/4" flexible copper tubing	2.86	g/in	144	411.43	not sure how much we will need for final design
1/4" copper tubing connector	33.00		2	66.00	
12vdc brushless submersible motor	71.00	g	1	71.00	ebay
60w Peltier Cooler	24.00		1	24.00	ebay
Aluminum 40mmx 40mm water block	40.00		1	40.00	ebay
1/4" flexible plastic tubing	2.31	g/in	18	41.50	ace hardware
Heat Sync	284.00		1	284.00	
Rosewill RCX-Z300 92mm Ball CPU Cooler Fan	68.00		1	68.00	amazon
8000 mah batteries	584.00	g	2	1,168.00	Hobbyking
				2,466.93	
Arduino and electronic components					
Arduino Uno R3	12.00		1	12.00	
Lithium Ion Polymer Battery - 3.7v 2500mAh	25.00		1	25.00	
ADXL345 - Triple-Axis Accelerometer (+-2g/4g/8g/16g) w/ I2C/SPI	5.00		1	5.00	
Waterproof DS18B20 Digital temperature sensor + extras	12.00		2	24.00	
				66.00	

B. Subscale Flight Results

Our subscale rocket is approximately ½ scale. The diameter and length are proportional to the full-scale because we are trying to replicate the performance of the full-scale rocket. The center of pressure, center of gravity, and stability margin should also be proportional. As long as we got these factors right, the mass was not an important factor in scaling. We tried to find a motor that had a similar thrust-to-weight ratio as the K1275.

	Full Scale	Subscale	Subscale %
Diameter	4.00	2.22	55.50%
Length	101.00	55.46	54.91%
Mass at Pad	10329.00	690.00	6.68%
CG	58.78	29.53	50.24%
CP	71.92	36.38	50.58%
Margin	3.29	3.09	93.92%
Thrust-to-weight	15.66	11.65	74.39%
	K1275	F79	

Table 1 - Rocket Scale Chart

Subscale Flight #1, December 9, 2017.

The first subscale flight flew straight and was a beautiful flight through apogee. At apogee, the first pyro channel on the Raven did not go off. The rocket was still blown apart as we used the motor ejection charge as a back-up. The main reason that the first ejection charge did not go off is thought to be caused by us overloading the altimeter with a more powerful battery than the altimeter could handle, causing it to wreck the first pyro channel. We are currently waiting for the altimeter to come back from Featherweight to possibly fix the first pyro channel and prove our theory. The second and third ejection charges blew, but the main parachute tangled, as we did not properly check that the parachute was dry so that we could prevent tangling. This caused the rocket to come down at a much faster rate than planned. The weather during the flight consisted of heavy snow and low winds.

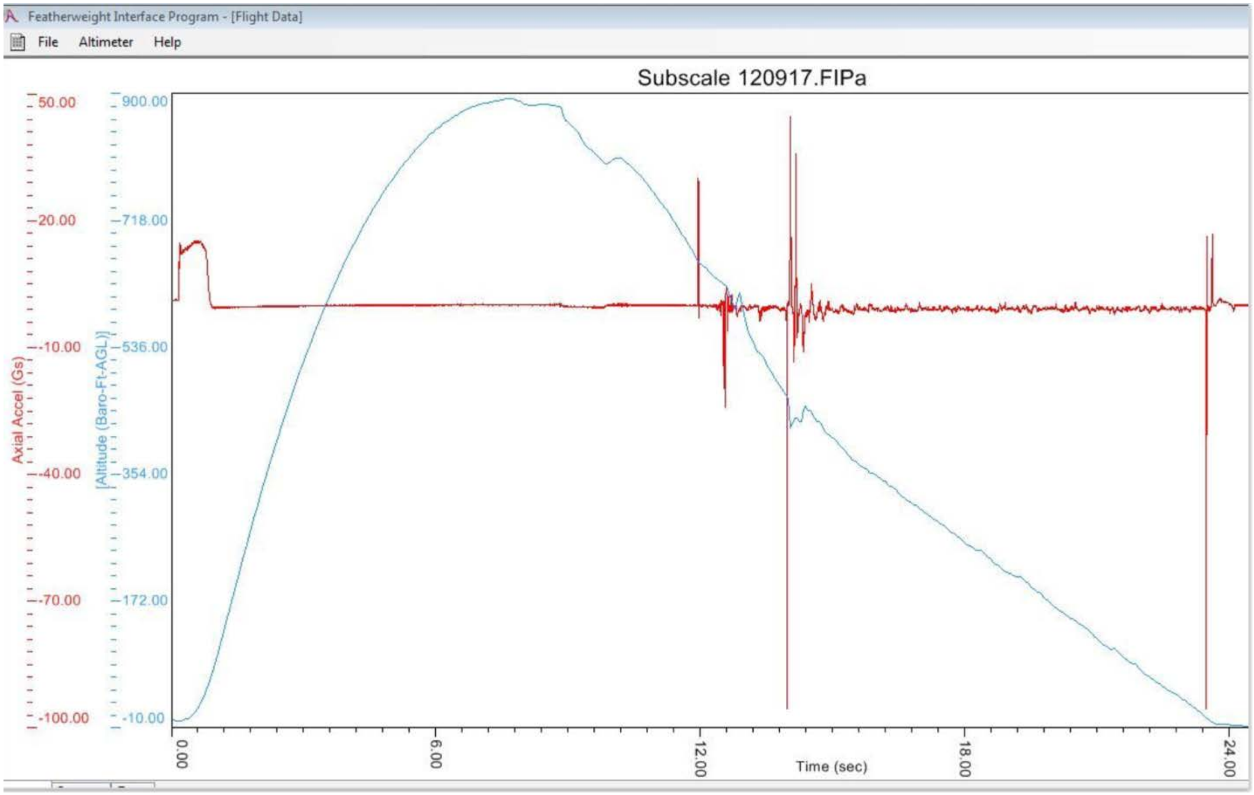
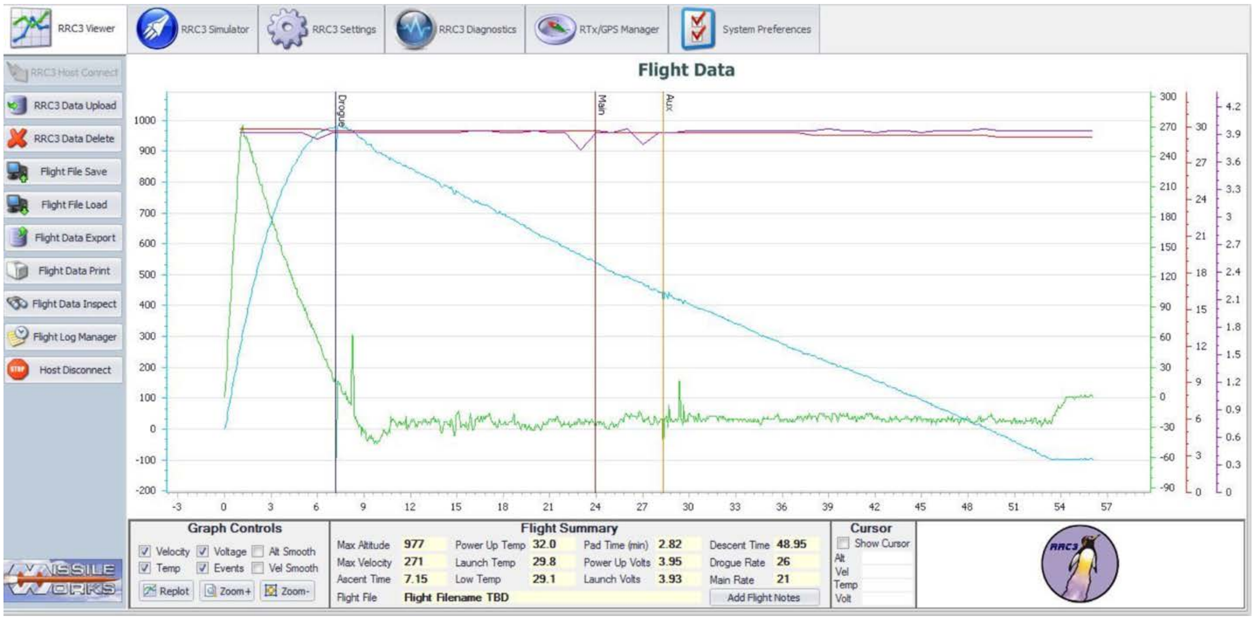


Figure 4 - Featherweight Raven Flight Chart from Subscale Flight #1

Subscale Flight #2, December 30, 2017

The second subscale flight was as straight as the first flight. It was configured with the RRC3 altimeter and all deployment events occurred as planned. We did not use a cable cutter or a drogue chute, instead, we used a streamer in place of the drogue chute since we were flying on a small field. The main chute fully deployed and the launch vehicle landed safely. We used excessively long shock cords wrapped in figure-8's and held together with rubber bands as a test to see if they would tangle upon deployment. They deployed fully with no tangling, so we plan to use this technique on the full-scale rocket. Using the imputed Cd from the first flight, the Rocksim simulation predicted that the launch vehicle would fly to an altitude of 977 feet. The RRC3 recorded an altitude of exactly 977 feet. We also had an Altimeter 3 on board in the booster section which recorded and altitude of 1,042 feet. We believe the large discrepancy was a result of inadequate venting for the Altimeter 3 and that the RRC3 altitude was the more correct of the two. The weather was a frigid 16 degrees and snowing, there was little wind so flight conditions were okay.

Below, is the RRC3 flight data from our second subscale flight.



Graph Controls

☑ Velocity ☑ Voltage ☐ Alt Smooth

☑ Temp ☑ Events ☐ Vel Smooth

Flight Summary

Max Altitude	977	Power Up Temp	32.0	Pad Time (min)	2.82	Descent Time	48.95
Max Velocity	271	Launch Temp	29.8	Power Up Volts	3.95	Drogue Rate	26
Ascent Time	7.15	Low Temp	29.1	Launch Volts	3.93	Main Rate	21

Flight File Flight Filename TBD

Cursor

☐ Show Cursor

Alt

Vel

Temp

Volt

Figure 5 - RRC3 Flight Chart from Subscale Flight #2

Subscale Flight Summaries

In the chart below we show the flight summaries for our two subscale flights.

	12/9/17	**12/30/17**
Time	12:40	12:15
Temperature (F)	30	15
Sky Conditions	Overcast	Overcast
Humidity	100	83
Lift-off weight (g)	783	723
Recovery:		
Pyro 1	bundled 8" Hemispherical	16" Hemispherical
Pyro 2	Cable Cutter	ignitor only
Pyro 3	16" Hemispherical	Streamer
Rocksim simulation		
Cd	0.7	0.55
Altitude	837	977
Max acceleration (fps)	543	403

	12/9/17	**12/30/17**
Rail Exit Velocity (fps)	89	94
Rocksim interpolated Cd (actual)	0.55	.55 based on RRC3 Data
Altimeter 3 results		
Altitude	888	1042
Max Gs	13.39	14.36
Raven Results		
Altitude	893	n/a
Max Gs	15.3	n/a
RRC3 Results		
Altitude	n/a	977
Max Gs	n/a	13.78
Comments	Lightly snowing and poor visibility. But calm conditions.	Lightly snowing and really cold.

Table 2 - Flight Summaries

Subscale flight impact on the design of the full-scale launch vehicle

The subscale flights showed that our overall design is reliable. The altimeter failure that we experienced highlighted our need to test both altimeters fully before flight. The parachute tangling on the first flight showed the need to pack the parachute properly, and ensure that we pack the recovery harnesses correctly to prevent tangling. Continued simulating confirmed that the Cd of the sub-scale for both flights (we did not use the Altimeter 3 data) is roughly .55. However, the subscale was not finished or painted in any way, so if we decide to wrap or paint the full-scale, the Cd would be marginally lower.

C. Recovery Subsystems

Our recovery system will perform three deployment events. The reason for this is to keep the number of g-forces upon the payload less than the g-forces sustained during boost.

The first event is at apogee when the drogue bundle is deployed. The drogue bundle is the drogue parachute tied up with a zip-tie connected to cable cutters that will go off at a lower altitude. When the cable cutter cuts the zip-tie at 1,000 ft., the drogue will open and slow the launch vehicle from about 125 ft/s to about 40 ft/s. At 600 ft., the third event will occur and will deploy the main parachute, slowing the rocket to 14 ft/s. We are using a long recovery harness which will allow for the payload bay to descend at an even slower rate once the propulsion section has landed.

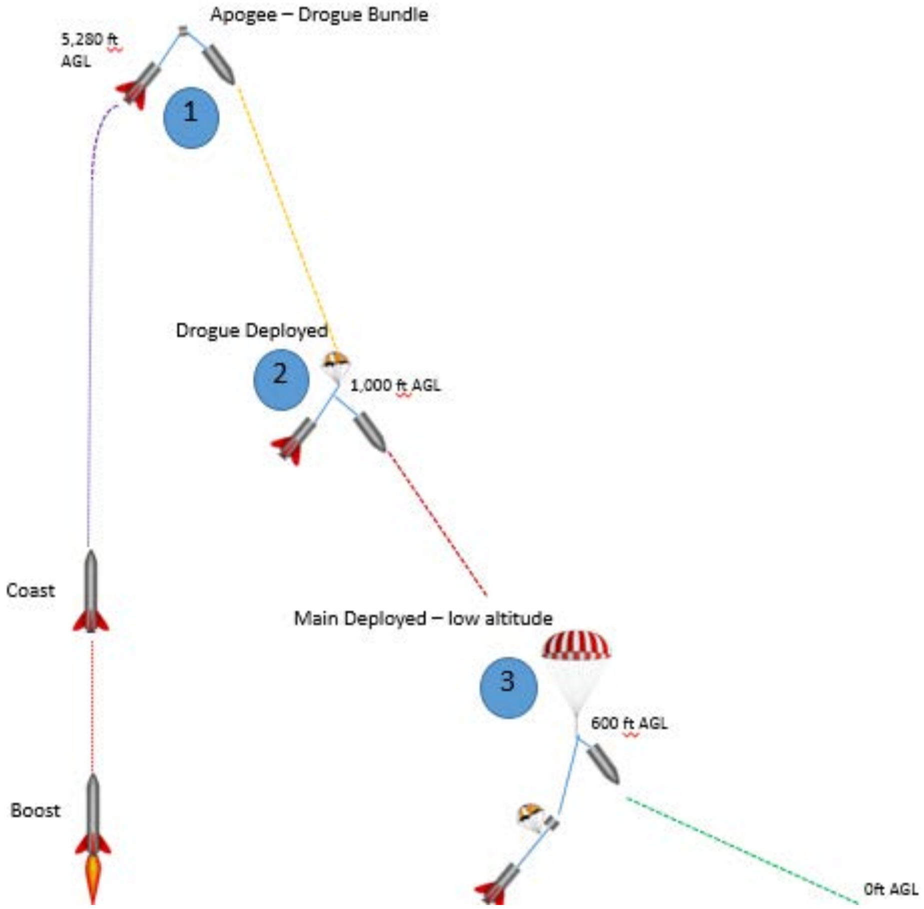


Figure 6 - 3 Deployment Events

The table below summarizes the final design components for our recovery system

Component	Final Design	Justification
Primary Flight Computer	Featherweight Raven	4 Pyro Channels + accelerometer
Back-Up Flight Computer	MissileWorks RRC3 Sport	3 pyro channels
Main Parachute	Fruity Chutes Iris Ultra Compact 84"	Has a coeffficient of drag of 2.2
Deployment Bag	Fruity Chutes	Allows parachute to open smoothly
Drogue Parachute/Nomax	3 Foot RocketMan Ballistic Drogue, Mach II	Built of durable ripstop nylon
Cable Cutter	Cable Cutter	Secures drogue until deployment at 1000 feet
Recovery Harness	35' 11/32" kevlar recovery harness with sewn loops	flame-proof and strong
Hardware	316 stainless steel eyebolts, quiklinks, and threaded rods	stainless steel is hardened and stronger than un-treated steel

Table 3 - Final Component Choices

The table above helps to show what our final component choices are for the recovery systems, along with justifications of why we chose those specific components. We have found that the Featherweight Raven and the MissileWorks RRC3 Sport are best suited for our three deployment events. The Fruity Chutes Iris Ultra compact parachute is a light, compact parachute with a comparatively high Cd. This parachute helps us to slow the launch vehicle enough, with a smaller amount of space, for our sensitive payload. The deployment bag is used with the main to allow the parachute to open more smoothly and without obstruction. The RocketMan ballistic drogue and nomax are both durable, and heat resistant, best suited for being located near the motor. The cable cutter is used to wrap and secure the drogue to limit the drift of the launch vehicle and allow us to use a larger drogue parachute.

For our recovery harness, we are using 11/32” tubular Kevlar with y connections at the end. Instead of tying Kevlar together with knots, we sew them together for better reliability in the long run. Even though it is more time consuming, sewing Kevlar together does not weaken the material.

Recovery system strength

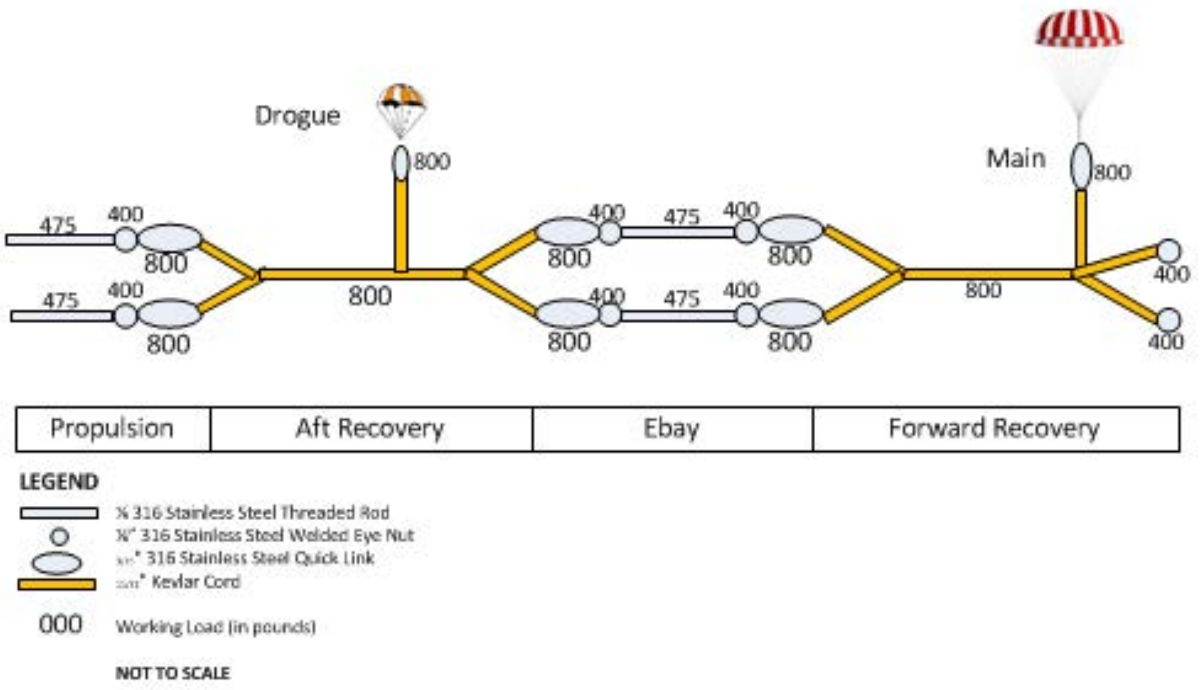


Figure 7 - Recovery System Strength

If worse came to worse, and the drogue did not deploy due to a faulty cable cutter, but the main parachute was to deploy, the shrimp would die, but could the rocket survive? This scenario is the one that will generate the most significant forces on our recovery system, so we designed for it.

The rocket would go from 125 fps down to 14 fps generating 80g's of force. At that rate, the upper section of the rocket, containing the upper recovery and payload (less the main parachute), with a mass of 9.3 lbs would generate 746 lbs of force. Our welded eyenuts only have a working load up to 400 lbs; however, since we are using a split harness, the loads on those specific components are still expected to be acceptable.

The propulsion and aft recovery sections will have a mass of 9.8 lbs (after motor burn-out), which will generate 780 lbs of force. As with the aft airframe and propulsion section assembly, we have a split harness which will divide the stress on the stainless-steel components eyenuts

The interfaces of the ejection charges to our altimeters connect to each other through terminal blocks. These terminal blocks have a screw on the inside side of the electronics bay that reach through the bulkhead, securing the terminal block to the bulkhead. These screws have wires connected to them that reach from the pyro channel on the altimeter to the screw. The screw is then attached to the ignitor that is secured by thumbscrews and washers. The picture below shows the recovery side of the bulkheads.

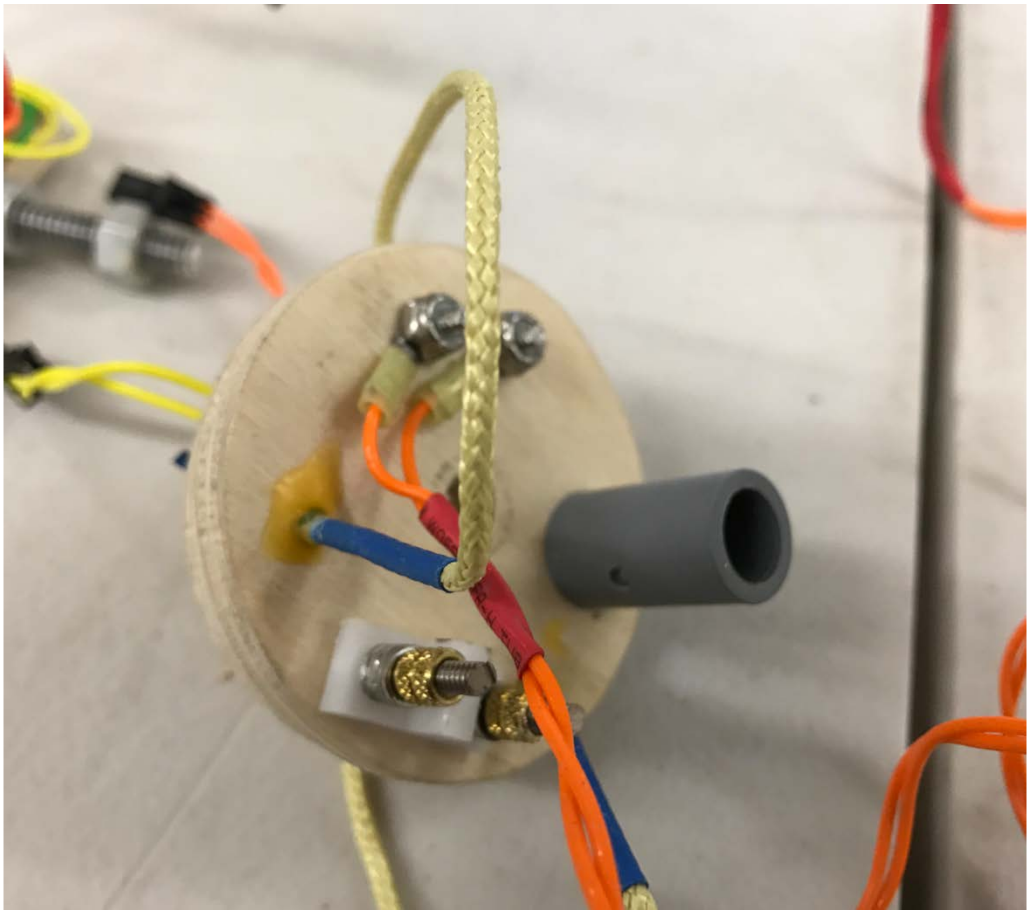


Figure 8 – Aft bulkhead as used on the subscale flights

The gray cylinder is our ejection canister (note the hole in the side for the ignitor). The white plastic with the screw protruding is the terminal block, where the ignitors will be secured. The orange wires are connected directly onto the screw, secured by nuts. The reason for this is because the orange wires are the wires that connect to the cable cutter. The cable cutter does not need an extra terminal block because the ignitor is placed inside of the cable cutter, and does need to be secured by thumbscrews on the terminal block.

Altimeters

For our recovery electronics, we are using two altimeters, one for the primary and one for the secondary. We will also be using two cable cutters to correspond with our three deployment events and to prove redundancy. For our two altimeters, we will be using the Featherweight Raven as our primary, and the MissileWorks RRC3 Sport as our secondary. The Featherweight Raven has four pyro control outputs, one more than is needed. It also contains an accelerometer which we will be using to measure acceleration for our payload experiment. In our sub-scale flight testing we configured each of these altimeters in the three-event configuration and tested them. Below are pictures of both the Raven and RRC3 altimeters as set up for the sub-scale launches, the same configuration will be used in the full-scale.

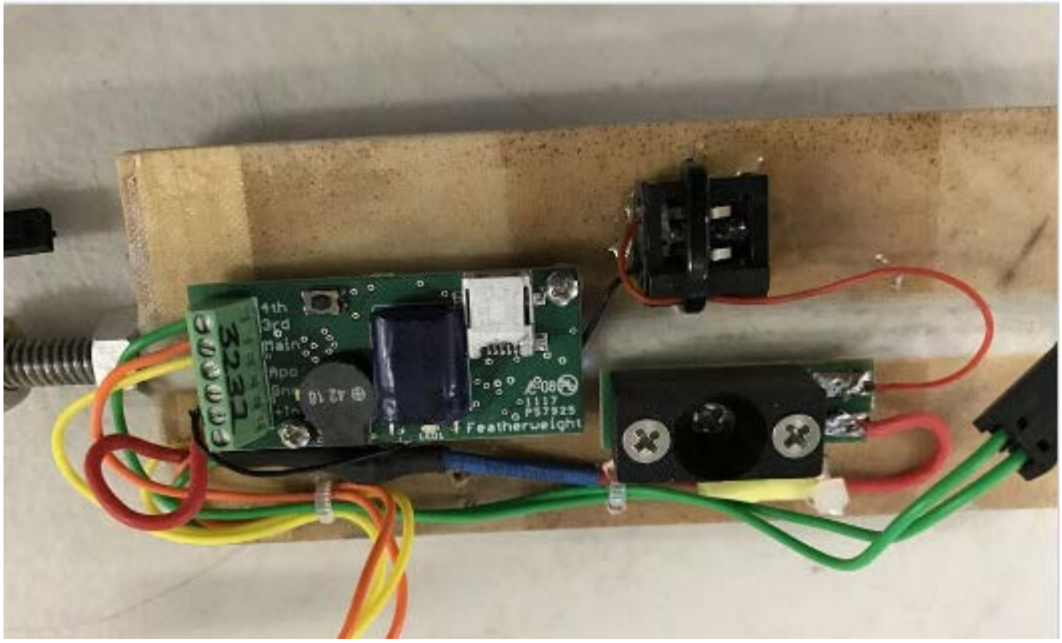


Figure 9 – Raven Altimeter as set up for our subscale flight

Figure 10 – RRC3 Altimeter as set up for our subscale flight

We have fully tested the configuration that will be used in the full- scale in the sub- scale model. The chart below shows the redundancy of our recovery system.

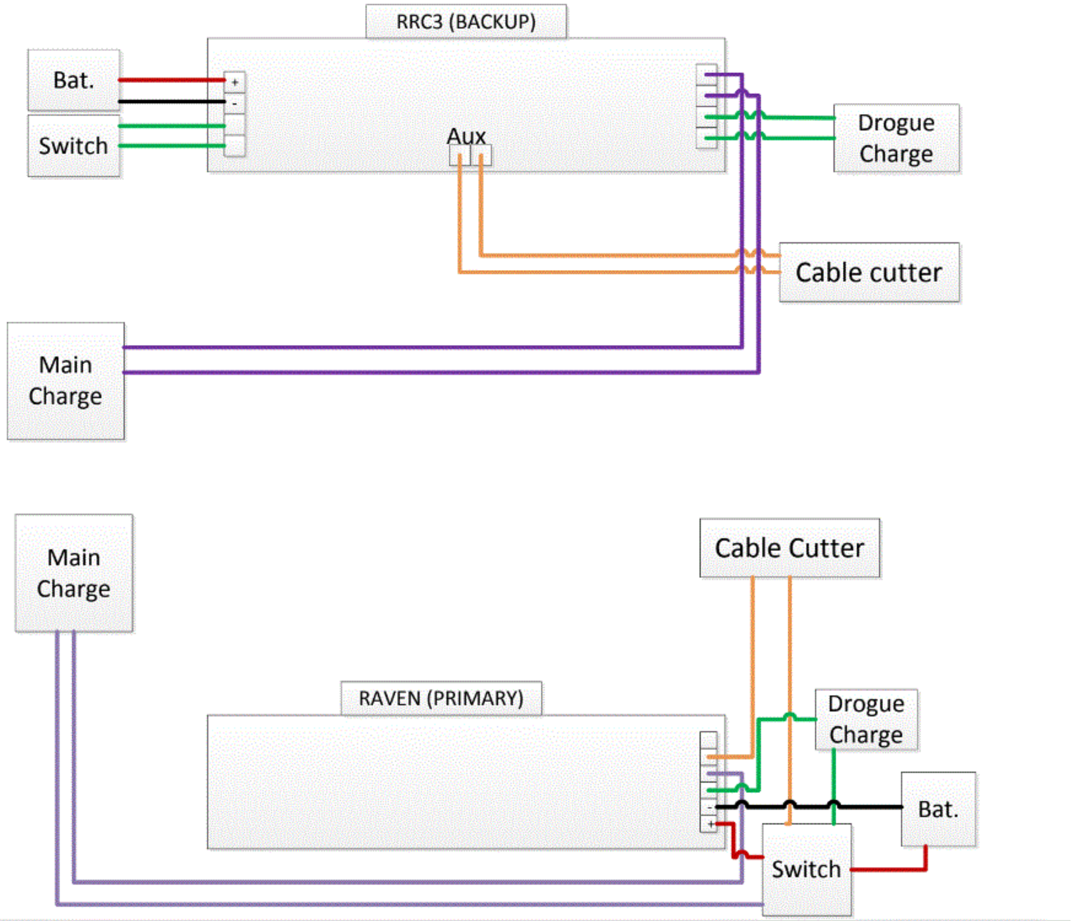


Figure 11-Redundat Flight Computer

GPS Frequency(s) of the Locating Trackers

The operating frequency that our tracker, the EggFinder TRS flight computer, is currently set at 919 MHz. Though it can be set from 915 to 921 MHz in two MHz margins.

D. Mission Performance Predictions

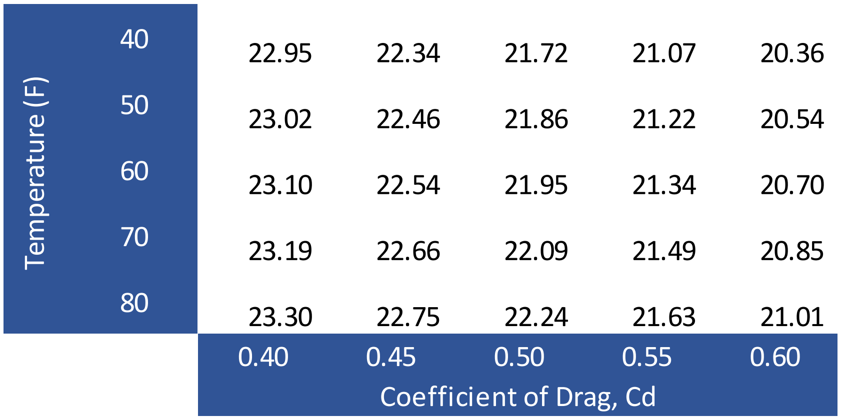
Simulation

We performed several simulations of our design in Rocksim, varying the coefficient of drag (Cd) assumptions and other factors. We were solving for the total mass of the airframe. Our results are shown below

Aerotech K-1275 - Mass Required to attain 5,280 Feet (Pounds)

Rocksim Constants:

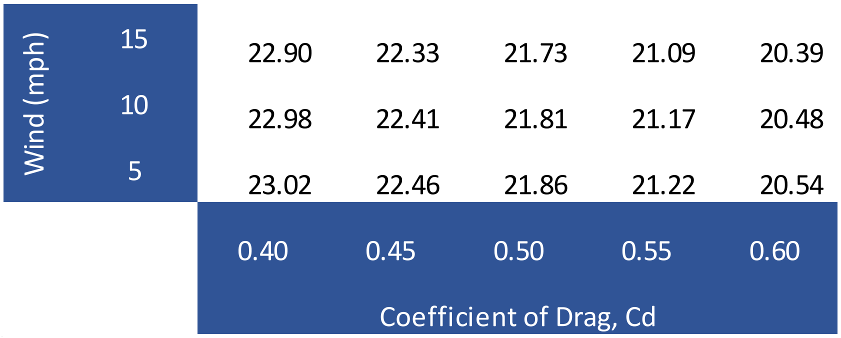
Rail Length	144 inches
Humidity	75%
Cloud Coverage	50%
Barometric Pressure	30 in.hg
Wind	5mph



Temperature (F)	40	22.95	22.34	21.72	21.07	20.36
	50	23.02	22.46	21.86	21.22	20.54
	60	23.10	22.54	21.95	21.34	20.70
	70	23.19	22.66	22.09	21.49	20.85
	80	23.30	22.75	22.24	21.63	21.01
		0.40	0.45	0.50	0.55	0.60
		Coefficient of Drag, Cd				

Rocksim Constants:

Rail Length	144 inches
Humidity	75%
Cloud Coverage	50%
Barometric Pressure	30 in.hg
Temperature	50 f



Wind (mph)	15	22.90	22.33	21.73	21.09	20.39
	10	22.98	22.41	21.81	21.17	20.48
	5	23.02	22.46	21.86	21.22	20.54
		0.40	0.45	0.50	0.55	0.60
		Coefficient of Drag, Cd				

Figure 12 - Simulations

Thrust Curve of Aerotech K1275 Motor.

The Thrust Curve of the K1275 Motor is shown below. The minimum acceptable thrust with a 23lb rocket would be 506 Newtons, which the K1275 easily surpasses.

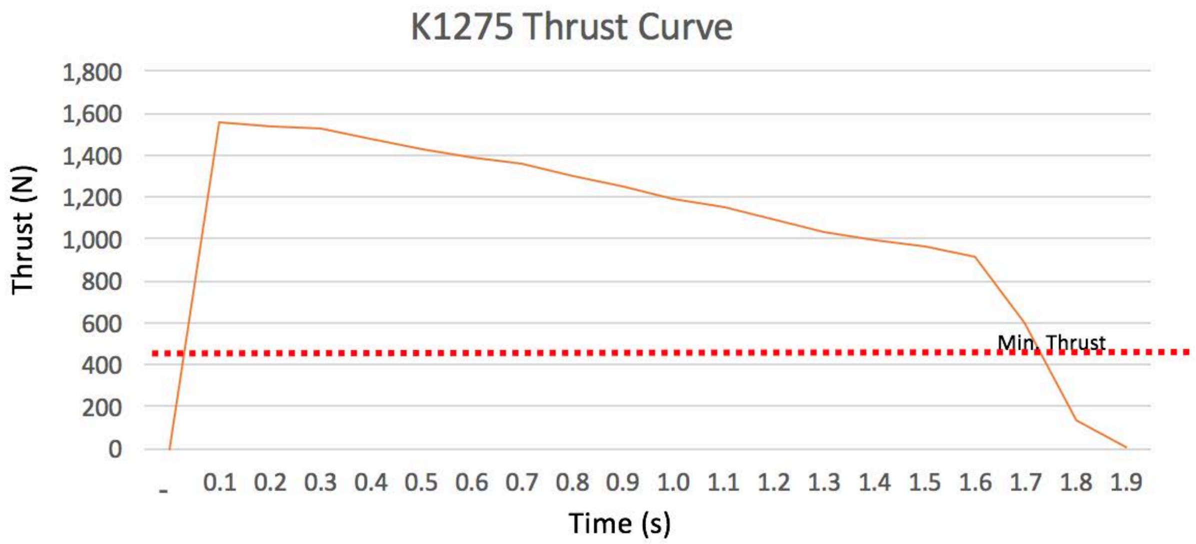


Figure 13 - Motor Thrust Curve

IV. Safety

A. Operation procedures

	RECOVERY		
☐		Altimeters	
☐			Ensure new 9V alkaline batteries are installed and voltage tested
☐			Test each Quest Q2G2 ignitor (3 total) for resistance and short. Should be in the range of 5-6 0hms.
☐			Ensure all wire connections to altimeter and battery are secure. Pyro 1 (yellow) to Drogue bundle, Pyro 2 (orange) to cable cutter, pyro 3 (green) to main.
☐			Ensure altimeter and battery are each secured to ebay sled
☐			Connect quick disconnect wires from altimeter to bulkheads, inspecting each to ensure they are secure
☐			Connect Quest Q2G2 Ignitors to Pyro 1 and Pyro 3 terminal blocks out exterior of bulkheads and install in charge wells:
☐			insert pyrodex 'head' into charge well hole, being careful not to break off pyrodex
☐			Secure leads to terminal blocks, ensuring tight connection and no shorting of leads
☐			Tape around ignitors on side of charge well with electrical tape to seal
☐			Install Q2G2 ignitor on cable cutter (Pyro 2).
☐			before attaching, install O-ring on ignitor
			Twist ignitor wire and Pyro wires securely and cover each individually with heat shrink tubing to prevent shorting (do not activate heat shrink)
☐			turn switch to ensure power to altimeter and ensure that all 3 pyro channels have continuity. Turn-off altimeter.
☐		Close up ebay (i.e. attach bulkheads), ensuring that switch(es) can be accessed and that no wires are crimped.	

		Bulkheads:
		Ensure bulkheads seal properly to coupler and "nuts" are snug and tight ((do not over tighten))
		Ensure altimeter wires aren't "crimped" or binding in any way
		Once bulkheads are secured, turn on altimeter again to ensure that all pyro channels have continuity
		Ensure Cable Cutter Ignitor wire is secured to shock cord (with tape, zip tie or other), providing for slack at either end
		Coil up wire so that it will fit into airframe without kinking
		Install empty cable cutter onto parawai using zip tie
DANGER		Install black powder
		in charge wells, ensuring that black powder is in direct contact with ignitors. Once installed, top off and pack with dog barf and secure with more electrical tape
		In cable cutter, and complete installation of cable cutter. Ensuring that Cable cutter is secured to shock cord by a leash in addition to the ignitor.
		Ensure end with Main charge well is pointed up (towards upper recovery and nose cone) and the one with the Drogue is pointed down (towards booster)
		Final Assembly and Check
		Test to ensure that all eyenuts and quicklinks securing recovery harnesses and parachutes are tight.
		Inspect body tubes for flaws and damage
		Inspect parachute compartments for sharp edges and petrutions that my keep the parachutes from fully deploying.
		Ensure screws securing rail buttons are tightly fastened, and appropriately aligned on the rocket
		Properly pack Iris Parachute in deployment bag according to Fruity Chutes directions & Youtube video

		wrap shock cords in 5 loop figure 8 pattern bundles and secure lightly with either masking tape or rubber bands. This is to prevent cord tangling	
		insert shock cords and parachutes into airframe - parachutes should be closest to the end of the body tubes so they come out first	
		Inspect retaining screws securing aft recovery section to Propulsion section and forward recovery section to Payload and Nose cone are	
		Connect ebay assembly to upper and lower airframe tubes. Ensure that the ebay is snug, but not tight. I needs to be able to separate	
		Once ebay is installed, insert 6 #2 nylon shear pins	
		Insert "remove before flight" flag in switch hole	
		PAYLOAD	
		components:	
DANGER			Lipo Batteries Fully Charged (for cooling system and Arduino)
			Arduino is functional
			All systems are functional:
			Water pump
			Peltier cooler
			Fan
			All wired connections are secured at their terminals
			All bolts and joints are tightly fastened

		Water containment:	
☐			All water tubes are connected securely
☐			Batteries and pump are tightly fastened to the sled
☐			Shrimp's water vessel is seeled from any other components
☐			Water vessel's cap is secured
☐			#6 screws that secure payload assembly in aiframe are installed and tight
	Motor		
☐ 🔍			have mentor assemble rocket motor - following directions
☐			Install motor into rocket. Ensure motor retaining cap is tight
☐			DO NOT install igniter in motor, instead tape it to the side of the rocket
☐ 🔍			One last inspection of rocket
☐			Take to RSO for RSO inspection
	Set-up on launcher		
☐			guide rocket onto rail, ensuring that it does not bind
☐			Ensure rocket motor is not sitting flush against blast shield nozzle is free of obstructions
☐			Raise rocket to vertical and have all team members back-up to a safe distance.
☐ DANGER			Remove "Remove before flight" flag from switch hole and arm altimeters with screw switch

			Using Smart Phone, activate Altimeter 3 for launch
			Insert ignitor into motor, ensuring that it is seated firmly against the delay element at the end of the motor.
			Before connecting Launch Controller, ensure that it has continuity - then disarm
			Connect launch controller to ignitor.
			RSO - Arm Launch Controller
			RSO - Launch rocket

Legend:

👓	Eye protection required
🧤	Protective gloves required
DANGER	Dangerous task, use caution
🔍	Second person sign-off required

Figure 14 - Operations Safety Checklist

Drift Calculation

With our three-deployment event set-up. If we achieve the target altitude of 5,280 feet, we will be able to stay within the 2,500-ft. recovery area as long as winds remain under 15mph. Our estimate for Drift is reflected in the table below:

	Distance	Decent Velocity	Time	Wind Speed				
Phase	**(ft)**	**(fps)**	**(s)**	**0**	**5**	**10**	**15**	**20**
Boost & Coast	5,280		18	-	132	264	396	528
Drogue Bundle (apogee	(4,280)	125	34	-	251	502	753	1,004
Drogue (1000ft)	(400)	40	10	-	73	147	220	293
Main - full load (600ft)	(550)	14	40	-	294	589	883	1,178
Main - payload	(50)	10	5	-	37	74	111	147
			Calculated Drift	-	788	1,575	2,363	3,151
			+ 10%	-	866	1,733	2,599	3,466

Figure 15 - Drift Calculations

B. Safety and Environment (Vehicle and Payload)

1. Personnel Hazard Analysis

Scale	Severity of Failure	Likelihood of Occurrence
1	Minimal or no impact	remote
2	Some	unlikely
3	Moderate	likely
4	major impact	highly likely
5	Unacceptable	near certainty

Figure 16 - Hazard Scale

Personnel Hazard Matrix-

Source	Hazard	Cause	Result	Severity	Likelihood	Mitigation
Compound slide miter saw	Laceration, esp of hands, fingers, limbs.	Incorrect use of equipment	- Damage to person - Damage to rocket	5	1	Use protective eyewear, close-toed shoes, remove all jewelry and do not wear loose-fitting clothing. Always assume the tool is powered. Concentrate on task while utilizing tool - do not become distracted. NEVER do more work than the tool is capable of. Be patient and let the tool do the work.
Variable speed jigsaw	Laceration, esp of hands, fingers, limbs.	Incorrect use of equipment	- Damage to person - Damage to rocket	5	1	Use protective eyewear, close-toed shoes, remove all jewelry and do not wear loose-fitting clothing. Always assume the tool is powered. Concentrate on task while utilizing tool - do not become distracted. NEVER do more work than the tool is capable of. Be patient and let the tool do the work.

Source	Hazard	Cause	Result	Severity	Likelihood	Mitigation
Epoxy resin	Eye or skin irritation.	Failure to avoid glue or hand contact with eyes. Not washing hands with proper solvent after use	- Irritated eyes and throat	2	2	Use gloves to contact glued surfaces and wear vapor-protective mask.
Fast hardening glue	Eye or skin irritation. Irritation of breathing passages.	Insufficient ventilation. Failure to wear gloves when handling glued surfaces. Not washing hands with proper solvent after use.	- Damage to person	2	2	Use protective eyewear, skin protection, and respiratory mask.
Slow hardening glue	Eye or skin irritation. Irritation of breathing passages.	Not washing hands after use Improper protection	- Damage to person	2	2	Use protective eyewear, skin protection, and respiratory mask.
Battery	Eye irritation from battery chemicals, inhalation, ingestion and toxic reaction, skin irritation.	Failure to wear gloves during use. Failure to wash hands with proper soap, solvent after use	- Damage to person - Damage to rocket	3	2	Use protective eyewear, skin protection, and respiratory mask.

Source	Hazard	Cause	Result	Severity	Likelihood	Mitigation
Epoxglas	Eye irritation, skin irritation, respiratory irritation.	Incorrect use of equipment	- Damage to person - Damage to rocket	2	3	Use protective eyewear, skin protection, and respiratory mask.
Dry lubricant	Eye or skin irritation. Irritation of breathing passages.	Improper protection	- Damage to person - Damage to rocket	3	2	Keep in cool, dry, ventilated storage and closed containers. Keep away from heat, sparks and open flames
Spray paint.	Eye or skin irritation. Irritation of breathing passages.	Improper protection	- Damage to person - Damage to rocket	2	2	Use protective eyewear, skin protection, and respiratory mask.
Super glue	Eye or skin irritation. Irritation of breathing passages.	Improper protection	- Damage to person	2	2	Use protective eyewear, skin protection, and respiratory mask.
Band saw	Lacerations or bruises.	Incorrect use of equipment	- Damage to person - Damage to rocket	5	2	Use protective eyewear, close-toed shoes, remove all jewelry and do not wear loose-fitting clothing. Always assume the tool is powered. Concentrate on task while utilizing tool - do not become distracted. NEVER do more work than the tool is capable of. Be patient and let the tool do the work.
Dremel	Lacerations or bruises.	Incorrect use of equipment	- Damage to person - Damage to rocket	4	3	Use protective eyewear, skin protection, and respiratory mask.

Source	Hazard	Cause	Result	Severity	Likelihood	Mitigation
Power drill	Lacerations or bruises.	Incorrect use of equipment	- Damage to person - Damage to rocket	4	3	Use hand protection, respiratory mask.
Drill press	Lacerations or bruises.	Incorrect use of equipment - Improper protection	- Damage to person - Damage to rocket	4	2	Use protective eyewear, close-toed shoes, remove all jewelry and do not wear loose-fitting clothing. Always assume the tool is powered. Concentrate on task while utilizing tool - do not become distracted. NEVER do more work than the tool is capable of. Be patient and let the tool do the work.
Radial arm saw	Lacerations or bruises.	Incorrect use of equipment - Improper protection	- Damage to person - Damage to rocket	5	1	Use protective eyewear, close-toed shoes, remove all jewelry and do not wear loose-fitting clothing. Always assume the tool is powered. Concentrate on task while utilizing tool - do not become distracted. NEVER do more work than the tool is capable of. Be patient and let the tool do the work.
Small hand too	Lacerations or bruises.	Incorrect use of equipment	- Damage to person	2	3	Use hand protection.

Table 4 - Personal Safety Hazards

2. Failure Modes and Effects Analysis -

Potential Failure	Cause	Consequence	Severity	Likelihooc	Mitigation
External Structural Failure	Fins break or fail	unstable flight/ vehicle failure	4	2	Construct with through the wall fins
External Structural Failure	Rail buttons break	unstable flight/ vehicle failure	3	3	Screwed in to prevent break off, also test for looseness before flight
External Structural Failure	Body tube fails	unstable flight/ vehicle failure	5	1	Inspect body tubes for flaws prior to flight
External Structural Failure	Body tubes come apart during flight	unstable flight/ vehicle failure	5	1	All body tubes will be mechanically fastened together
Motor Failure	Motor improperly assembled	rocket Failure	1	2	Check motor to the fullest possible degree before launch
Motor Failure	Ignitor improperly installed	unstable flight possible rocket failure	5	2	Test before launch
Internal Structural Failure	Centering rings not aligned correctly	unstable flight	3	1	Build carefully and measure multiple times
Internal Structural Failure	Motor retention fails	motor falls out	5	3	Test before launch.

Potential Failure	Cause	Consequence	Severity	Likelihood	Mitigation
Shock Cord Failure	Excessive loading	rocket components come in ballistically	5	2	Design fitting for proper load (eyebolts & quick links)
Shock Cord Failure	De-taches from eye bolts	rocket components come in ballistically	5	2	Check eyebolts, quicklings and recovery harness for proper fit prior to flight
Shock Cord Failure	Cut by other objects in rocket	rocket components come in ballistically	5	1	Inspect parachute compartments for sharp edges prior to intalling parachutes
Shock Cord Failure	Burned by ejection charges	rocket components come in ballistically	5	2	Shock cord made from fireproof kevelar
Altimeter Failure	Ejection charges do not go off	parachutes don't deploy/rocket comes in ballsitic	5	2	Observe the motor before loading to see if the ejection charge is on
Ejection Charge Failure	Igniter failure	parachutes don't deploy/rocket comes in ballsitic	5	3	Test deployment system before launch
Parachute Failure	Parachutes packed too tightly	parachutes fail to deploy, or tangle upon deployment	5	3	Ground test parachutes; Inspect parachute packing during final assembly
Parachute Failure	Parachutes detach from shock cord	rocket comes in ballistic	5	3	Check if parachutes are properly secured

Potential Failure	Cause	Consequence	Severity	Likelihood	Mitigation
Parachute Failure	Parachute burns from ejection charges	parachute opens partially, or not at all	5	3	Protect parachutes and flammable shroud lines with flameproof shroud lines with flameproof material
Payload Environment Fails	Water environment leaks	contaminates the rest of the rocket, including motor/electronics	4	2	Test environment before launch.

Table 5 - Failure Mode Analysis

3. Project Risks

Project Risks

What	Likelihood	Impact	Mitigation
Fundraising	Medium	Medium	Begin fundraising early
Out of stock components	Medium	Medium	Order early as early as possible
Time understanding requirements	High	High	Schedule tasks early with detail and communicate!
Arduino programming	Medium	High	Need to start ASAP
Cooling system not being completed	Medium	High	Accelerate schedule-test early
Shrimp do not survive trip to Huntsville	Medium	High	Look for alternate sources of shrimp in Huntsville

Figure 17 - Project Risks

V. Payload Criteria

A. Design of Payload Equipment

Our scientific experiment is testing if brine shrimp can survive the g-forces of a launch. To ensure the shrimp do not die of any other circumstances, we must take out all other variables. The main concern is heat, because the main launch will be in Alabama where there can be high temperatures. To keep the shrimp alive, we have developed a cooling system which is mounted to a sled. The structure of the sled is made out of wood, with 2 layers of fiberglass adding strength while keeping it light. The sled is reinforced with 4mm hollow carbon rods with 2/56 threaded rod through them, allowing the sled to become rigid and strong.

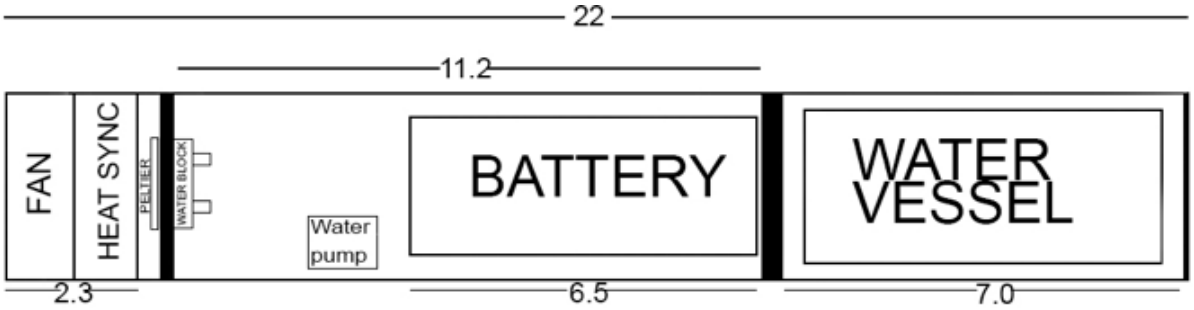


Figure 18 - Payload Block Diagram

Where the water vessel is (bottom) there are 4 supporting carbon rods, making the water vessel removable and rigid. The water vessel will be completely covered by a coupler when fully assembled. There will also be a larger copper tube covering most of the shrimp's water vessel, increasing efficiency in cooling.

The middle section has 2 supporting rods, one on either side keeping the bulkheads secure and adding rigidity. The batteries are the largest component of the payload, they supply all necessary power to the pump, Peltier cooler, and fan. To secure the 2 large 8000mah batteries and the water pump which is located on the other side, we use steel brackets. At the top of the sled there is the fan, heat sink, Peltier cooler, and water block. The heat from the Peltier cooler is absorbed by the heat sink and is taken away by the fan. Our main concern with the payload is components may come loose during launch or landing. We have and will pay special attention to the mounting and securing of the components to the sled.

This picture is of our working prototype:

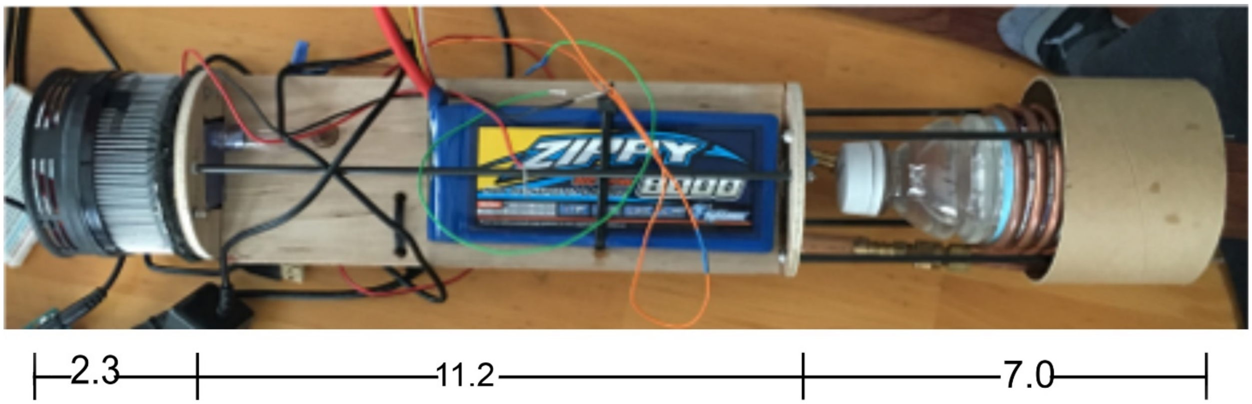


Figure 19 – Mock-up of Payload bay sled and assembly

Figure 20 - 10oz Water Vessel, without water: 28 g, with water: 293 g

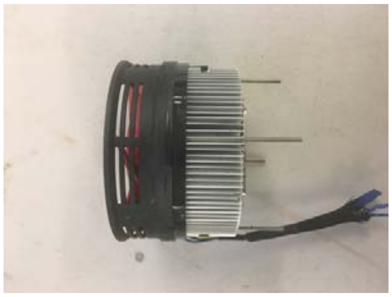


Figure 21 - Fan: 67.7 g

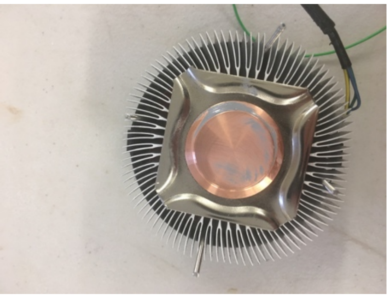


Figure 22 - Heat Sink: 284 g

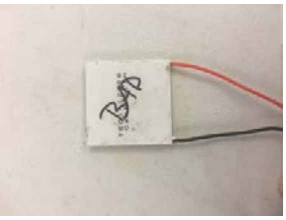


Figure 23 - Peltier Cooler: 24 g

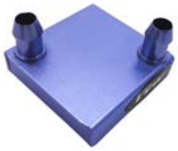


Figure 24 - Water Block: 40 g

Figure 25 - Vinyl Tubing 1.8g per Inch

Figure 26 - Water Pump: 58 g

Figure 27 - Battery x 2: 584 g

The Arduino will be mounted above the sled inside the nose cone of the rocket, it will tell the cooling system when to turn on and when to turn off. The list will be from the top of the sled to the bottom. The fan is mounted to the heat sink to wick away the heat generated from the Peltier cooler. The Peltier cooler is mounted to the heat sync and water block, the heat generated from the Peltier goes to the heat sink and the cold generated from the Peltier goes to the water block. Below the water block is a water pump, which pumps water from the water block to cool the water. The batteries are the largest component of the payload, they supply all necessary power to the pump, Peltier cooler, and Arduino. The water vessel containing the shrimp is surrounded by copper tubing which will have the cold water from the water block running through it cooling the water.

#6 screws and nuts will mount the sled holding the components of the payload to the body tube, keeping the payload secure and keep it from moving within the body tube of the rocket. The payload will be located at the topmost body tube of the rocket, and the Arduino will be mounted within the nosecone, saving space.

B. Payload Electronics

For our Payload, an Arduino Uno microcontroller is used to turn the cooling system on and off and to record temperature data. C++ was used as our code to operate our Arduino. Temperatures are recorded on the flash memory of our Arduino, which is called EEPROM in the program. Each real number, also referred to as a float, takes up 4bytes. EEPROM only has a storage space of one kilobyte (1024 bytes), but temperature is required to be recorded for four hours (14,400 seconds, the estimate amount of time the rocket would be placed on the platform in the sun and the flight time), so the floats are converted into unsigned integers, called uint8t_t's in the code, which only use one byte of space. This way, the Arduino can hold 1024 uint8t_t's. Two data points will be recorded: the temperature and the Boolean (on or off) variable indicating if the pump is on or off. Boolean variable also takes up 1 byte of space. Therefore, the EEPROM only has enough capacity for 512 bytes for each variable. Dividing 14,400 seconds by 512 bytes, the sampling rate is taken as 28 seconds.

Two programs were written for the Arduino: one to record temperature data and activate the cooling system and one to read the logged temperature data after the flight for analysis. A copy of these programs is shown in Appendix C.

Switch, Indicator Wattage, and Location:

The Arduino is used to turn our cooling system on and off. The cooling system needs 12v to power it. However, the Arduino only provides a 5v signal. To solve this problem, there are two relays to switch the Arduino's 5v signal to two 12v signals – one for the Peltier cooler and the other for both fan and pump. Two relays are needed to handle the high electrical load capacity. (The Peltier draws 5A and each relay is only capable of handling 5A. The pump and fan combined draw less than 5A). These relays are located on the electronics board.

Payload Electrical Schematic

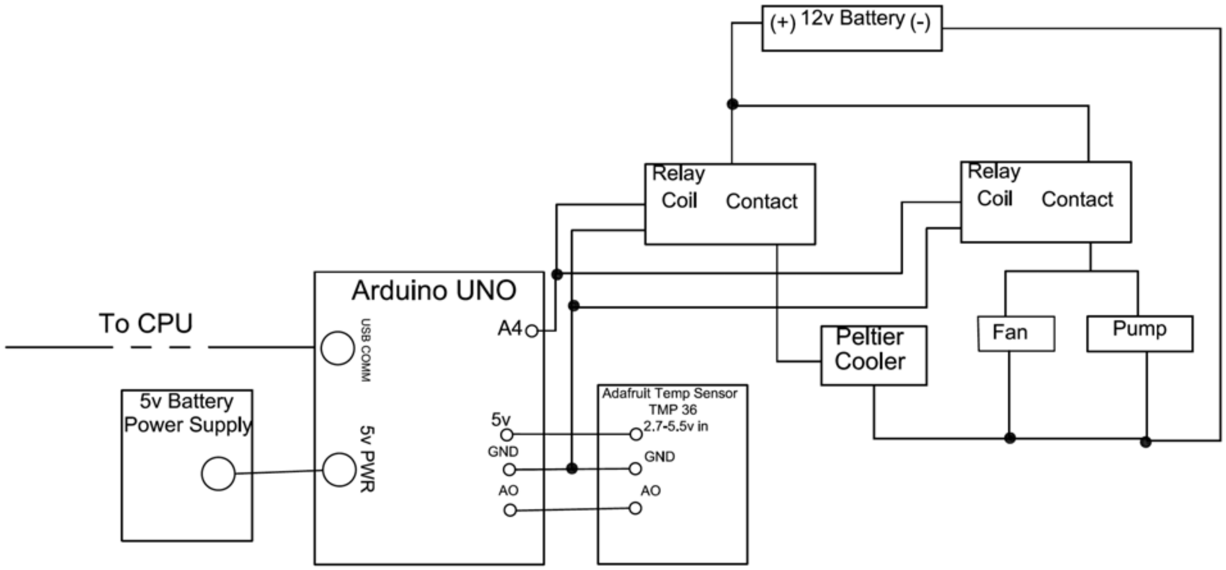


Figure 28- Arduino Electrical Diagram

VI. Project Plan

A. Testing

Drop test:

This test is where the water vessel containing the shrimp will be dropped at a series of heights which will replicate the amount of g force that the shrimp are expected to be exposed to during our experiment. There will be three test groups of shrimp for three different set of g forces 10-15-20g. After the g-force tests if the shrimp are alive, they may have been damaged and will be observed after 24 and 48 hours to ensure their survivability. This test will determine whether or not the payload requires a shock suppression system. If shrimp fail this test, we will implement a shock absorption device consisting of a series of springs.

Heat Test

The test is to insure the cooling system works and maintains a temperature below 85° when exposed to ambient temperature of 120° for an extended period of time. The cooling system will have to keep the temperature stable for 30 min to ensure the functionality of the cooling system.

Battery Test

If payload does not function for 50% of the 4 hours, we will increase the number of batteries, or decrease the demand of power. To determine the batteries required we use this formula. By adding the consumption of each component, we know what size battery is required.

Fan-	300MAh
Peltier-	4500MAh
Pump-	300MAh
Total-	5100MAh
x2 hours-	10,200MAh

By these calculations we have chosen to use two 8000 mah 3cell 11.1volt lipo batteries, if the cooling system functions for the required 2 hours it will be a success.

LAUNCH VEHICLE TESTS

Motor test

If the rocket exceeds altitude in simulation we will place ballast in the rocket, reducing altitude and increasing weight. If the altitude of the rocket is too low, we will change motors to a more powerful alternative or shed weight. Reducing the weight of the rocket any more is very difficult, because we have already designed the rocket to be as efficient as possible. The ballast bay is located to the side of the motor mount, this is not preferable but it is the only option. It conserves space and is efficient in the design.

B. Requirements Compliance

1. Verification Plan

General Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
1.1. Students on the team will do 100% of the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder or any variant of ejection charges, or preparing and installing electric matches (to be done by the team's mentor).	Observation	The team will record their progress and the steps to success, showing that the team members have done all of the work.	75%
1.2. The team will provide and maintain a project plan to include, but not limited to the following items: project milestones, budget and community support, checklists, personnel assigned, educational engagement events, and risks and mitigations.	Analysis	The project plan consists of the events necessary for the project's success. Milestones, budget, community support, checklists, personnel assigned, educational engagement, and risks and mitigations have all been provided.	100%
1.3. Foreign National (FN) team members must be identified by the Preliminary Design Review (PDR) and may or may not have access to certain activities during launch week due to security restrictions. In addition, FN's may be separated from their team during these activities.	Observation	Our team does not have any FN team members	

General Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
1.4. The team must identify all team members attending launch week activities by the Critical Design Review (CDR). Team members will include: 1.4.1. Students actively engaged in the project throughout the entire year. 1.4.2. One mentor (see requirement 1.14). 1.4.3. No more than two adult educators.	Observation Analysis	All members attending launch week, will be identified by CDR. Their individual roles throughout the year will be recorded No more than two adult educators will attend launch week activities	100%
1.5. The team will engage a minimum of 200 participants in educational, hands-on science, technology, engineering, and mathematics (STEM) activities, as defined in the Educational Engagement Activity Report, by FRR. An educational engagement activity report will be completed and submitted within two weeks after completion of an event. A sample of the educational engagement activity report can be found on page 30 of the handbook. To satisfy this requirement, all events must occur between project acceptance and the FRR due date.	Analysis	Educational engagement will engage a minimum of 200 participants, hands-on science, technology, engineering, and mathematics will be shown through a set of experiments.	Date has been scheduled with a school. 25%

General Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
1.6. The team will develop and host a Web site for project documentation.	Observation	The team's website is www.stmonicarocketryclub.com, all of our due documents have been uploaded to this site. And all future documents will be uploaded.	100%
1.7. Teams will post, and make available for download, the required deliverables to the team Web site by the due dates specified in the project timeline.	Observation, Analysis	All documents, private or public, will be available for download on the website by the due dates specified in the project timeline.	50% of all documents have been uploaded
1.8. All deliverables must be in PDF format.		All documents will be converted into PDF format.	100%
1.9. In every report, teams will provide a table of contents including major sections and their respective sub-sections.	Observation, Analysis	Reports will have a table of contents, including major sections and their respective sub-sections.	100% of all present documents
1.10. In every report, the team will include the page number at the bottom of the page.	Observation	The page number that we will include on the bottom of the page will correlate with our table of contents.	100%
1.11. The team will provide any computer equipment necessary to perform a video teleconference with the review panel. This includes, but is not limited to, a computer system, video camera, speaker telephone, and a broadband Internet connection. Cellular phones can be used for speakerphone capability only as a last resort.	Observation	The team has two locations for video teleconferences, one main and one backup. Both consist of a computer system, video camera, speaker phone and a solid internet connection.	100%

General Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
1.12. All teams will be required to use the launch pads provided by Student Launch's launch service provider. No custom pads will be permitted on the launch field. Launch services will have 8 ft. 1010 rails, and 8 and 12 ft. 1515 rails available for use.	Test	Our design was made to accommodate for launch services provided.	100%
1.13. Teams must implement the Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194) Subpart B-Technical Standards (http://www.section508.gov): §1194.21 Software applications and operating systems. §1194.22 Web-based intranet and Internet information and applications.	Analysis	Our teams will implement the EIT accessibility standards.	75%

General Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
1.14. Each team must identify a "mentor." A mentor is defined as an adult who is included as a team member, who will be supporting the team (or multiple teams) throughout the project year, and may or may not be affiliated with the school, institution, or organization. The mentor must maintain a current certification, and be in good standing, through the National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) for the motor impulse of the launch vehicle and must have flown and successfully recovered (using electronic, staged recovery) a minimum of 2 flights in this or a higher impulse class, prior to PDR. The mentor is designated as the individual owner of the rocket for liability purposes and must travel with the team to launch week. One travel stipend will be provided per mentor regardless of the number of teams he or she supports. The stipend will only be provided if the team passes FRR and the team and mentor attends launch week in April.	Observation	Our mentor maintains a current certification, through NAR or TRA. He is certified to fly, and has flown the motor of which our design has. He has had a minimum of 2 flights in this or a higher impulse class, prior to PDR. Our mentor is designated as the individual owner of the rocket, for liability purposes and this rocket will travel with us to launch week.	100%

Table 6 - General Requirements

Design Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
2.1. The vehicle will deliver the payload to an apogee altitude of 5,280 feet above ground level (AGL).	TEST/DEMOMSTRATION	To test this requirement the team will launch the vehicle prior to the FRR either with the payload or a simulated weight of the payload.	0%
2.6. The launch vehicle will be designed to be recoverable and reusable. Reusable is defined as being able to launch again on the same day without repairs or modifications.	INSPECTION	The materials of the vehicle must be thoroughly inspected to ensure quality before use.	25%
2.7. The launch vehicle will have a maximum of four (4) independent sections. An independent section is defined as a section that is either tethered to the main vehicle or is recovered separately from the main vehicle using its own parachute.	INSPECTION	Our rocket design has 4 sections	100%
2.8. The launch vehicle will be limited to a single stage.	INSPECTION	The team will ensure that the design has only one stage.	100%
2.9. The launch vehicle will be capable of being prepared for flight at the launch site within 3 hours of the time the Federal Aviation Administration flight waiver opens.	DEMONSTRATION	The team will demonstrate at every launch that the rocket is capable of being prepared within 3 hours of the flight waiver being opened.	
2.10. The launch vehicle will be capable of remaining in launch-ready configuration at the pad for a minimum of 1	TEST/DEMONSTRATION	The team will demonstrate at every launch that the rocket is able to remain in launch-ready configuration for a minimum of 1 hour without losing functionality.	50%

hour without losing the functionality of any critical on-board components.		All systems are designed to last 4 hours.	
2.11. The launch vehicle will be capable of being launched by a standard 12-volt direct current firing system. The firing system will be provided by the NASA-designated Range Services Provider.	TEST	The team will test the rocket on a 12-volt direct current firing system.	0%
2.12. The launch vehicle will require no external circuitry or special ground support equipment to initiate launch (other than what is provided by Range Services).	DEMONSTRATION	The team will demonstrate that all launch equipment is internal or provided by Range Services.	100%
2.13. The launch vehicle will use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR).	INSPECTION/ DEMONSTRATION	The team will ensure that the K-class motor has been approved by NAR, TRA, or CAR, and will demonstrate that the motor has the ability to propel the rocket to the predicted height.	100%
2.13.1. Final motor choices must be made by the Critical Design Review (CDR).	DEMONSTRATION	The team will show that their final motor has been selected prior to the Critical Design Review.	100%
2.13.2. Any motor changes after CDR must	DEMONSTRATION	The team will show that the motor has not been changed after CDR	100%

be approved by the NASA Range Safety Officer (RSO), and will only be approved if the change is for the sole purpose of increasing the safety margin.		unless it is necessary to increase safety.	
2.16. The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail.	TEST	The team will simulate and test the rocket to ensure it has a minimum static stability margin of 2.0 at the point of rail exit.	100%
2.17. The launch vehicle will accelerate to a minimum velocity of 52 fps at rail exit.	TEST	In simulation, our rocket exceeds the minimum velocity of 52 fps at rail exit.	100%
2.18. All teams will successfully launch and recover a subscale model of their rocket prior to CDR. Subscales are not required to be high power rockets.	TEST/DEMONSTRATION	We have demonstrated the ability of the subscale rocket at a launch prior to CDR.	100%
2.18.1. The subscale model should resemble and perform as similarly as possible to the full-scale model, however, the full-scale will not be used as the subscale model.	TEST/DEMONSRATION	We have built our subscale rocket, tested its ability at a launch, and demonstrated its similarity to the full-scale rocket.	100%
2.18.2. The subscale model will carry an altimeter capable of reporting the model’s apogee altitude.	INSPECTION	The altimeter of choice is capable of reporting the model's apogee altitude.	100%
2.19. All teams will successfully launch and	TEST/DEMONSTRATION	We will test the full-scale rocket in a launch prior to FRR and	20%

recover their full-scale rocket prior to FRR in its final flight configuration. The rocket flown at FRR must be the same rocket to be flown on launch day. The purpose of the full-scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight. A successful flight is defined as a launch in which all hardware is functioning properly (i.e. drogue chute at apogee, main chute at a lower altitude, functioning tracking devices, etc.). The following criteria must be met during the full-scale demonstration flight:		demonstrate a successful launch with the same rocket that will be used on the final launch day.	
2.19.1. The vehicle and recovery system will have functioned as designed.	DEMONSTRATION	The team will demonstrate at a launch that the recovery system will function as designed.	0%
2.19.2. The payload does not have to be flown during the full-scale test flight. The following requirements still apply:		The payload may or may not be flown within the rocket at the full-scale test flight.	0%
2.19.2.1. If the payload is not flown, mass simulators will be used to simulate the payload mass.	TEST/DEMONSTRATION	The team will test the weight of the payload with either the payload itself or an object of similar mass, and demonstrate that	0%

		the rocket is functional with this payload.	
2.19.2.1.1. The mass simulators will be located in the same approximate location on the rocket as the missing payload mass.	INSPECTION	The team will ensure that in case of the payload not being completed in time, the mass simulators will be located in the same approximate location as the missing payload mass.	100%
2.19.4. The full-scale motor does not have to be flown during the full-scale test flight. However, it is recommended that the full-scale motor be used to demonstrate full flight readiness and altitude verification. If the full-scale motor is not flown during the full-scale flight, it is desired that the motor simulates, as closely as possible, the predicted maximum velocity and maximum acceleration of the launch day flight.	TEST/DEMONSTRATION	Due to the insufficient size of our test field, the motor for the full-scale flight will not be the same as the launch day motor, but will have a proportionate thrust so as to closely simulate the maximum velocity and acceleration that will occur on launch day.	
2.19.5. The vehicle must be flown in its fully ballasted configuration during the full-scale test flight. Fully ballasted refers to the same amount of ballast that will be flown during the launch day flight. Additional ballast may not be added without a re-flight of the full-scale launch vehicle.	INSPECTION	The team will ensure that the amount of ballast used at the full-scale test flight is equal to the amount used at the final launch.	0%

2.19.6. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components will not be modified without the concurrence of the NASA Range Safety Officer (RSO).	DEMONSTRATION	The team will demonstrate that no vehicle components have been altered after the full-scale test flight.	0%
2.19.7. Full scale flights must be completed by the start of FRRs (March 6, 2018). If the Student Launch office determines that a re-flight is necessary, then an extension to March 28, 2018 will be granted. This extension is only valid for re-flights; not first-time flights.	DEMONSTRATION	The team will show that any test flights will have taken place prior to March 6, 2018.	0%
2.20. Any structural protuberance on the rocket will be located aft of the burnout center of gravity.	INSPECTION	The team will ensure that there will be no structural protuberances on the rocket except for the fins, rail buttons, and sheer pins, which are located aft of the burnout CG.	100%
2.21. Vehicle Prohibitions	INSPECTION	The team will ensure that none of the following prohibited items are used in the rocket or for the launch of the rocket.	
2.21.1. The launch vehicle will not utilize forward canards.	INSPECTION	The vehicle will not utilize forward canards.	100%
2.21.2. The launch vehicle will not utilize forward firing motors.	INSPECTION	The vehicle will not utilize forward firing motors.	100%
2.21.3. The launch vehicle will not utilize motors that expel titanium sponges	INSPECTION	The vehicle will not utilize motors that expel titanium sponges.	100%

(Sparky, Skidmark, MetalStorm, etc.)			
2.21.4. The launch vehicle will not utilize hybrid motors.	INSPECTION	The vehicle will not utilize hybrid motors.	100%
2.21.5. The launch vehicle will not utilize a cluster of motors.	INSPECTION	The vehicle will not utilize a cluster of motors.	100%
2.21.6. The launch vehicle will not utilize friction fitting for motors.	INSPECTION	The vehicle will not utilize friction fitting in its motor tube.	100%
2.21.7. The launch vehicle will not exceed Mach 1 at any point during flight.	INSPECTION	The vehicle will not exceed Mach 1 at any point during flight.	100%
2.21.8. Vehicle ballast will not exceed 10% of the total weight of the rocket.	INSPECTION	The vehicle ballast will not exceed 10% of the net vehicle weight.	0%

Table 7 - Design Requirements

Recovery Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
3.1. The launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a lower altitude. Tumble or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue-stage descent is reasonable, as deemed by the RSO.	Demonstration/analysis	The current design of the launch vehicle utilizes a three-stage deployment system. Refer to section III for details.	50%

Recovery Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
3.2. Each team must perform a successful ground ejection test for both the drogue and main parachutes. This must be done prior to the initial subscale and full-scale launches.	Demonstration.	The team will demonstrate a successful ground ejection test prior to the initial launch.	50%
3.3. At landing, each independent sections of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf.	Analysis.	Analysis through calculations will prove that upon landing, the launch vehicle will have a maximum kinetic energy of 75 ft-lbf	0%
3.4. The recovery system electrical circuits will be completely independent of any payload electrical circuits.	Inspection.	Inspection will prove that the recovery system electrical circuits are completely independent of any payload electrical circuits.	0%
3.5. All recovery electronics will be powered by commercially available batteries.	Inspection.	Inspection will prove that all recovery electronics are powered by commercially available batteries.	50%
3.6. The recovery system will contain redundant, commercially available altimeters. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.	Inspection.	Inspection will prove that the altimeters are redundant and powered by commercially available alkaline batteries.	50%

Recovery Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
3.7. Motor ejection is not a permissible form of primary or secondary deployment.	Inspection.	The launch vehicle will not utilize motor ejection.	0%
3.8. Removable shear pins will be used for both the main parachute compartment and the drogue parachute compartment.	Inspection.	Inspection will prove that removable sheer pins will be used.	0%
3.9. Recovery area will be limited to a 2500 ft. radius from the launch pads.	Analysis.	Analysis will prove that the launch vehicle will land in the designated 2500 ft. radius recovery area. Refer to section xx for details.	25%
3.10. An electronic tracking device will be installed in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.	Inspection.	Inspection will prove that an electronic tracking device will be located in the launch vehicle and will transmit the position of the tethered vehicle or any independent section to a ground receiver.	0%
3.10.1. Any rocket section, or payload component which lands untethered to the launch vehicle will also carry an active electronic tracking device.	Inspection.	The design of the launch vehicle will allow it to only land as one piece. Inspection will prove that this piece contains an active electronic tracking device.	0%

Recovery Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
3.10.2. The electronic tracking device will be fully functional during the official flight on launch day.	Test.	The electronic tracking device will be tested to be fully functional during the official launch on launch day.	0%
3.11. The recovery system electronics will not be adversely affected by any other on-board electronic devices during flight (from launch until landing).	Test/inspection.	Tests and inspection will prove that the recovery system electronics will not be adversely affected by any other on-board electronic devices during flight.	50%
3.11.1. The recovery system altimeters will be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.	Inspection.	Inspection will prove that the recovery system altimeters will be physically located in a separate compartment within the vehicle from any other radio frequency transmitting device and/or magnetic wave producing device.	0%
3.11.2. The recovery system electronics will be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system electronics.	Inspection.	Inspection will prove that the recovery system electronics will be shielded from all onboard transmitting devices.	50%

Recovery Requirements

Requirement	Verification	How Satisfied	Status
3.11.3. The recovery system electronics will be shielded from all onboard devices which may generate magnetic waves (such as generators, solenoid valves, and Tesla coils) to avoid inadvertent excitation of the recovery system.	Inspection.	The current design of the launch vehicle does not include any onboard devices that may generate magnetic waves. Inspection will prove this.	50%
3.11.4. The recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.	Test/inspection.	Tests and inspection will prove that the recovery system electronics will be shielded from any other onboard devices which may adversely affect the proper operation of the recovery system electronics.	50%

Table 8 - Recovery Requirements

Experiment Requirements

Requirement	Verification	How Satisfied	Status
4.1. The launch vehicle will carry a science or engineering payload. The payload may be of the team's discretion, but must be approved by NASA. NASA reserves the authority	We will analyze the requirements and make sure that our payload meets them.	We will only fly a NASA approved payload.	50%

Experiment Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
to require a team to modify or change a payload, as deemed necessary by the Review Panel, even after a proposal has been awarded.			
4.2. Data from the science or engineering payload will be collected, analyzed, and reported by the team following the scientific method.	We will inspect if this work was done.	We will be collecting data, graphs and charts during our experiment, and will analyze them as we go along.	50%
4.3. Unmanned aerial vehicle (UAV) payloads of any type will be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given the authority to release the UAV.	We will inspect our payload for a UAV.	We do not have a UAV.	100%
4.4. Any payload element that is jettisoned during the recovery phase, or after the launch vehicle lands, will receive real-time RSO permission prior to initiating the jettison event.	We will test for a payload item that could be jettisoned and inspect if an item did jettison.	We do not have any payload element that will be jettisoned.	100%
4.5. The payload must be designed to be recoverable and reusable. Reusable is defined as being able to	We will test if our design is reusable.	Our design is reusable.	50%

Experiment Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
be launched again on the same day without repairs or modifications.			
The cooling system is effective and works properly.	We will test if the cooling system will work.	We will use an air heated box which we will put our cooling system in. We will then verify if the cooling system can cool the shrimp.	50%
The Arduino is programmed correctly and is functional.	We will test the Arduino.	We will test if the components attached to the Arduino react when they are put under the circumstances that they are supposed to react to.	50%
If the payload gets below the temperature of 75 degrees.	We will test and then adjust the cooling system.	We will adjust the cooling system to have a shutoff to solve this problem.	
If the payload exceeds the temperature 85 degrees.	We will test and adjust the cooling system.	The cooling system will be functional for a longer duration of time.	0%
That the cooling system functions for 2 hours.	We will test if the battery lasts 2 hours with all components attached.	We will attach the battery to all systems and test if it lasts for the time we require.	50%
That the shrimp holder does not leak.	We will test if the shrimp holder leaks.	We will observe the payload before, and after launch to ensure there are not leaks.	0%
The impact that the shrimp can withstand.	We will test on the impact that the shrimp can withstand without dying.	We will drop our payload from different heights to replicate the level of g's the shrimp can survive.	0%

Table 9 - Payload Requirements

Safety Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
5.1. Each team will use a launch and safety checklist. The final checklists will be included in the FRR report and used during the Launch Readiness Review (LRR) and any launch day operations.	Analysis	The team will use a launch and safety checklist, and it will be included in the FRR report and used during the LRR and any launch day operations.	50%
5.2. Each team must identify a student safety officer who will be responsible for all items in section 5.3.	Analysis, Observation	The team will identify a student safety officer who will be responsible for all item in section 5.3.	100%

5.3. The role and responsibilities of each safety officer will include, but not limited to: 5.3.1. Monitor team activities with an emphasis on Safety during: 5.3.1.1. Design of vehicle and payload 5.3.1.2. Construction of vehicle and payload 5.3.1.3. Assembly of vehicle and payload 5.3.1.4. Ground testing of vehicle and payload 5.3.1.5. Sub-scale launch test(s) 5.3.1.6. Full-scale launch test(s) 5.3.1.7. Launch day 5.3.1.8. Recovery activities 5.3.1.9. Educational Engagement Activities 5.3.2. Implement procedures developed by the team for construction, assembly, launch, and recovery activities 5.3.3. Manage and maintain current revisions of the team's hazard analyses, failure modes analyses, procedures, and MSDS/chemical inventory data 5.3.4. Assist in the writing and development of the team's hazard analyses, failure modes analyses, and procedures.	Analysis, Observation, Test	The role and responsibilities of each safety officer will include, but not limited to: Monitor team activities with an emphasis on Safety during: Design of vehicle and payload Assembly of vehicle and payload Ground testing of vehicle and payload Sub-scale launch test(s) Full-scale launch test(s) -Launch day -Recovery activities Education Engagement Activities Implement procedures developed by the team for construction, assembly, launch, and recovery activities Manage and maintain current revisions of the team's hazard analyses, failure modes analyses, procedures, and MSDS/chemical inventory data Assist in the writing and development of the team's hazard analysis, failure modes analysis	

Safety Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
5.4. During test flights, teams will abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch Initiative does not give explicit or implicit authority for teams to fly those certain vehicle configurations and/or payloads at other club launches. Teams should communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.	Analysis, Observation	Teams will abide by the rules and guidance of the local rocketry club's RSO. The allowance of certain vehicle configurations and/or payloads at the NASA Student Launch Initiative does not give explicit or implicit authority for teams to fly those certain vehicle configurations and/or payloads at other club launches. Teams should communicate their intentions to the local club's President or Prefect and RSO before attending any NAR or TRA launch.	0%
5.5. Teams will abide by all rules set forth by the FAA.	Analysis, Observation	Teams will abide by all rules set forth by the FAA.	50%

Table 10 - Safety Requirements

2. Team Derived Requirements

Recovery Specific Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
Ensure that all wires are secured.	Inspection/test.	The team will inspect and test that all wires are secured by giving them a slight tug	0%
Test the EggTimer TRS for any faults	Inspection/test.	Through Inspections and tests, we will ensure that the EggTimer TRS is functioning properly.	50%

Table 11 - Recovery Specific Requirements

Payload Specific Requirements			
Requirement	**Verification**	**How Satisfied**	**Status**
The cooling system is affective and works properly.	Test	Heat test Section VI .4	0%
Payload cannot be below 75°	Test	Heat test Section VI .4	0%
Payload cannot exceed 85°	Test	Heat test Section VI .4	0%
Battery has to give power to all components for 2 hours	Test	Battery test Section VI .4	0%
Water vessel does not leak	Test	Drop test Section VI .4	0%
The impact that the shrimp can withstand.	Test	Drop test Section VI .4	0%

Water does not leak from hose connections in payload bay.	Observation	Check all hose connection and secure with hose clamps.	0%

Table 12 - Payload Specific Requirements

C. Budgeting and Timeline

EXPENSE BUDGET SUMMARY

Budget Item	Amount	Comment
Full Scale Rocket and Paylo	$ 1,577	Includes payload and electronics expenses
Subscale Rocket	$ 100	Do not need electronics or recovery
Motors	$ 500	2x K class @ $150 ea. Motor Case $150; 4 F motors - $50
Huntsville Travel/Lodging	$ 5,923	
Educational Engagement	$ 200	
Fundraising	$ 200	
Website	$ 100	
Other	$ 250	
	$ 8,850	

Huntsville Travel/Lodging

Budget Item	Price	Quantity	Total	Comment
Hotel/Lodging	$ 133.58	24	$ 3,205.92	six nights
Vehicle	0	2	$ -	Borrowing cars from parents
Gas	3	308	$ 923.08	1000mi. @ 13 mpg.
Food	23	78	$ 1,794.00	breakfast free, lunch $8, dinner $15
			$ 5,923.00	

FULL SCALE ROCKET AND PAYLOAD COMPONENT LISTING & Budget

				Cost	
Totals				**$ 1,577.44**	

Lookup Description	Unit	$/Unit	Quantity	Calculated Price	Comment
BOOSTER					
3.9" BlueTube Airframe	g / in	$ 0.81	22	$ 17.85	Booster, Exterior Body Tube
Tailcone_390 to 54mm	g	$ 54.00	1	$ 54.00	
2.1" BlueTube Airframe	g / in	$ 0.50	22	$ 10.98	54mm motor mount
3.9" BlueTube Coupler	g / in	$ 0.83	8	$ 6.66	Coupler between booster and aft recovery
Centering Ring 3.9" to 2.1"	g	$ 7.20	3	$ 21.60	centering rings for motor mount
1/4-20 stainless threaded rod	g/in	$ 0.12	48	$ 5.70	2 threaded rod stiffeners to go through centering rings
1/4-20 eye nut	g	$ 4.62	2	$ 9.24	eye nuts to attach booster to aft recovery
1/4-20 Hex Nut	g	$ 0.24	2	$ 0.47	
1/4" Split Lock Washer	g	$ 0.25	4	$ 0.99	
1/4" Washer	g	$ 0.50	4	$ 1.99	
1515 rail button- pair (large)	g	$ 2.50	1	$ 2.50	
1/4" plywood, CF Composite	g/ea	$ 1.00	3	$ 3.00	Fins
Aluminum Ballast Tubes	g/in	$ 0.39	42	$ 16.33	
7/16 Threaded Insert	g	$ 6.00	2	$ 12.00	
7/16 Threaded Bolt	g	$ 2.00	2	$ 4.00	
Paint & Glue				$ 20.00	
				$ 187.31	

FULL SCALE ROCKET AND PAYLOAD COMPONENT LISTING & BUDGET (CONT)

Lookup Description	Unit	$/Unit	Quantity	Calculated Price	Comment
LOWER RECOVERY					
3.9" BlueTube Airframe	g / in	$ 0.81	17	$ 13.79	
Rocketman drogue balistick 3 feet		$ 90.00	1	$ 90.00	
Cable Cutter	g	$ 30.00	2	$ 60.00	
12x12 nomax		$ 9.00	1	$ 9.00	
Harness: 11/16 tubular 3 loop - 35 ft long, y harness		$ 70.00	1	$ 70.00	
3/16" Quik Link	g	$ 1.95	4	$ 7.80	2 attach to booster, 2 attach to e-bay
Paint & Glue				$ 5.00	
				$ 255.59	
ELECTRONICS BAY					
Raven Altimeter	g	$ 155.00	1	$ 155.00	
RRC3 Altimeter	g	$ 70.00	1	$ 70.00	
Wiring	g	$ 4.00	6	$ 24.00	
Screw Switch	g	$ 3.00	2	$ 6.00	
Charge Holder (3.0g) - pair	g	$ 10.00	2	$ 20.00	
2 wire Terminal Block	g	$ 3.00	1	$ 3.00	Required for cable cutters
1/4-20 stainless threaded rod	g/in	$ 0.12	22	$ 2.61	2 pieces that extend through ebay
1/4-20 eye nut	g	$ 4.62	4	$ 18.48	2 on each end of ebay
1/4-20 Hex Nut - aluminum	g	$ 0.07	8	$ 0.58	for interior of ebay to secure sled
1/4" Split Lock Washer	g	$ 0.25	4	$ 0.99	
1/4" Washer	g	$ 0.50	4	$ 1.99	
1/4" Balsa, composite lay-up	g/in^2	$ -	28	$ -	8 x 3.5 ebay sled
9V alkaline	ea	$ 2.50	2	$ 5.00	1 for each altimeter
3.9" Airframe Bulkhead	g	$ 5.40	2	$ 10.80	
3.9" Coupler Bulkhead	g	$ 5.40	2	$ 10.80	
3.9" BlueTube Coupler	g / in	$ 0.83	9	$ 7.49	
Paint & Glue				$ 5.00	
				$ 341.74	
FORWARD RECOVERY					
3.9" BlueTube Airframe	g / in	$ 0.81	22	$ 17.85	
FruityChute Iris Ultra Compact - 84 with Spectra Lines	0	$ 294.00	1	$ 294.00	
4" Deployment bag - 9" long	0	$ 36.00	1	$ 36.00	
Harness: 11/16 tubular 2 loop - 35 ft long, y harness	0	$ 76.00	1	$ 76.00	
3/16" Quik Link	g	$ 1.95	4	$ 7.80	2 to attach to ebay and 2 to payload
Paint & Glue				$ 5.00	
				$ 436.65	

FULL SCALE ROCKET AND PAYLOAD COMPONENT LISTING & BUDGET (CONT)

Lookup Description	Unit	$/Unit	Quantity	Calculated Price	Comment
PAYLOAD					
3.9" BlueTube Airframe	g / in	$ 0.81	14	$ 11.36	
3.9" Nose Cone - 12.75"	g	$ 23.05	1	$ 23.05	LOC precision
3.9" BlueTube Coupler	g / in	$ 0.83	8	$ 6.66	Fwd recovery to Payload
3.9" Airframe Bulkhead	g	$ 5.40	1	$ 5.40	
3.9" Coupler Bulkhead	g	$ 5.40	1	$ 5.40	
1/4-20 eye nut	g	$ 4.62	2	$ 9.24	
Paint & Glue				$ 5.00	
				$ 66.11	
Payload Frame					
3.9" Coupler Bulkhead	g	$ 5.40	3	$ 16.20	
3.9" BlueTube Coupler	g / in	$ 0.83	8	$ 6.66	Coupler covers habitat and will serve as attachment point to airframe
1/4" Plywood - fiberglass reinforced	in ^2	$ -	48	$ -	
Carbon fiber rod - .110" ID, .156" OD	g/in	$ 0.22	88	$ 19.51	supports for 2/56 threaded rod
2/56 stainless steel threaded rod	g/in	$ 0.08	88	$ 7.09	
2/56 nut		$ 0.08	20	$ 1.52	
#2 washer		$ 0.03	30	$ 0.79	
#6 weld nuts		$ 0.08	6	$ 0.46	attachment point to airframe
#6 screws		$ 0.03	6	$ 0.16	to attach payload frame to airframe
				$ 52.38	
Cooler Components					
8 oz habitat (with water)	g	$ -	1	$ -	recyled juice bottle
1/4" flexible copper tubing	g/in	$ 0.08	144	$ 12.00	not sure how much we will need for final design
1/4" copper tubing connector		$ 2.00	2	$ 4.00	
12vdc brushless submersible motor	g	$ 7.00	1	$ 7.00	ebay
60w Peltier Cooler		$ 5.50	1	$ 5.50	ebay
Aluminum 40mmx 40mm water block		$ 6.00	1	$ 6.00	ebay
1/4" flexible plastic tubing	g/in	$ 0.27	18	$ 4.86	ace hardware
Heat Sync		$ -	1	$ -	
Rosewill RCX-Z300 92mm Ball CPU Cooler Fan		$ 13.00	1	$ 13.00	amazon
8000 mah batteries	g	$ 34.00	2	$ 68.00	Hobbyking
				$ 120.36	
Arduino and electronic components					
Arduino Uno R3		$ 64.95	1	$ 64.95	
Lithium Ion Polymer Battery - 3.7v 2500mAh		$ 14.95	1	$ 14.95	
ADXL345 - Triple-Axis Accelerometer (+-2g/4g/8g/16g) w/ I2C/SPI		$ 17.50	1	$ 17.50	
Waterproof DS18B20 Digital temperature sensor + extras		$ 9.95	2	$ 19.90	
				117.30	

Table 13 - Budget

D. Funding Plan

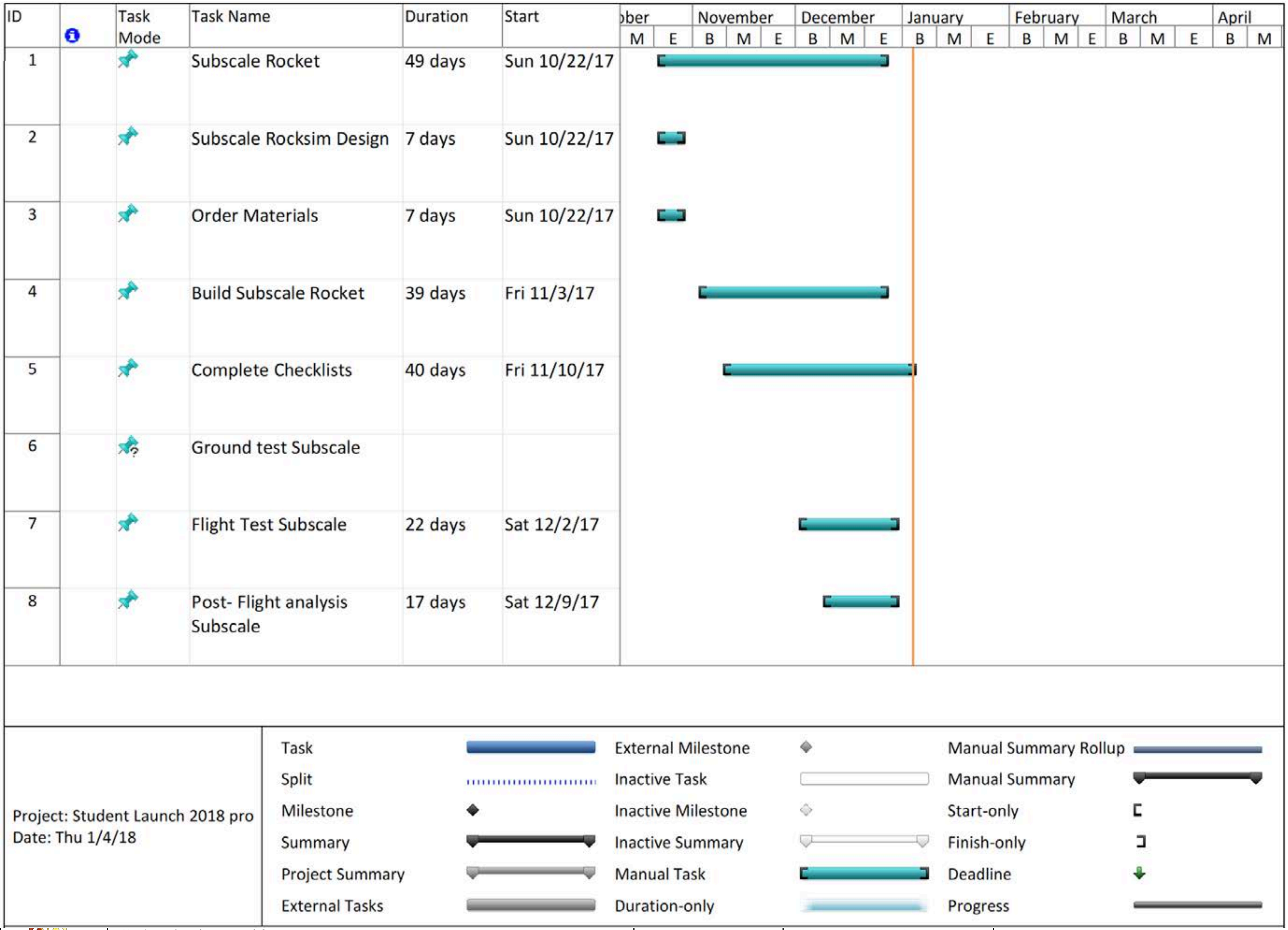
The material acquisition plan is that we will purchase the parts necessary using the NY Space Grant and the St Monica Rocketry Club checking account. The funds in the checking account are from donations, fundraising and the Go Fund Me account. These accounts are funded enough to provide for all builds. We are likely to fall short when it comes to travel and expenses to Alabama.

We projected an income of $11,300 from fundraising; however, we are only at $4,408. We have an additional potential income of $2,500. This gives us a grand total of only $6,908.

The difference between the budget and the potential income ($8,850) and potential income ($6,908) is $1942.

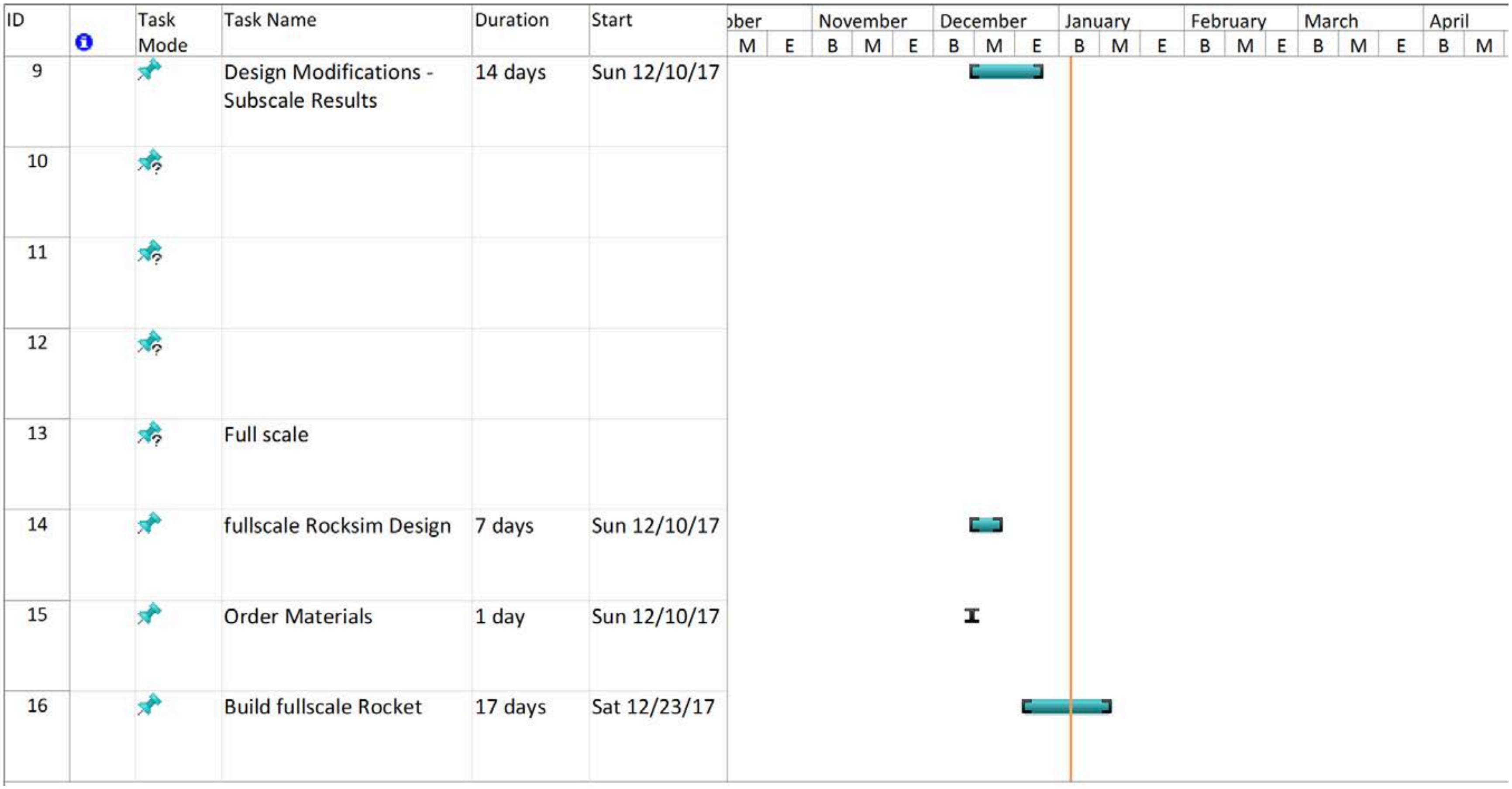
This difference will be distributed between the 11 team members, and each team member will donate $177 to make up this difference.

E. Timeline

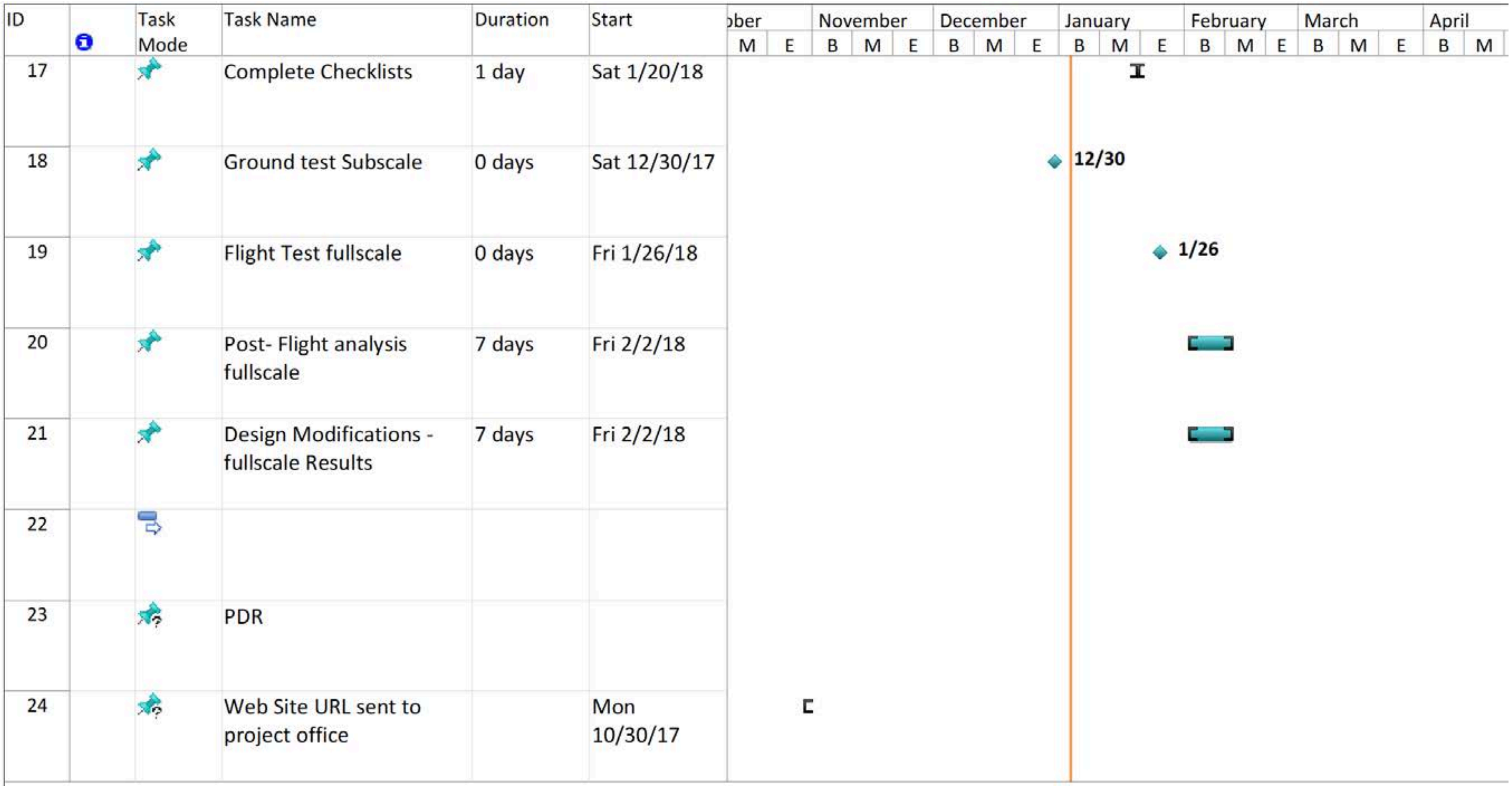


ID	ℹ	Task Mode	Task Name	Duration	Start
1		📌	Subscale Rocket	49 days	Sun 10/22/17
2		📌	Subscale Rocksim Design	7 days	Sun 10/22/17
3		📌	Order Materials	7 days	Sun 10/22/17
4		📌	Build Subscale Rocket	39 days	Fri 11/3/17
5		📌	Complete Checklists	40 days	Fri 11/10/17
6		📌?	Ground test Subscale		
7		📌	Flight Test Subscale	22 days	Sat 12/2/17
8		📌	Post- Flight analysis Subscale	17 days	Sat 12/9/17

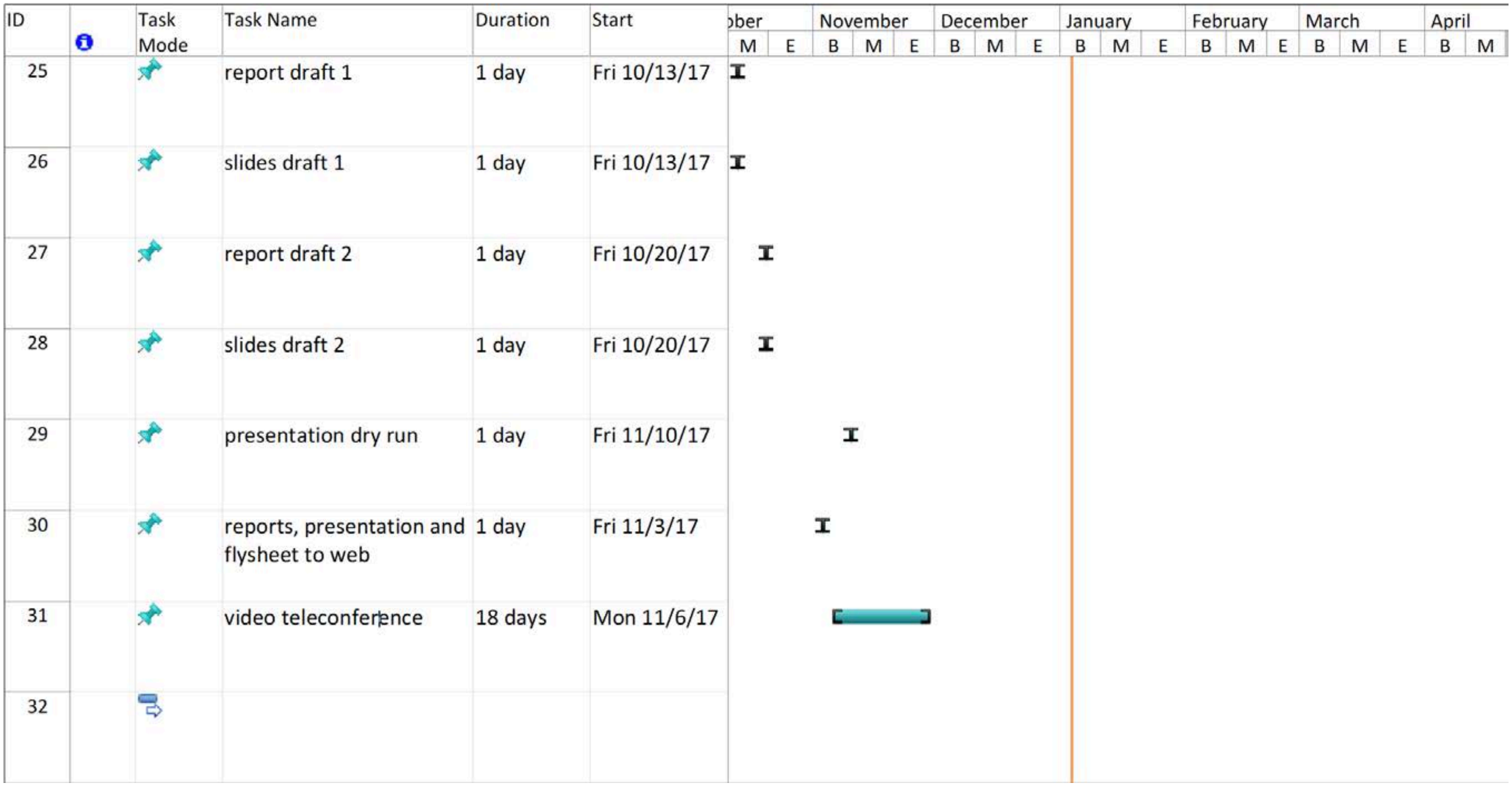
Project: Student Launch 2018 pro
Date: Thu 1/4/18



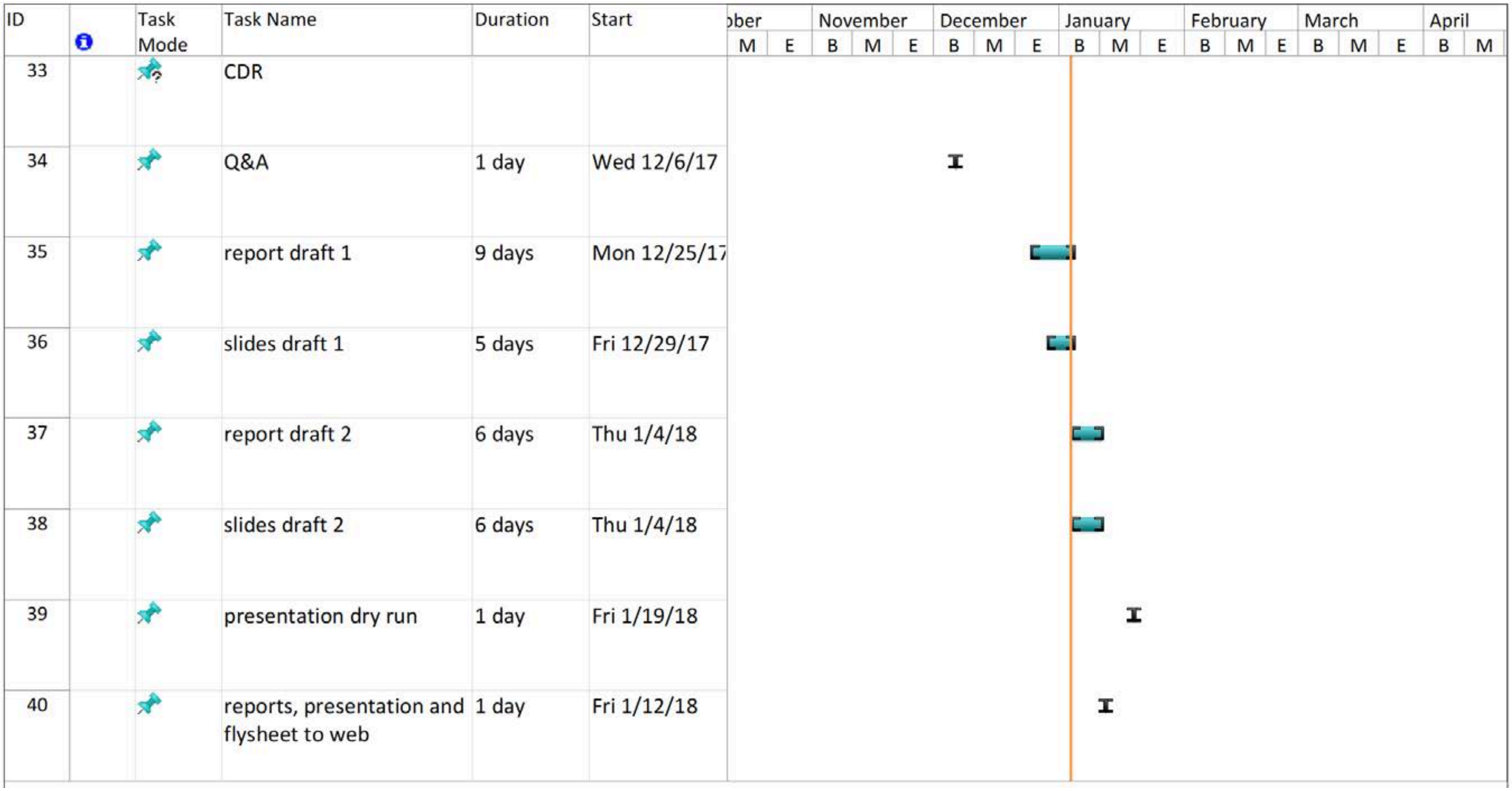
ID		Task Mode	Task Name	Duration	Start
9			Design Modifications - Subscale Results	14 days	Sun 12/10/17
10					
11					
12					
13			Full scale		
14			fullscale Rocksim Design	7 days	Sun 12/10/17
15			Order Materials	1 day	Sun 12/10/17
16			Build fullscale Rocket	17 days	Sat 12/23/17



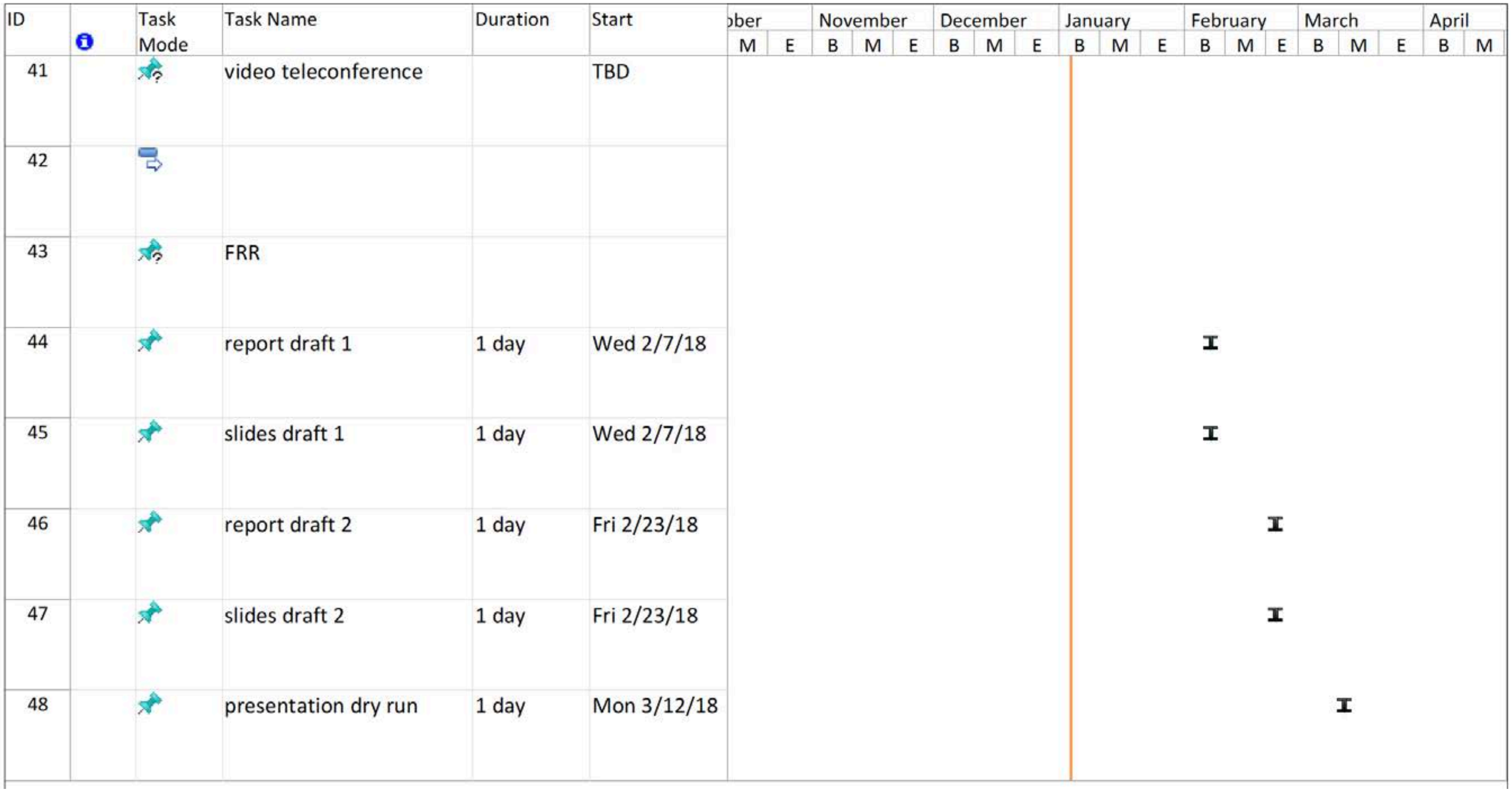
ID		Task Mode	Task Name	Duration	Start
17			Complete Checklists	1 day	Sat 1/20/18
18			Ground test Subscale	0 days	Sat 12/30/17
19			Flight Test fullscale	0 days	Fri 1/26/18
20			Post- Flight analysis fullscale	7 days	Fri 2/2/18
21			Design Modifications - fullscale Results	7 days	Fri 2/2/18
22					
23			PDR		
24			Web Site URL sent to project office		Mon 10/30/17



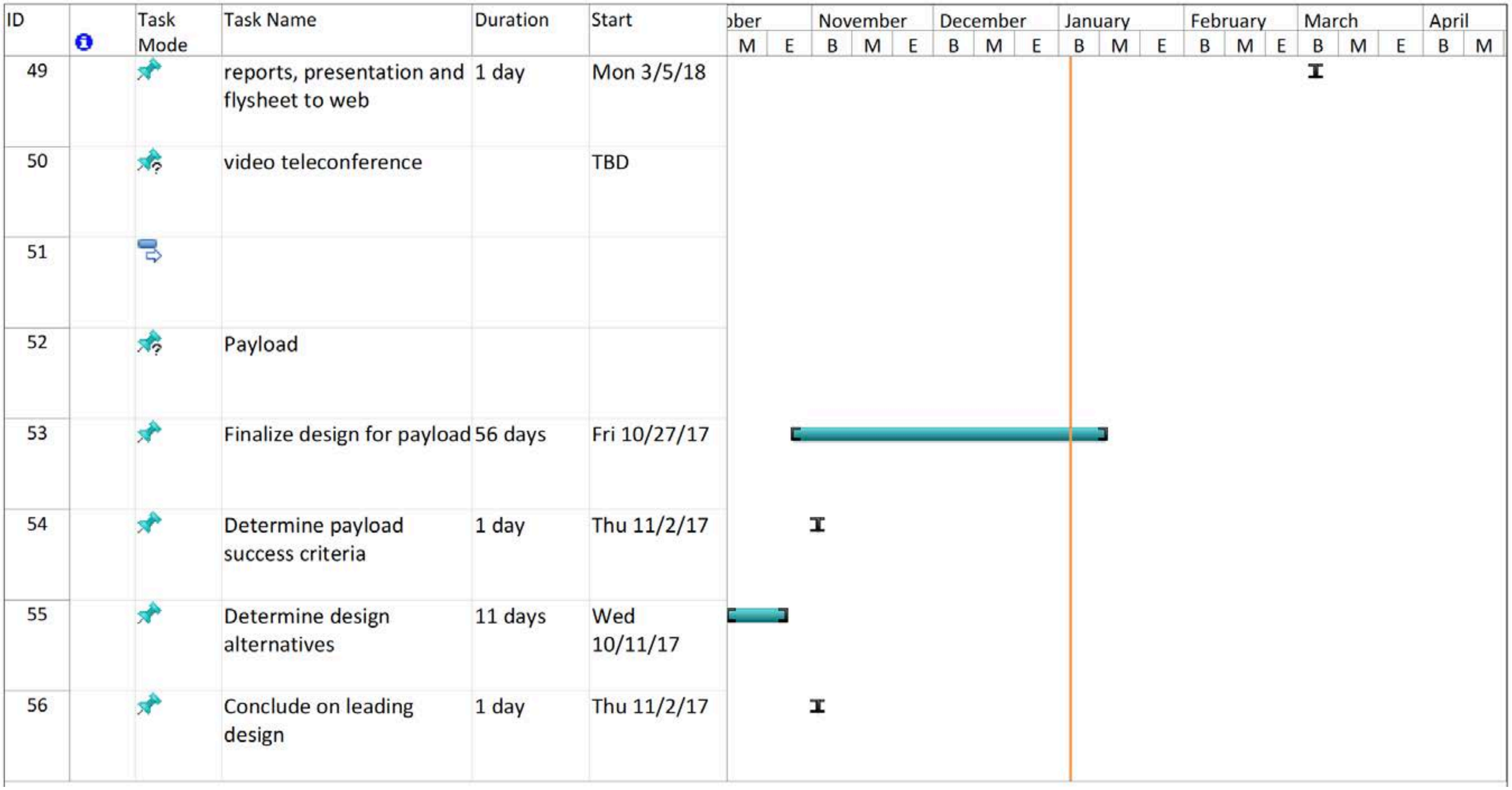
ID		Task Mode	Task Name	Duration	Start
25		📌	report draft 1	1 day	Fri 10/13/17
26		📌	slides draft 1	1 day	Fri 10/13/17
27		📌	report draft 2	1 day	Fri 10/20/17
28		📌	slides draft 2	1 day	Fri 10/20/17
29		📌	presentation dry run	1 day	Fri 11/10/17
30		📌	reports, presentation and flysheet to web	1 day	Fri 11/3/17
31		📌	video teleconference	18 days	Mon 11/6/17
32					



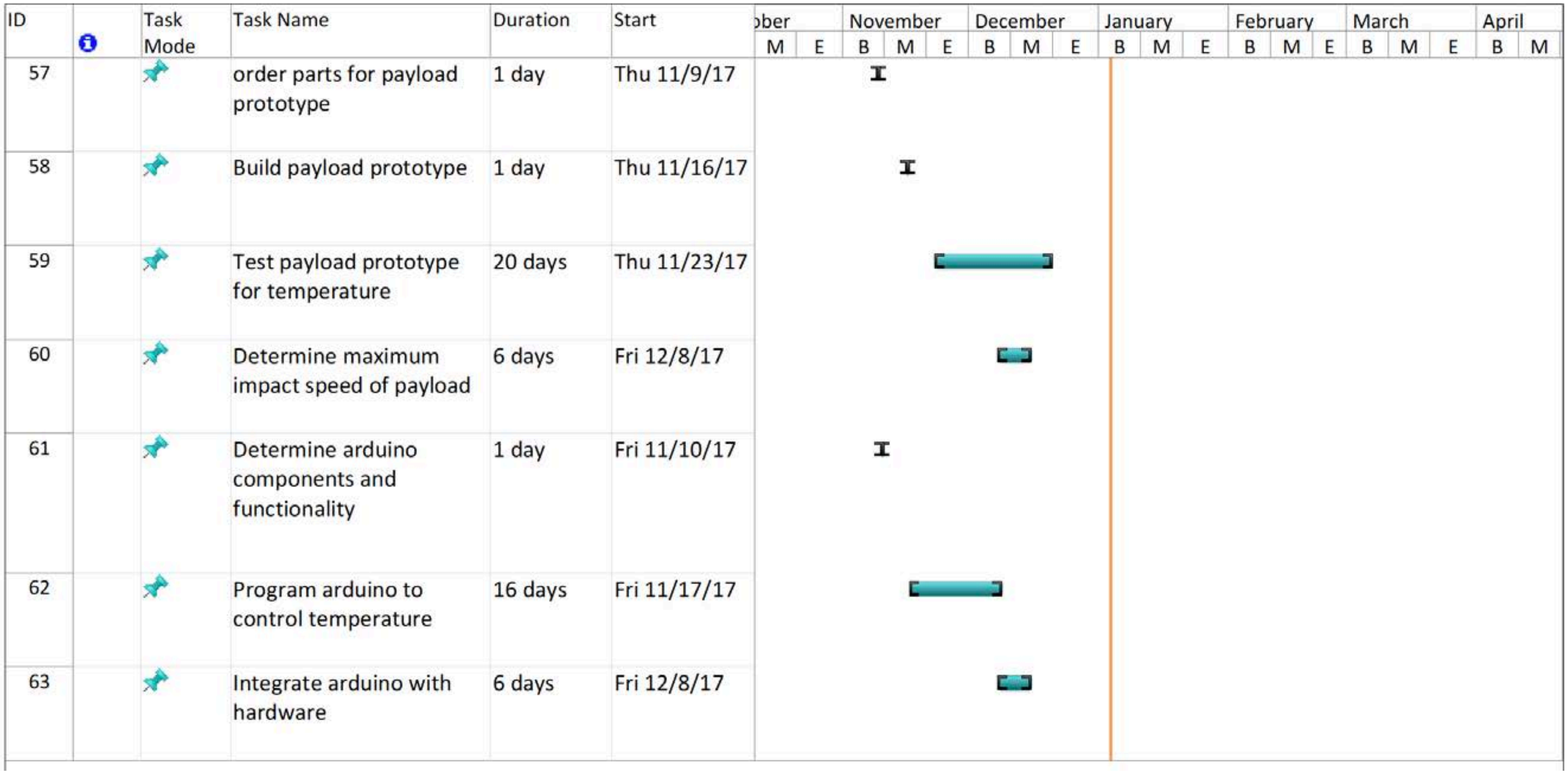
ID	ℹ	Task Mode	Task Name	Duration	Start
33		📌	CDR		
34		📌	Q&A	1 day	Wed 12/6/17
35		📌	report draft 1	9 days	Mon 12/25/17
36		📌	slides draft 1	5 days	Fri 12/29/17
37		📌	report draft 2	6 days	Thu 1/4/18
38		📌	slides draft 2	6 days	Thu 1/4/18
39		📌	presentation dry run	1 day	Fri 1/19/18
40		📌	reports, presentation and flysheet to web	1 day	Fri 1/12/18



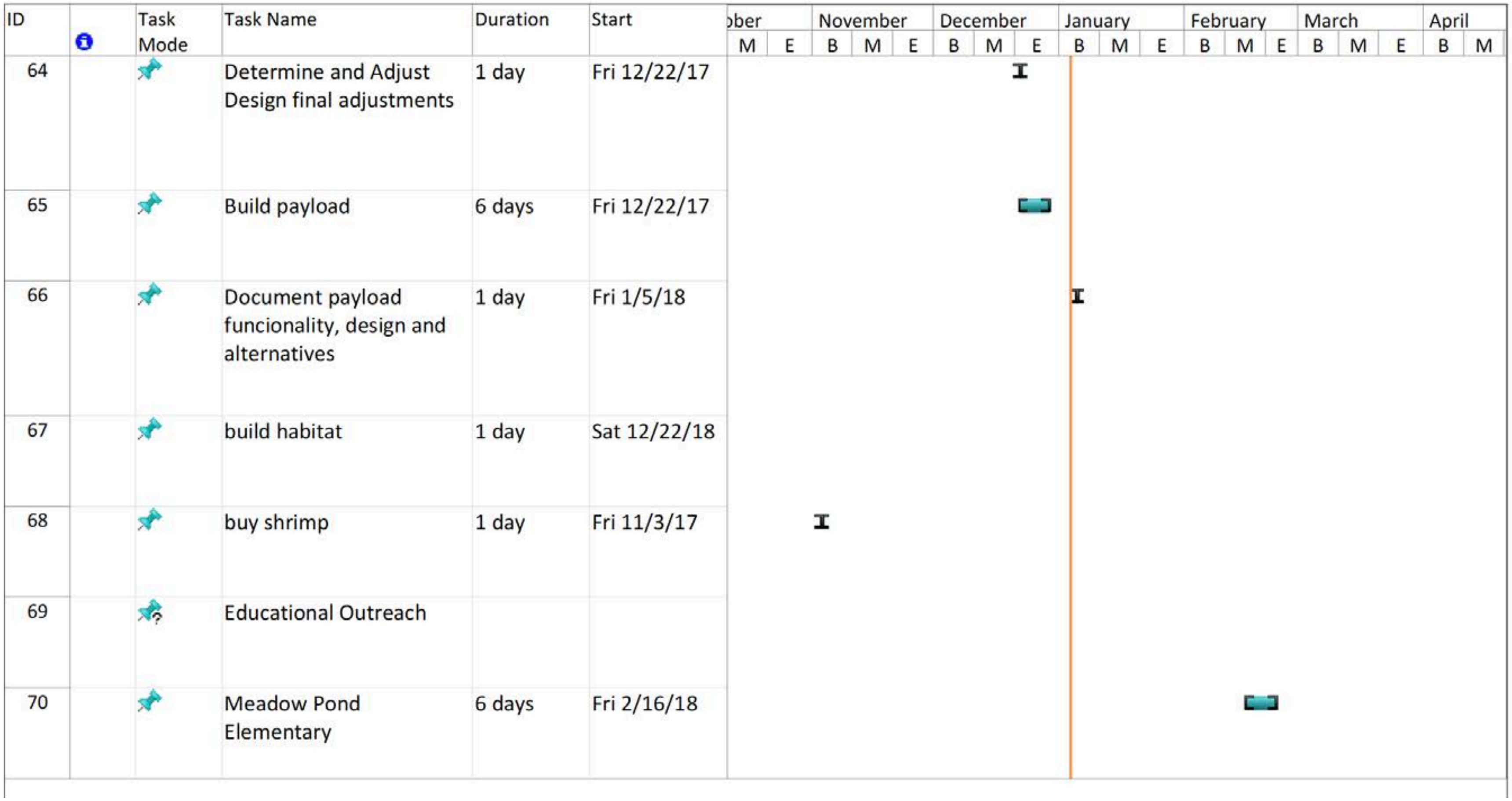
ID	ℹ	Task Mode	Task Name	Duration	Start
41		📌?	video teleconference		TBD
42		⇨			
43		📌?	FRR		
44		📌	report draft 1	1 day	Wed 2/7/18
45		📌	slides draft 1	1 day	Wed 2/7/18
46		📌	report draft 2	1 day	Fri 2/23/18
47		📌	slides draft 2	1 day	Fri 2/23/18
48		📌	presentation dry run	1 day	Mon 3/12/18



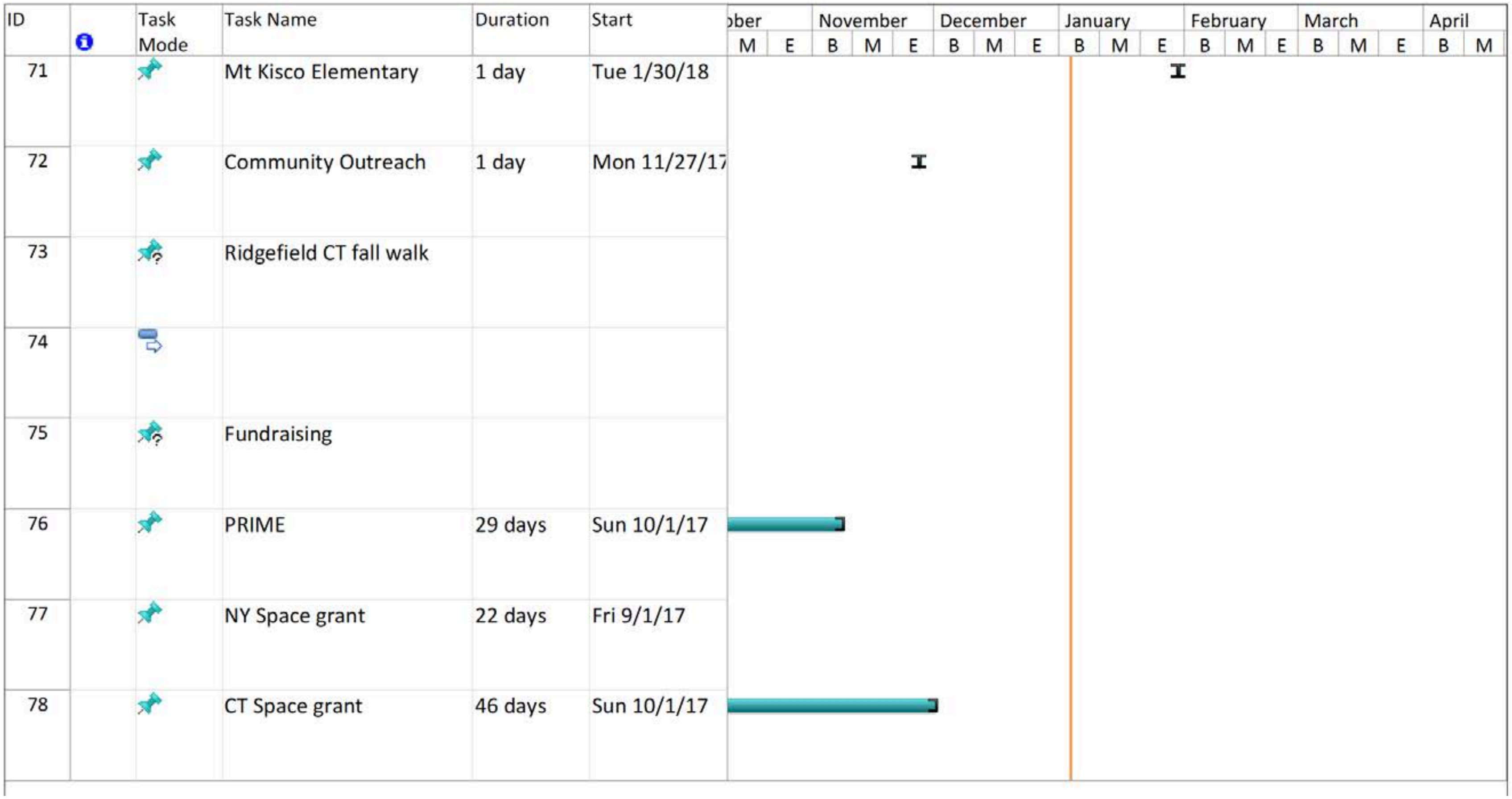
ID	ℹ	Task Mode	Task Name	Duration	Start
49		📌	reports, presentation and flysheet to web	1 day	Mon 3/5/18
50		📌?	video teleconference		TBD
51		⇨			
52		📌?	Payload		
53		📌	Finalize design for payload	56 days	Fri 10/27/17
54		📌	Determine payload success criteria	1 day	Thu 11/2/17
55		📌	Determine design alternatives	11 days	Wed 10/11/17
56		📌	Conclude on leading design	1 day	Thu 11/2/17



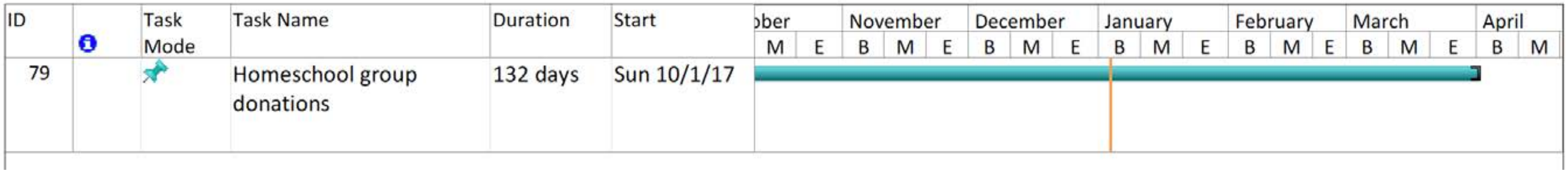
ID	ℹ	Task Mode	Task Name	Duration	Start
57		📌	order parts for payload prototype	1 day	Thu 11/9/17
58		📌	Build payload prototype	1 day	Thu 11/16/17
59		📌	Test payload prototype for temperature	20 days	Thu 11/23/17
60		📌	Determine maximum impact speed of payload	6 days	Fri 12/8/17
61		📌	Determine arduino components and functionality	1 day	Fri 11/10/17
62		📌	Program arduino to control temperature	16 days	Fri 11/17/17
63		📌	Integrate arduino with hardware	6 days	Fri 12/8/17



ID	ℹ	Task Mode	Task Name	Duration	Start
64		📌	Determine and Adjust Design final adjustments	1 day	Fri 12/22/17
65		📌	Build payload	6 days	Fri 12/22/17
66		📌	Document payload funcionality, design and alternatives	1 day	Fri 1/5/18
67		📌	build habitat	1 day	Sat 12/22/18
68		📌	buy shrimp	1 day	Fri 11/3/17
69		📌?	Educational Outreach		
70		📌	Meadow Pond Elementary	6 days	Fri 2/16/18



ID		Task Mode	Task Name	Duration	Start
71			Mt Kisco Elementary	1 day	Tue 1/30/18
72			Community Outreach	1 day	Mon 11/27/17
73			Ridgefield CT fall walk		
74					
75			Fundraising		
76			PRIME	29 days	Sun 10/1/17
77			NY Space grant	22 days	Fri 9/1/17
78			CT Space grant	46 days	Sun 10/1/17



ID	ℹ	Task Mode	Task Name	Duration	Start
79		📌	Homeschool group donations	132 days	Sun 10/1/17

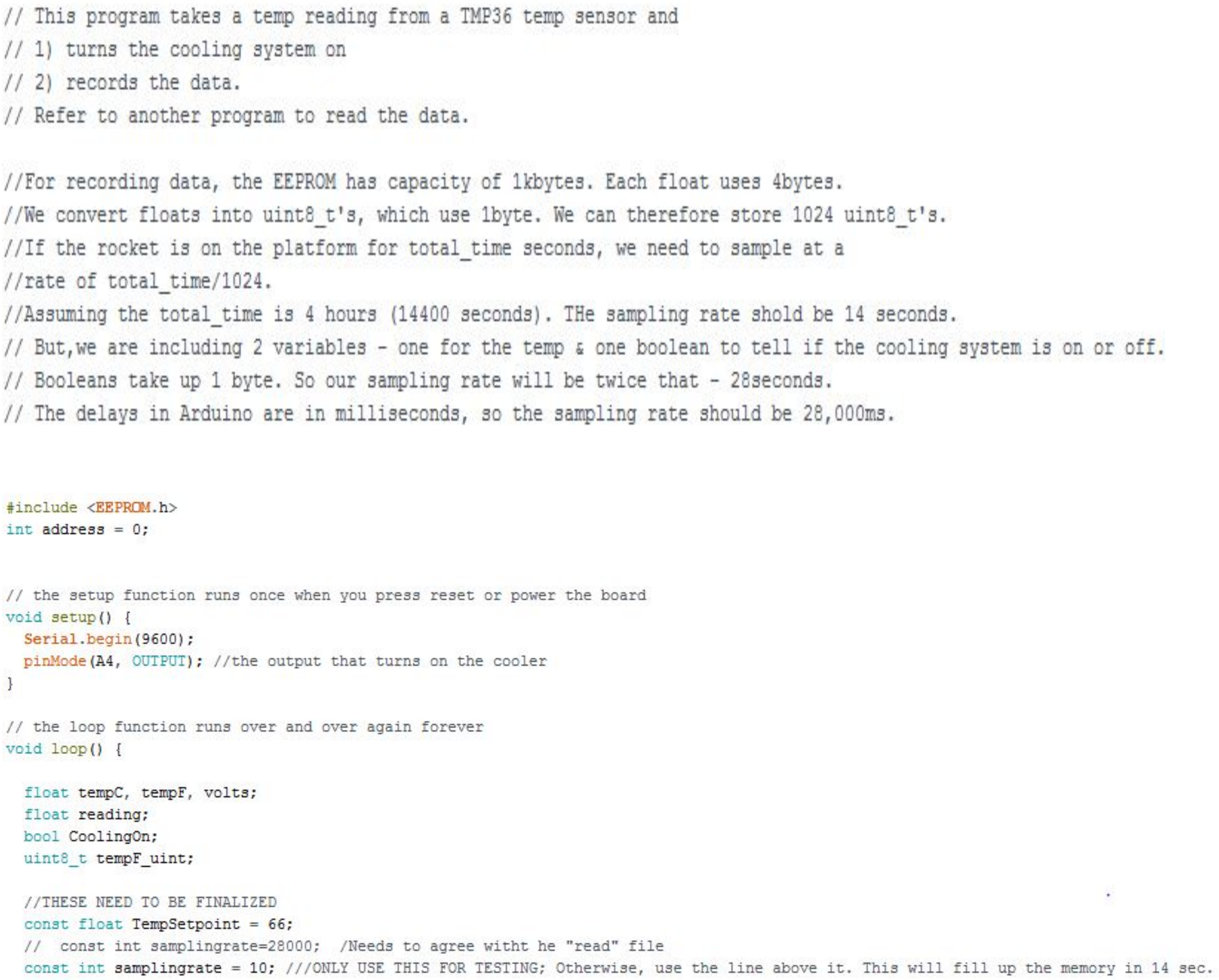
Table 14 - Project Timeline

VII. Appendix

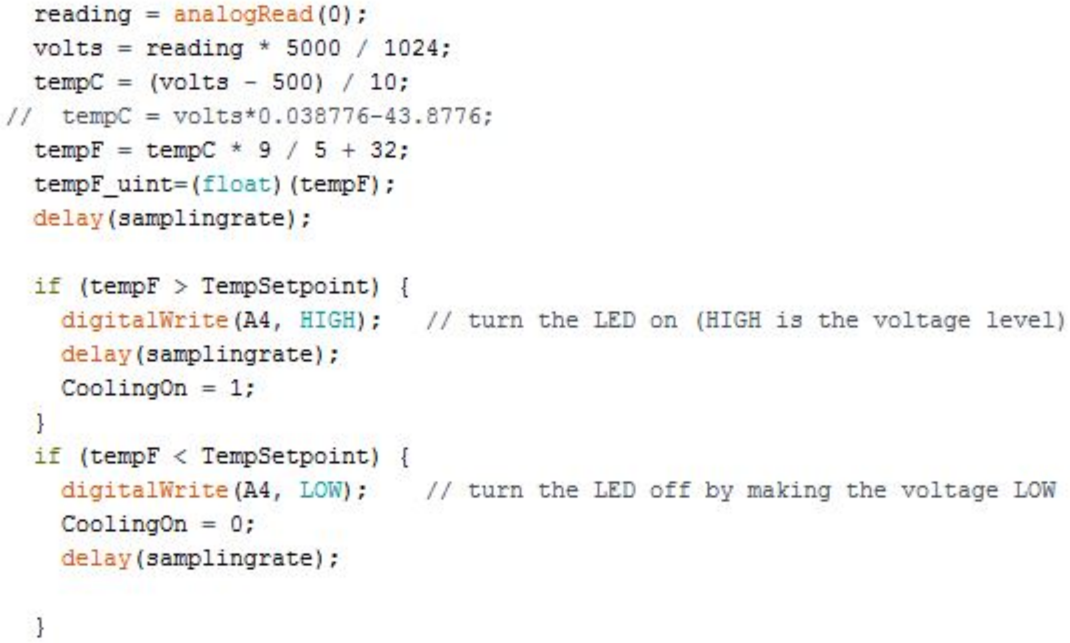
A. Table of Figures

B. Table of Tables

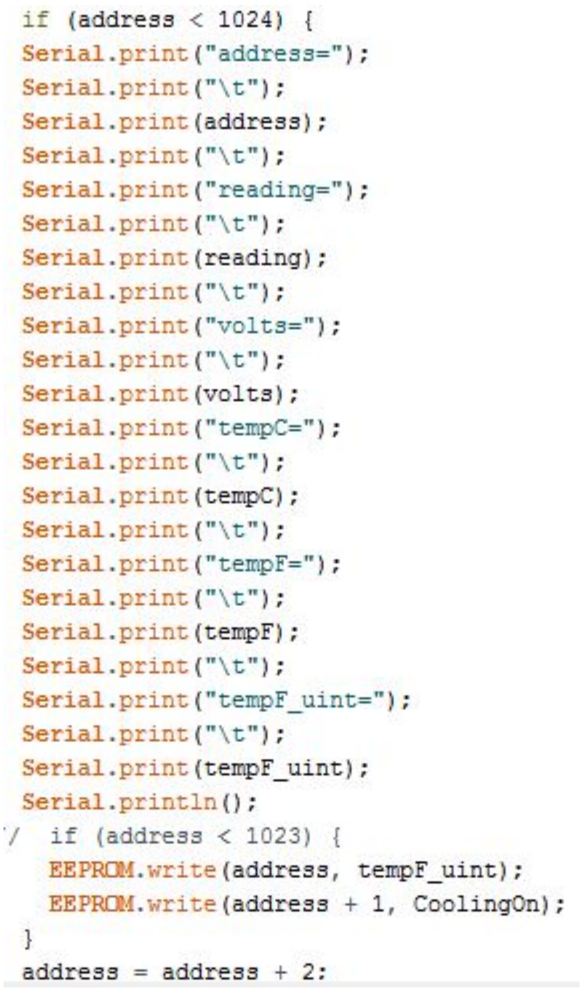
C. Code for Temperature Control



```
// This program takes a temp reading from a TMP36 temp sensor and
// 1) turns the cooling system on
// 2) records the data.
// Refer to another program to read the data.

//For recording data, the EEPROM has capacity of 1kbytes. Each float uses 4bytes.
//We convert floats into uint8_t's, which use 1byte. We can therefore store 1024 uint8_t's.
//If the rocket is on the platform for total_time seconds, we need to sample at a
//rate of total_time/1024.
//Assuming the total_time is 4 hours (14400 seconds). THe sampling rate shold be 14 seconds.
// But,we are including 2 variables - one for the temp & one boolean to tell if the cooling system is on or off.
// Booleans take up 1 byte. So our sampling rate will be twice that - 28seconds.
// The delays in Arduino are in milliseconds, so the sampling rate should be 28,000ms.


#include <EEPROM.h>
int address = 0;


// the setup function runs once when you press reset or power the board
void setup() {
  Serial.begin(9600);
  pinMode(A4, OUTPUT); //the output that turns on the cooler
}

// the loop function runs over and over again forever
void loop() {

  float tempC, tempF, volts;
  float reading;
  bool CoolingOn;
  uint8_t tempF_uint;

  //THESE NEED TO BE FINALIZED
  const float TempSetpoint = 66;
  //  const int samplingrate=28000;  /Needs to agree witht he "read" file
  const int samplingrate = 10; ///ONLY USE THIS FOR TESTING; Otherwise, use the line above it. This will fill up the memory in 14 sec.
```



```
  reading = analogRead(0);
  volts = reading * 5000 / 1024;
  tempC = (volts - 500) / 10;
//  tempC = volts*0.038776-43.8776;
  tempF = tempC * 9 / 5 + 32;
  tempF_uint=(float)(tempF);
  delay(samplingrate);

  if (tempF > TempSetpoint) {
    digitalWrite(A4, HIGH);   // turn the LED on (HIGH is the voltage level)
    delay(samplingrate);
    CoolingOn = 1;
  }
  if (tempF < TempSetpoint) {
    digitalWrite(A4, LOW);    // turn the LED off by making the voltage LOW
    CoolingOn = 0;
    delay(samplingrate);

  }
```



```
if (address < 1024) {
Serial.print("address=");
Serial.print("\t");
Serial.print(address);
Serial.print("\t");
Serial.print("reading=");
Serial.print("\t");
Serial.print(reading);
Serial.print("\t");
Serial.print("volts=");
Serial.print("\t");
Serial.print(volts);
Serial.print("tempC=");
Serial.print("\t");
Serial.print(tempC);
Serial.print("\t");
Serial.print("tempF=");
Serial.print("\t");
Serial.print(tempF);
Serial.print("\t");
Serial.print("tempF_uint=");
Serial.print("\t");
Serial.print(tempF_uint);
Serial.println();
/  if (address < 1023) {
   EEPROM.write(address, tempF_uint);
   EEPROM.write(address + 1, CoolingOn);
}
address = address + 2;
```

}