MAXQ Final Report

MAXQ Senior Design Team
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April 24th, 2020

Dr. Richard Wabrek and Dr. James Mahar
Instructor, ME/CE 4496A/B
Idaho State University
921 South 8th Avenue
Pocatello, Idaho, 83209

Dear Dr. Wabrek and Dr. Mahar:

I submit herewith a report entitled 20200424_MAXQ_FinalReport documenting the work completed between 19 August 2019 to 24 April 2020.

The purpose of this report is to outline our design for our high powered rocket. It includes a breakdown of our individual systems, components selected, as well as the associated budgets and analysis. Enclosed you will find our Gantt chart, rocket design, and adjustments to our project due to COVID-19.

Any questions regarding the technical or administrative aspects of this report should be directed to me, and I will share them with my team.

Sincerely,

Derrick Likes

Enclosure: 20200424_MAXQ_Final Report

cc: Derek Anderson, Shishir Khanal, Jonny Henderson

TECHNICAL REPORT

ME 4496 PROJECT DESIGN II

# MAXQ Final Report

For

Dr. Richard Wabrek
Dr. James Mahar
Idaho State University
Pocatello, Idaho

By

Derrick Likes
Shishir Khanal
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MAXQ Senior Design Team
Pocatello, Idaho

24 April 2020

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

# Executive Summary

Idaho State University currently does not have an aerospace engineering program. This project was started to bridge the gap between the several engineering disciplines offered at ISU and the aerospace industry, as well as provide new aerospace opportunities for ISU students.With the assistance of Dr. Marco Schoen, a collegiate aerospace competition was selected to help us achieve this goal. We started a legacy engineering senior design project that will stimulate and grow interest in the aerospace engineering field for years to come. Our team designed a high-powered rocket to compete in the Intercollegiate Rocket Engineering Competition, in conjunction with the Spaceport America Cup. The competition has many categories and guidelines, our team has been accepted into the 10K (10,000 foot), COTS (commercial off the shelf) category. We are required to build a high-powered rocket that travels safely to at least 10,000 feet using a commercially sourced engine and is recoverable.

The rocket consists of several different systems. The primary structure is the fuselage. This six-inch by ten-foot frame is the backbone of the rocket. Inside of the fuselage, there is a payload bay that holds all of the critical positioning and tracking computers as well as the flight controller that acts as the brain of the entire rocket. This flight controller determines, in conjunction with an altimeter, the height of the rocket, and triggers other critical components of the rocket to deploy at the correct moment. There is a launch system containing a rocket engine and launch lugs to get the rocket off the ground. There is a recovery system consisting of a nose cone and a parachute to ensure the rocket makes a safe landing.

The following table breaks down the various systems with their associated designer and estimated cost:

*Table 1: Cost break-down of chosen design.*

| Component | Lead Designer | Estimated Cost |
|---|---|---|
| Launch, Recovery, Nose Cone | Derrick Likes | $1050 |
| Propulsion, Avionics, Electronics | Shishir Khanal | $1550 |
| Fuselage, Payload Bay, Fins | Derek Anderson | $1200 |
| | Total: | $3800 |

For every system, there were several choices available. We evaluated every selection individually and decided which products would be ideal for our rocket based on competition regulations, price, and reliability. The following table defines components that have been selected for the final rocket design:

*Table 2: Final component selection.*

| System | Chosen Product |
|---|---|
| Launch | Nylon Rail Button Design |
| Propulsion | Solid Commercial Off The Shelf Engine |
| Nozzle | Graphite |
| Fuselage | Carbon Fiber, Cerakote Finish |
| Fins | Clipped Delta Fins |
| Recovery | Dual Parachute Deployment: Main/Drogue |
| Structure Joints | 3D Printed |
| Avionics Controller | Atomic Pi |
| Altimeter | MPL3115A2 |
| GPS Tracker | RTx System |
| Orientation Sensor | Pi Hat |
| Camera Sensor | Jetson Nano |
| Power | Power Relay |

Furthermore, we have an industry aerospace engineer assisting us with this project. MAXQ is excited to apply the engineering principles we have learned throughout our education to represent Idaho State University in this international rocket competition.

The COVID-19 pandemic, unfortunately, placed dramatic restrictions on this project. On March 24th 2020 the Spaceport America Cup event organizer, HeroX, decided to cancel the competition for this year. This was devastating news for our team who had been working so hard to get this project up and running as a new senior design legacy project for Idaho State University. This feeling was also shared through all of the other 200 teams that were scheduled to compete in this year's event. Many of the teams were international and couldn't physically leave their countries

to fly to New Mexico. Shortly after the cancellation, Idaho State University as well as most other American universities also banned university sponsored travel. This made the competition impossible for this school year. One consolation, however, was made by HeroX. Those teams that would like to come back next year and compete could have their places held and not have to reapply for the competition. The application process is very detailed and grueling, not to mention more than 300 teams apply with only 200 being selected. Next year, the senior design team will automatically be accepted.

Despite all of the unfortunate news, all was not lost. By the time the competition was cancelled, we had already finalized our design and had begun ordering parts for the final build of the rocket. Thankfully, our grant was still intact and ready to be used to further this project for this school year and for next year's design team. Our definition of a successful project was to have a competition ready rocket that would do exceptionally well at the competition, fly safely, and withstand the rigors of multiple high powered rocket launches. This definition had to be adjusted for the current circumstances. Our amended definition of a successful project is having correct system components computer designed, simulated, and on site ready to be assembled. In this report you will see the details of our analysis of the various systems of this project. The competition has very high standards of construction and safety. These requirements were followed in every phase of our design to ensure our rocket would be competition ready. By our estimations, we have 80% of the parts needed to build the rocket on campus in storage ready to be constructed. The remaining parts could not be ordered because of shipping restrictions and others needed flight certifications completed before they could be ordered and shipped. These certification flights were canceled due to COVID-19.

Another component of a successful project was the continuation of funding for next year's team, and the associated success of this new senior design project. To ensure this project continues at ISU, a new grant was submitted to The Idaho Space Grant Consortium on April 1st, 2020. This grant will provide next year's team with financing to build upon this design report and build a rocket to compete in the 2021 Spaceport America Cup. This grant is currently under consideration from NASA and results will be announced in the fall of 2020.

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# Introduction

### Background

High-powered rockets are an exciting and difficult area of aerospace engineering. In the hobbyist realm, they are an excellent means for gaining valuable experience and learning about aerospace. They are the perfect choice for a college senior design project because of their relatively inexpensive construction, as well as their technical difficulty. With the surge in the private sector for rocket engineers, companies like SpaceX, Blue Origin, and Virgin Galactic are in need of more graduates ready to enter the aerospace industry.

The Spaceport America Cup is the perfect competition for students who desire a future in the aerospace industry. The competition, held every year in New Mexico, has a wide range of entry classes. This is important because there are classes for first time entrants, such as ISU, as well as classes for highly proficient professionals with decades of experience. This classification process ensures that even smaller schools with very little experience can still do very well in the competition. The Intercollegiate Rocket Engineering Competition is designed for all levels of engineers to compete and develop their skills in aerospace engineering [appx].

### Problem Description

The team's main focus of this project is to develop and build a high powered rocket to compete in the Spaceport America Cup, fulfill the requirements of ME/CE 4496 A/B, and create a legacy project that can be used for years to come in the ISU Mechanical Engineering department. We also have to conform to the competition rules and regulations [appx], as well as complete all of our tasks for our NASA grant from the Idaho Space Grant Consortium.

### Design Chosen

1. Launch/Rail
    a. For the launch stage of the project there are two main points to address. First was the actual launch rail and launch pad setup. Rather than reinvent the wheel and make our own design for the launch pad, we decided to use a similar design to what would be used in the competition. This would ensure we didn't have any issues at the competition.
    b. Second was how the rocket would attach to the launch rail. We decided to go with rail buttons. These buttons would actually penetrate the fuselage, which

makes the connection to the rocket stronger to resist any cracking or breaking upon launch. For a high powered rocket, this was the best option.

2. Propulsion
    a. The motor being used for this project will be a N-10000-VM-P solid fuel motor.
    b. The motor will be mounted to the thrust plate by a flanged retainer and centered by the centering rings.
3. Structures
    a. Deviations from the original design matrices from previous reports occurred during the design process.The first deviation was the decision to aerojet the 3d printed nose cone instead of cerakote. This was at the direction of the supplier of the 3d printing, Idaho Steel. They provided samples that proved that the surface finish of the aerojet parts would be superior to those that were painted with cerakote.
    b. Another deviation from the design matrices came in the decision to implement a simple fiberglass fuselage coupler. This design choice was due to ordering deadlines and the ability to manufacture a radax joint in time was not feasible.
4. Avionics
    a. The avionics for this project will be composed of main avionics and backup avionics.
    b. GPS/RTX system from missileworks will be used for main avionics.
    c. Stratologger CF will be used as backup avionics.
    d. Camera and Blackpowder ignition will be run by a Beagleboard controller.
    e. Telemetry will be done by using the DAQ software and LCD screen.
5. Recovery
    a. For the recovery sequence of the project we decided to use a dual parachute recovery system. The first stage is a drogue parachute that deploys at apogee. This parachute will slow down and stabilize the rocket. It will also reduce rocket drift, due to the fact that the rocket will be roughly two miles in the air at apogee. The second parachute is the main chute. This will do the bulk of the descent control work. The main chute will slow the rocket down to a safely recoverable speed.

## Specifications

The specifications for this rocket build are strictly set by the Spaceport America Cup Rules and Guidelines. Details about the specific rocket specifications and requirements can be found in the attached competition documentation.

## Objectives

1. To use the skills gained studying mechanical engineering at ISU to design, test, and build a high powered rocket
2. To design the rocket within the guidelines of the IREC. We have selected a high-powered rocket design to compete in the 10,000 ft. altitude, commercial off the shelf (COTS) category [31]
3. To meet all the course requirements for Project Design I and II (ME 4496A/B)

## Constraints

1. Rocket launched at 84 degrees with respect to the horizontal (i.e. ground)
2. Rocket should accommodate 17 ft launch rail
3. Launch rail speed must be at least 100 ft./s
4. Rocket must be stable upon launch (i.e. it must have a static margin of 1.5 to 2 body calibers
5. Rocket must reach approximately 10,000 ft in altitude
6. A radio beacon must be included in the rocket
7. PVC, Quantum Tube by Public Missiles Ltd., or stainless steel are prohibited in use for load bearing components (e.g. combustion chamber)
8. Rocket must allow for (un)loading of propellant in launch configuration
9. Propellant(s) must be non-toxic [appx]

## Metrics

1. Must be retrievable after launch
2. Reach a specified target altitude
3. Achieve a team-specified target descent rate
4. Must have backup recovery systems [appx]
5. Project must be within budget set by NASA
6. Must have a launchable rocket by May 2020

## Brief Description of Systems

**Launch**

The launch system consists of a launch rail and the anchors that will interface the rocket fuselage with the launch rail. The rail will be tilted at 84 degrees from horizontal to ensure the safety of those at the launch range. The launch rail has a slot on the side that will accept several different styles of launch lugs.

**Structures**

The structures consist of the fuselage, nose cone, fins, and payload bay. The fuselage is the backbone of the rocket. Everything will tie to this structure for security and strength. The fins will ensure the rocket stays stable and oriented in the correct direction during flight. The nose cone will house the parachute and ensure that the rocket has a low coefficient of drag. They payload bay will hold all of our flight computers and electronics required for the competition [appx].

**Avionics**

The avionics consist of the flight controller, altimeter, GPS systems, cameras, and various other electronics. The altimeter will tell the controls when to deploy the parachute and at what altitude. The flight controller will record all flight data for verification after recovery. The GPS will allow us to track and recover the rocket after launch, and the cameras will be able to take pictures and videos of the flight.

**Recovery**

The recovery will consist of a dual stage deployment parachute system. The drogue parachute will slow down our rocket to a speed that will ensure stability and limit drift. The main parachute will slow the rocket down to a speed that will be recoverable. A competition requirement is that the rocket must be recovered, not destroyed upon impact. The main chute will slow the rocket down to a recoverable speed.

# Discussion

## Technical Information

### Launch

The launch rail for the competition is standard. Everyone will use a similar 17 foot launch rail. We decided rather than come up with a new idea, we would utilize the same design the competition uses to ensure a successful launch without any issues.

*Figure 1: Rocket on launch rail* [32]


For the launch rail/rocket attachment interface, we decided to use the rail buttons. These buttons are fairly standard in the high powered rocket world. There are multiple ways to interface the rocket with the launch rail but these proved to be the best suited for the competition. The rail button design was selected primarily because it is the strongest and most reliable. Other methods involve using high strength glues or rivets. The rail buttons are fitted to the fuselage by drilling two holes in the carbon fiber. Inside of the fuselage there are large rounded washers that are bolted to the body on the onside and are fitted with rail buttons on the outside. When correctly fitted, they provide superior strength and detachment resistance. At the competition, if your rocket launch lugs look flimsy and weak, they will subject the rocket to a “shake test” before flight. They attach the rocket to a frame similar to the launch rail and shake it back and forth

while fully loaded with motors and payload. If the launch lugs break off, you must fix it before launch. Failure does occur occasionally, but rail buttons rarely have any issues.

*Figure 2: Rail buttons* [35]

**Budget/Details - Rail Button**

- Material: Nylon
- Weight: 19.2 grams
- Cost: $11

**Problems Encountered**

- No problems were encountered with the rail button selection.
- We didn't end up building the launch rail, due to rocket motor restrictions that prevented us from ordering the motors. Before we could launch the rocket, we needed to get certified using smaller rockets. The COVID-19 pandemic prevented us from attending launch certification flights, so we couldn't test our rocket stand. So we didn't build it, but the materials are ready for next year's team to build it.

**Propulsion**

The rocket propulsion involved with the selection of the propellants and design and optimization of the nozzle and the motor.

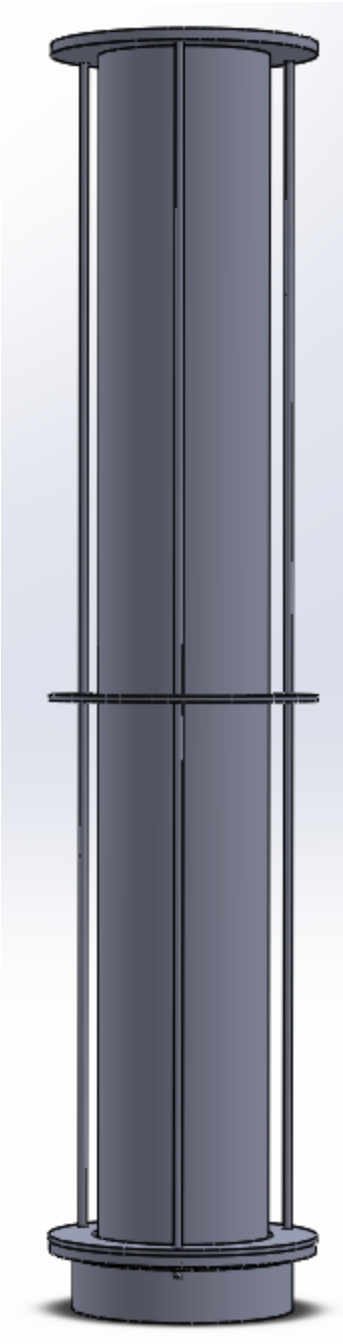
**Constraints:**

Following are the constraints set by the Spaceport America Cup:

- The rocket must achieve the height of 10,000 ft
- The specific impulse of the propellent must be less than 9208 lbf s
- The rocket should depart with the velocity greater than 10 ft/s

**Rocket Motor: Solid Propellent Engine**

*Figure 3: Propulsion Assembly* [36]



The solid propellant Engine consists of a mixture of propellant, oxidizer and an ignition rod. The weight to thrust ratio and specific impulse of the solid propellent engine is lower than other types of engines. The solid propellant engine is easy to develop and handle. The efficiency of this type of engine is lowest. The high powered solid rocket motors need rocketry certification

from either TRA or NAR. From the simulation through RockSim N-class N-10000-VM-P motor was chosen. The motor achieves the apogee of 11203 ft without any nozzle requirement. The design above is constructed from the limited specification provided by the each part supplier

**Budget/Details - Propellent**

- Motor: N-10000-VM-P
- Weight: 7338 grams
- Cost: $899.99(Aerotech N3300)

**Thrust Plate**

*Figure 4 6" Thrust Plate* [37]

**Budget/Details - Thrust Plate**

- Supplier: SC Precision
- Weight: 266 grams
- Cost: $67.45

**Motor Hardware**

*Figure 5: 6" Aerotech 98mm Motor Hardware* [37]

**Budget/Details - Motor Hardware**

- Supplier: Aerotech
- Weight: 6804 grams
- Cost: $520

**Centering Ring**

*Figure 7: 6” Centering Rings* [38]


**Budget/Details - Centering Rings**

- Supplier: Proline Composites
- Weight: 63.9 grams
- Cost: $39.9(for 2)

**Bulkhead**

*Figure 28: 6” Bulklhead* [39]


**Budget/Details - BulkHead**

- Supplier: Proline Composites
- Weight: 135 grams
- Cost: $9.80

**Flanged Retainer**

*Figure 29: Flanged Retainer* [40]

**Budget/Details - Flanged Motor Retainer**

- Supplier: Aero Pack
- Weight: 230 grams
- Cost: $98.89

**Threaded rod**

*Figure 30: Threaded Rod* [41]

**Budget/Details - Flanged Motor Retainer**

- Product #: LC.03401012.HD.DAR
- Diameter ¾”
- Cost: $67.5

**Nut**

**Budget/Details - Nuts**

- Product #: 842176125206
- Diameter ¾”
- Cost: $48.45 (for 3)

**Problems Encountered:**

1. The N-class motors needed certification to be bought. Due to the COVID-19 pandemic, the certification got cancelled. Hence, the motor could not be purchased and the system was not built. However, the design of the propulsion system was made and the drawings are provided in Appendix VII

**Structures**

As previously stated, the fuselage will support all other components of the rocket and most withstand the loads of both thrust and drag effectively. Strength and rigidity of this component is paramount and components were selected with this consideration in mind. Flex of the fuselage or any joint could result in the deviation from the correct path of flight. The nose cone will have to withstand the pressure of flight and also be removable to service inside components as well as deploy the parachute. The fins will maintain the stability of the rocket as well as provide essential rotation of the rocket for stability.

*Figure 10: Open rocket configuration 1*

**Design Alternative 1 -**

- Nose cone: 3-d printed nylon-6, ogive
- Fuselage material: carbon fiber
- Fins: carbon fiber clipped delta wings
- Total price: $875.49

*Figure 11: Open rocket configuration 2*

**Design Alternative 2 -**

- Nose cone: 3-d printed nylon-6, ogive
- Fuselage material: “Blue tube”
- Fins: carbon fiber clipped delta wings
- Total price: $650.49

*Figure 12: Open rocket configuration 3*

**Design Alternative 3 -**

- Nose cone: 3-d printed nylon-6, conical
- Fuselage material: carbon fiber
- Fins: carbon fiber clipped delta wings

- Total price: $875.49

**Joint**

Because our rocket will be 112 inches long, ease of transportation and lack of stock dictated that we include a joint in our design. At the center of the fuselage we will require a joint that connects the two carbon fiber sections of the fuselage. Part of the regulations for the competition state that the joint must extend at least two body calibers past each adjoined section. The joint will also have to be proven to be sufficiently stiff otherwise as part of the competition guidelines[41].

*Figure 13: sample radax joint* [42]

**Design Alternative 1 -**

- Material: aluminum
- Design type: radax

**Design Alternative 2 -**

- Material: 3d printed nylon 6
- Design type: radax

*Figure 14: fiberglass tube coupler* [44]

**Design Alternative 3 -**

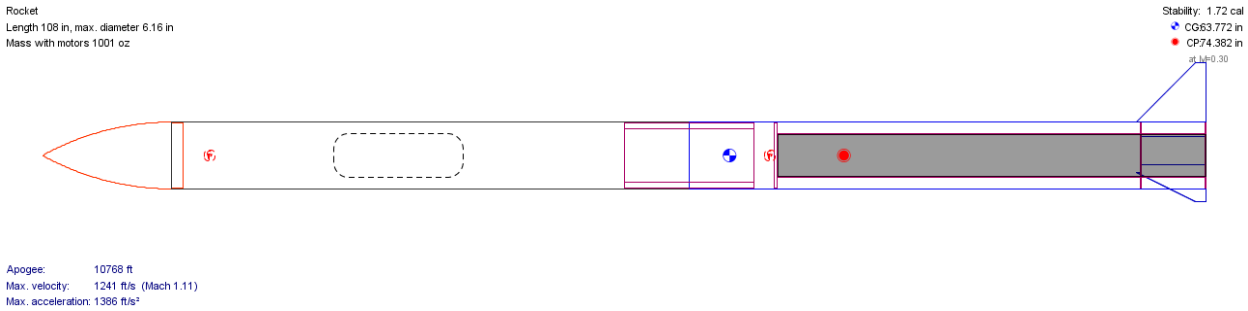
- Material: fiberglass
- Design type: tube

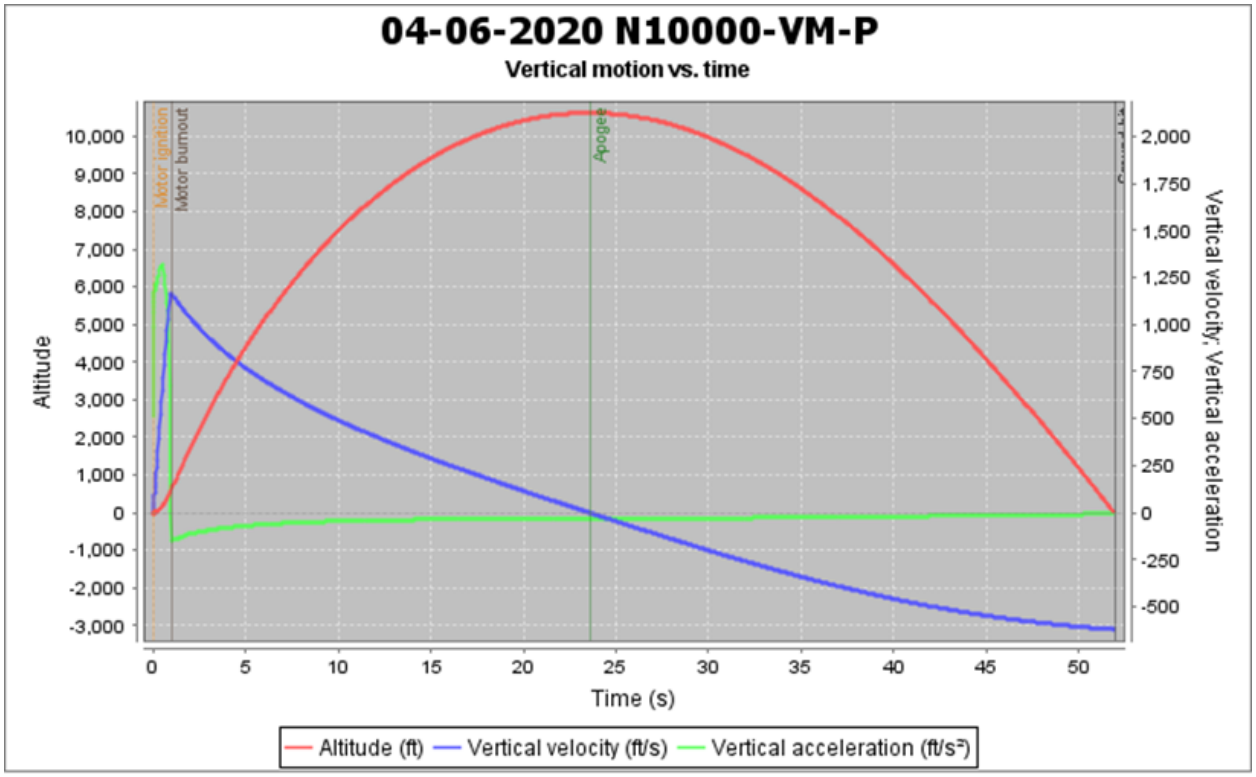
**Structures design process**

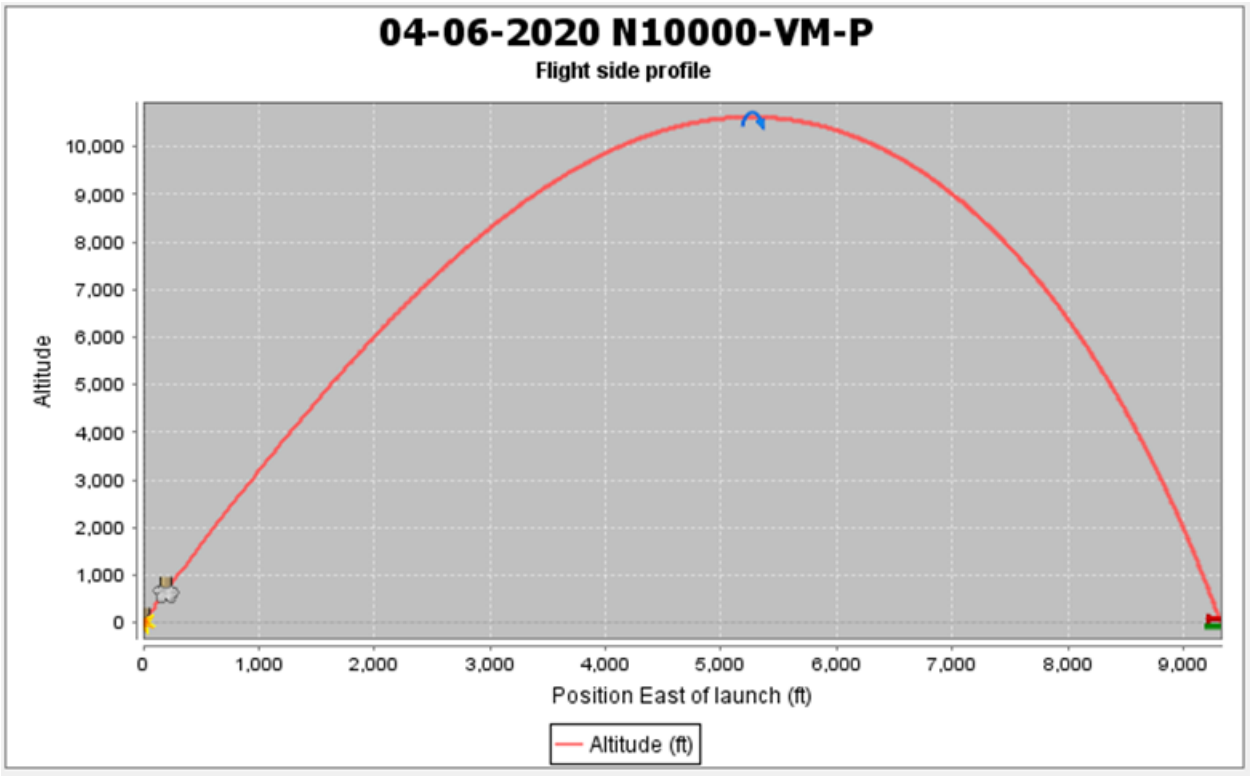
After the material choices were made, all components were added to the open rocket simulation. This included all masses and dimensions in order to create a simulation as close to the real world as possible. When laying out the fuselage, it was decided that the full lengths of carbon fiber tubing would be utilized in order to keep the greatest number of options for future teams. A similar concept was kept in mind when sizing the motor, specifically that the motor selected this year would have plenty of headroom in thrust and rod velocity, in order to ensure that next year's team could add payload if they wanted. An iterative design approach was then utilized to size the motor to meet the competition required. The results from the final motor selection are shown in the open rocket simulation results that follow:

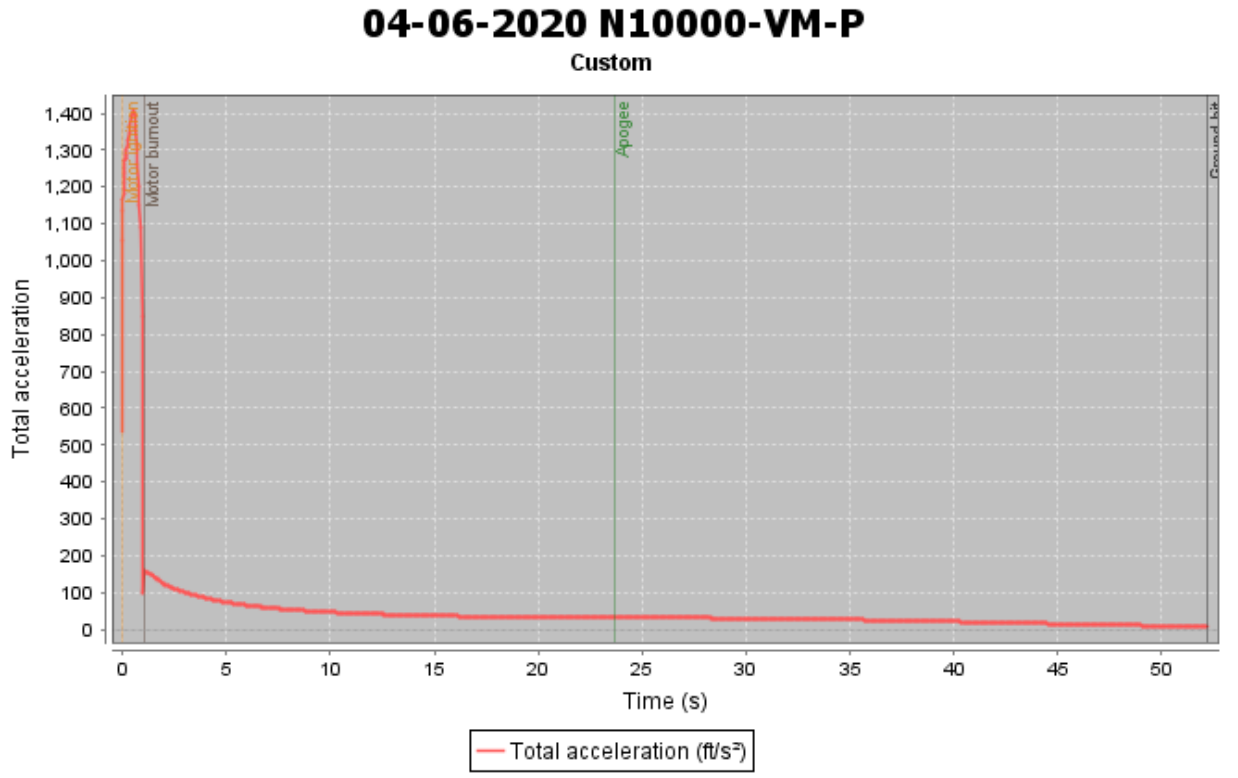
*Figure 15: Results from OpenRocket simulation* [43]

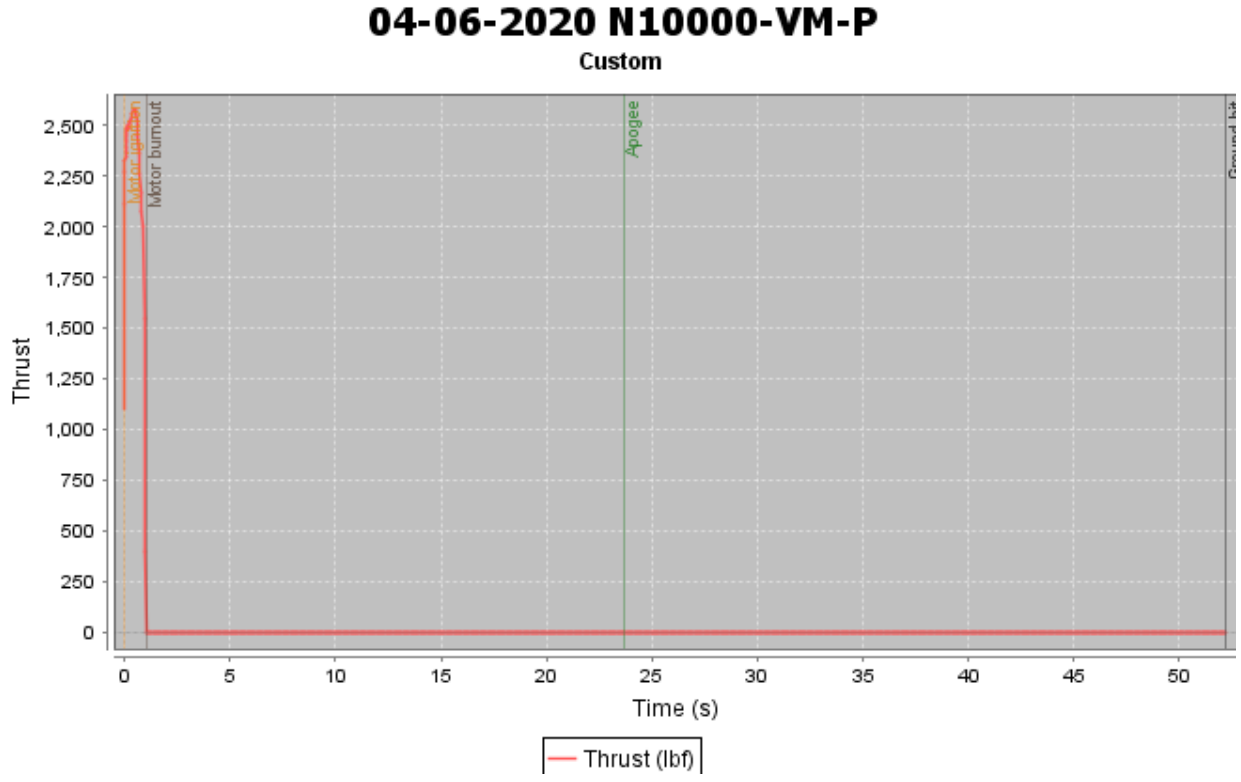
| Competition Requirements | | | | | | |
|---|---|---|---|---|---|---|
| | Target Apogee | Velocity off stand (Min) | | | total impulse (Max) | Stability (Range) |
| | 10,000 | 100 ft/s | | | 9208 lbf-s | 1.5-2 cal |
| Current Simulation Results | | | | | | |
| Motor | Apogee | velocity off stand | time to apogee | max acceleration | total impulse | Stability |
| N-10000-VM-P | 11203 ft | 224 ft/s | 23.7 s | 26.8 ft/s^2 | 2320 lbf-s | 1.71 cal |

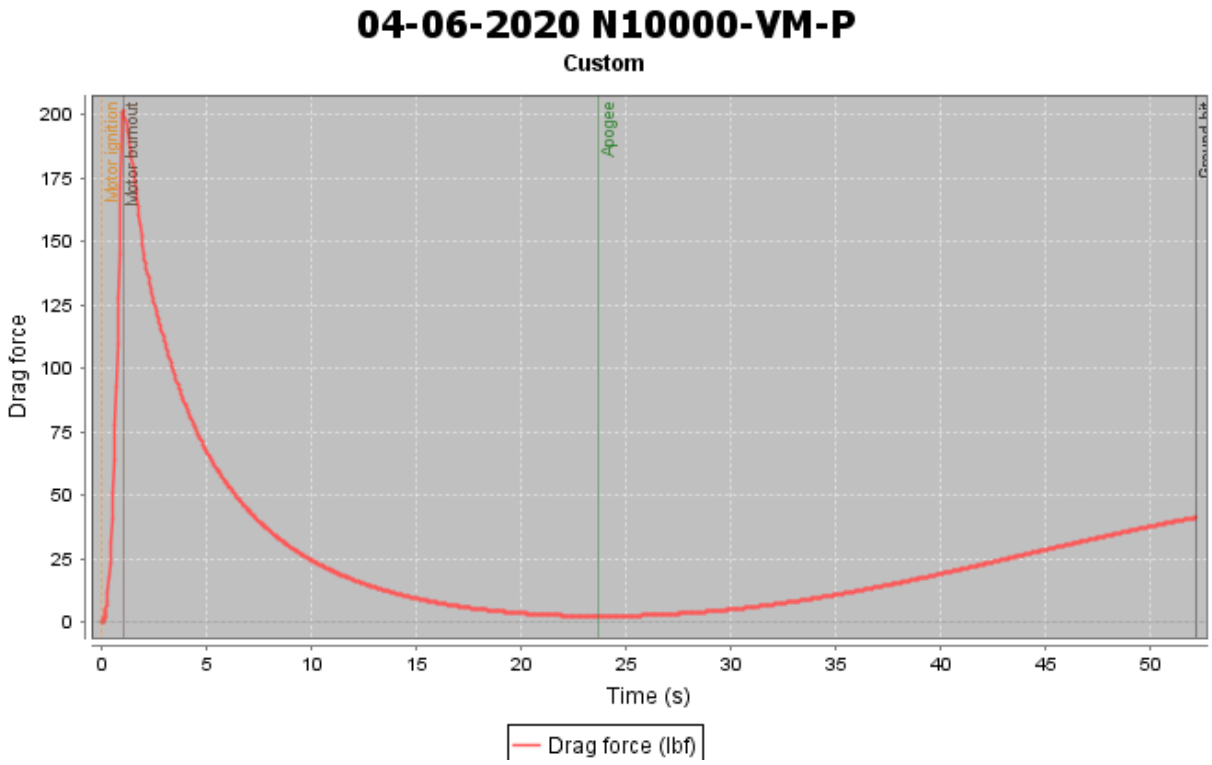



04-06-2020 N10000-VM-P
Vertical motion vs. time
Motor ignition
Motor burnout
Apogee
Altitude
Vertical velocity, Vertical acceleration
Time (s)
Altitude (ft)
Vertical velocity (ft/s)
Vertical acceleration (ft/s²)


04-06-2020 N10000-VM-P
Flight side profile
Altitude
Position East of launch (ft)
Altitude (ft)


04-06-2020 N10000-VM-P
Custom
Total acceleration
Time (s)
Motor burnout
Apogee
Total acceleration (ft/s²)


04-06-2020 N10000-VM-P
Custom
Thrust
Time (s)
Motor burnout
Apogee
Thrust (lbf)




After the completion of the simulation stage, a 3d model was created using Autodesk Inventor. A stress analysis was then performed on the structure components that would bear the greatest forces. The maximum drag force from the OpenRocket simulation was used in the stress analysis for the nose cone. The maximum thrust force was used in the stress analysis of the bulkhead and fuselage. The reports from these stress analyses are shown at the end of this report in Appendix A and the designs were deemed as sufficient.

**Avionics, Control System and Power**

The avionics and Control System are designed and selected to equip the rocket with the adequate amount of active and backup avionics and power to accurately achieve the predicted height while maintaining the controllability of the rocket to maintain the stability and the parachute deployment. One of the primary objectives of the avionics is to achieve the optimal height of 10,000 ft using the minimal amount of fuel.

A short list of constraints for this system is as follows:

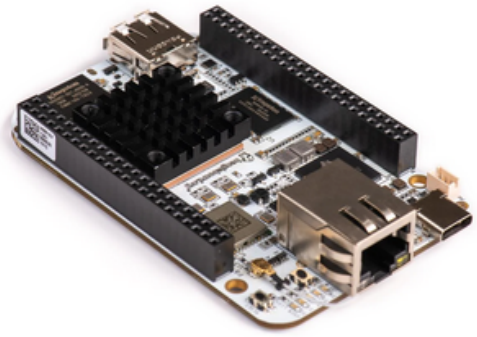
1. Should have both active and backup avionics powered separately.
2. Should use off-the shelf flight computers.
3. Should have the static margin of 1.5 to 2 body calibers.
4. Should not be overstable (body caliber > 2 body calibers).
5. Should not be guided towards the spatial target.

6. Should be able to be ignited from 50 ft away.
7. Should be equipped with a radio beacon.

The following list of various controllers and electronics are the options we were considering when designing this rocket:

**Controller: BeagleBoard[2,3]**

*Figure 16: BeagleBoard 358-BBONE-AI*

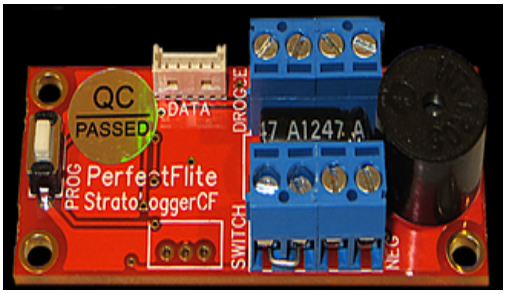


- Cost: $125
- Weight: 48 gms
- Dimension:89 mm x 54 mm x 15 mm
- Memory: 1 Gb RAM, 16 Gb storage
- Power: Max Power (P) = I*V = 3A*5V = 15 W

**Altimeter**

**Design Alternative 1 - Stratologger CF[6]**

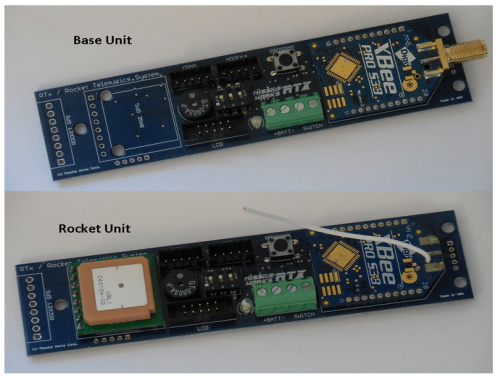
*Figure 17: Stratologger CF*




- Cost: $79.95
- Weight: 10.8 gms
- Dimension: 50.8 mm x 21.34 mm x 12.7 mm
- Capacity: Max Altitude 100,000 ft above sea level
- Power: Max Power (P) = I*V = 0.0015A*9V = 0.0135 W
- Misc: 20 samples per sec

**Radio/GPS Tracking: RTx/GPS System[13]**

*Figure 18: RTx/GPS System*




- Cost: $259.95
- Weight: No mass Data Available
- Dimension: 114.3 mm x 28.5 mm
- Misc: Recommended by competition
- Capacity: Includes Altimeter
- Power: Max Power (P) = I*V = 0.07 A* 9V = 0.00047 W

**Camera Sensor: Arducam Sony[16]**

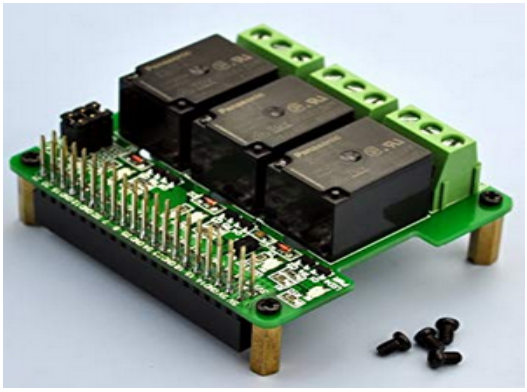
*Figure 20: Arducam Sony*


- Cost: $64.99
- Clairity: 8 MP
- Weight: 54 gms
- Dimension:36 mm x 36 mm
- Misc: HD Support
- Power: Max Power (P) = I*V = 0.02 A* 5V = 0.1 W
- Misc: Raspberry Pi compatible

**Power Supply**

1. **Li-ion Power/ LI-PO Batteries[19]**

*Figure 21: Power Relays*



- $16.99
- 907 gms
- Max Power Dissipation (P) = I*V = 10 A* 250V = 2500 W

**Recommended Power to Main Avionics**

This information is obtained from the Missileworks phone contact with missileworks representatives.

| Component | Battery Type | MAH | Volts |
|---|---|---|---|
| GPS Transmitter | Li-Po | 750 | 3.7 |
| GPS Receiver | Li-Po | 950 | 3.7 |
| Altimeter (MissileWorks) | Li-Po | 400 | 9 |
| Altimeter Stratologger | Li-Po | 400 | 9 |

**Problems Encountered :**

- Because of the COVID-19, some of the redundant avionics could not be purchased. However, the testing of the main avionics was performed.

**Telemetry:**

DAQ software & LCD screen can be used for telemetry. Following link can be used to access the DAQ software:
https://www.missileworks.com/downloads/

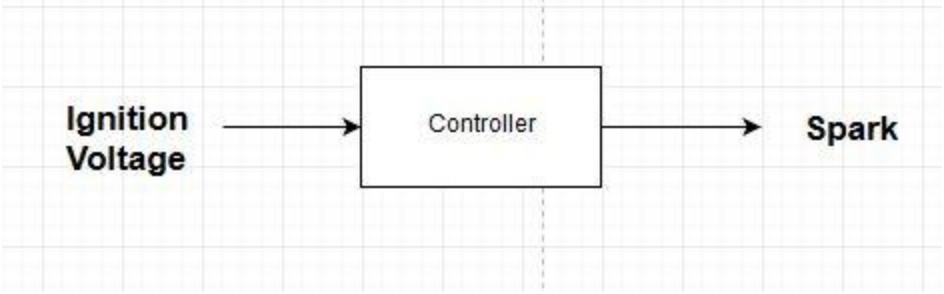
## Controls

### Ignition Control

The major purpose of the ignition control is to ignite the rocket from a distance of at least 50 ft away from the rocket.

2. **Control Mechanism:**
   The ignition event is created by supplying enough voltage to a highly resistive metal piece coated with a flammable material to ignite the motor of the rocket.

*Figure 22: Block Diagram for Ignition Control*




3. **Control Options: External Ignition control[22]**

*Figure 23: Wireless Ignition Controller*

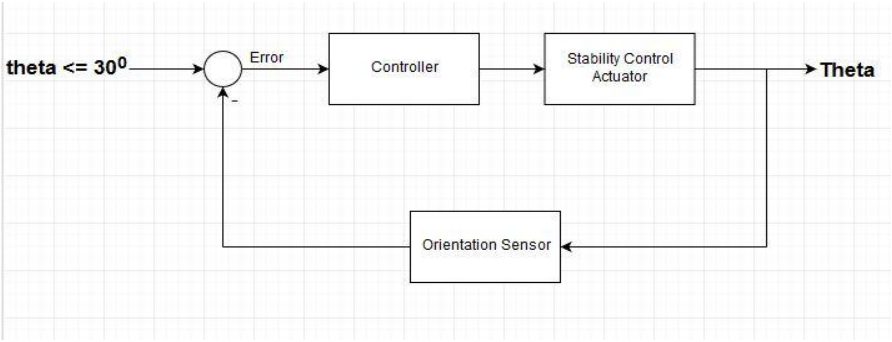
- $58.13
- Connected externally to the rocket
- Detaches during launch

**B. Orientation Control**

1. **Control Mechanism**

Orientation sensors are used to determine the attitude of the rocket. The competition rules dictate that the rocket should not be aimed towards a spatial target. Hence, soft control mechanism will be implemented to avoid the loss of the stability of the rocket. The orientation sensor data will be used to continuously check the stability of the rocket and the stability control actuators will be used to appropriately change the orientation of the rocket.

***Figure 41: Block Diagram for Orientation Control***



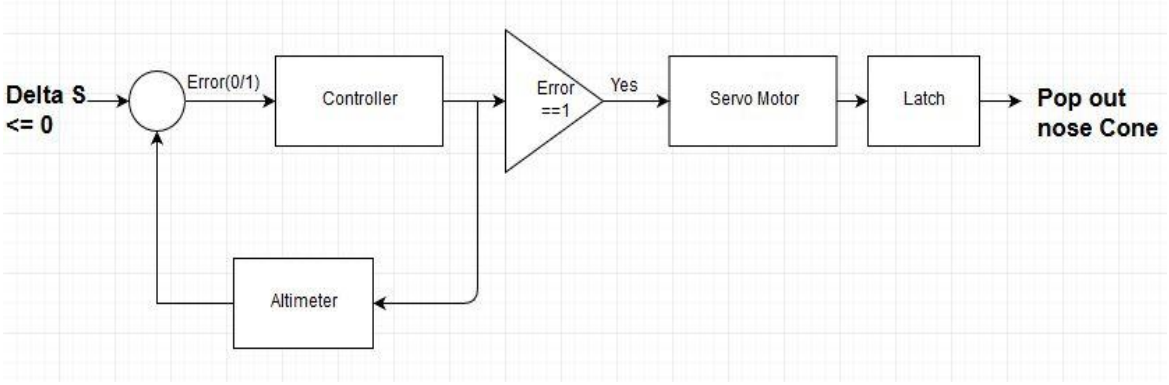

**Problems Encountered:**

- After discussion with Buddy Michaelson, it was concluded that the controls was illegal for the competition and was discontinued.

## C. Parachute Deployment Control

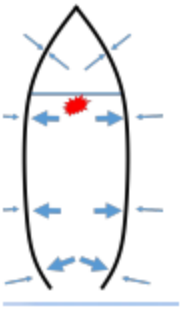
### 1. Control Mechanism

*Figure 23: Block Diagram for Parachute Deployment Control*




### 2. Nose Cone Control Options: Black Powder Ignition

*Figure 51: Black Powder Ignition*



- $5.64/2 oz
- The ignition of black powder can be induced by a charge

**Recovery**

After the rocket has successfully launched and reached its maximum altitude, recovery becomes the most important system left to deploy. The competition states that the rockets descent velocity must be less than 30 ft/sec to be recoverable. Previous data has shown that anything that is moving faster than that threshold will be destroyed upon impact. The other criteria for the recovery stage is that the parachute deployment must be a two stage event [appx]. So besides the main parachute, there must be a separate event that slows and stabilizes the rocket before the main chute deploys. After researching our options, we decided on the drogue parachute paired with the main parachute. The drogue parachute deploys at apogee. Because the rocket will be traveling roughly two miles into the sky, it was important to have a setup that would also help with rocket drift. When the drogue chute deploys it will slow the rocket significantly and stabilize any spinning or rolling that could damage the fuselage. Once it is stabilized, it will fall more safely until about 1500 feet. At this altitude the on-board computers will deploy the main parachute that will slow the descent to under 20 ft/sec. At this speed the rocket will be able to survive impact without any serious damage.

*Figure 6: Drogue parachute* [37]

**Budget/Details - Drogue Parachute**

- Material: Ripstop Nylon
- Weight: 2.26 pounds
- Cost: $150

**Problems Encountered**

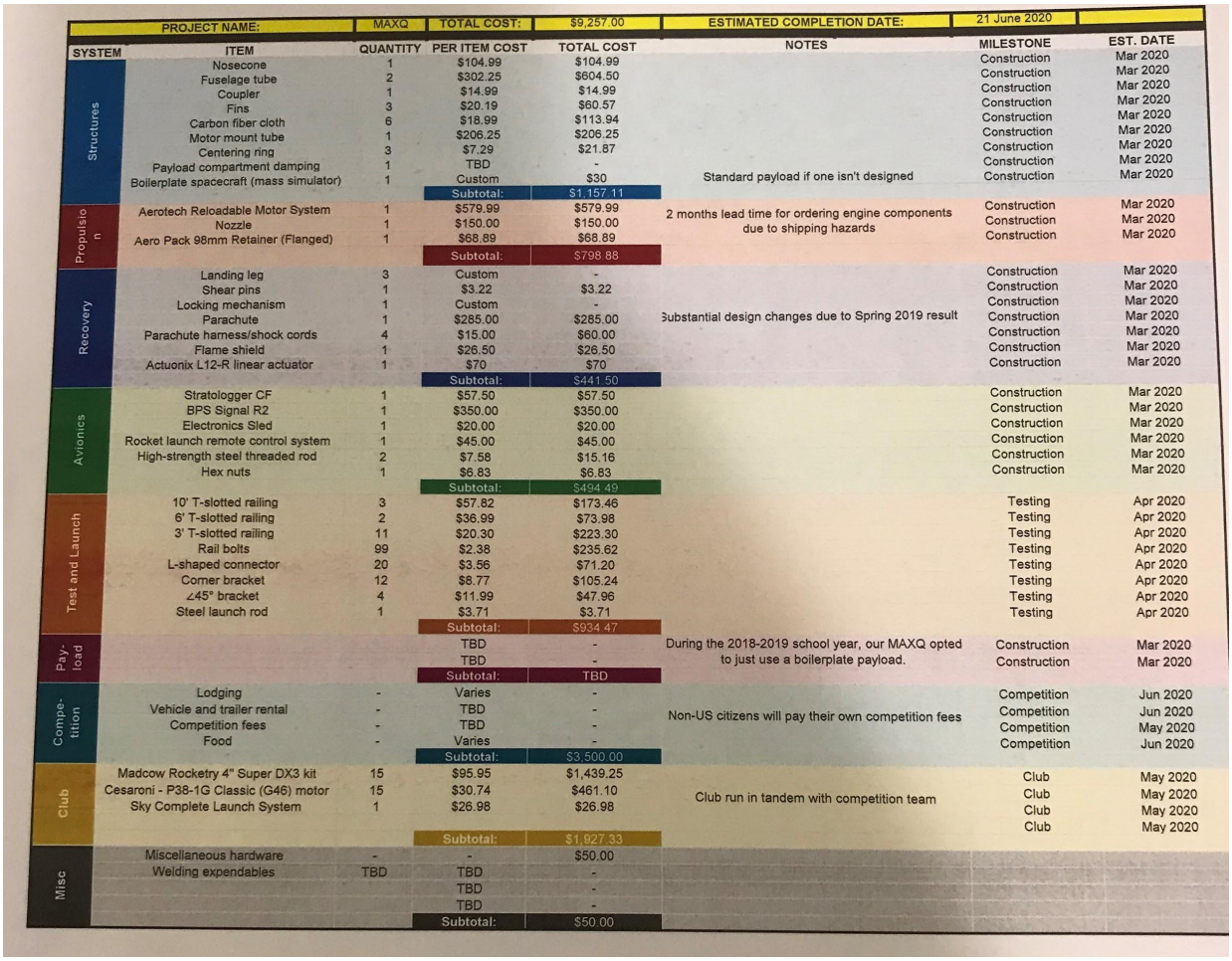
- We had initially decided to use a reef line for this project. The reef line would have wrapped around the main parachute, limiting it from fully opening until a certain altitude. This would have worked as well. The issue that we encountered was associated with the budget. When we started ordering the necessary hardware, there were some very specific pieces that were required to make a reef line work, and they were quite expensive. For this reason we adjusted our design to use a dual parachute system instead.

**Budget**

This is our budget, per the NASA Grant that we have been awarded. The values contained within the budget are the official values that have been awarded, however our design has changed slightly. There are a few elements that were contained in last year's design that we opted not to go forward with for the second iteration of this project. That being said, the grant money can be allocated to other areas of the project, as long as it is reported to NASA. Because this competition is an established international competition, vendors were readily available for every part we needed. We were encouraged by the event coordinators to use the vendors that were sponsoring the competition to support their various businesses. This worked out great, because in the process we made some professional connections that were willing to help answer

questions that came up during the build. Some of the funds were not used, such as the travel areas of the budget, due to COVID-19. The other areas were strictly followed to be in compliance with NASA's allotment of funds. See attached budget for details:

*Figure 8: Project budget*



| PROJECT NAME: | | MAXQ | TOTAL COST: | $9,257.00 | ESTIMATED COMPLETION DATE: | 21 June 2020 | |
|---|---|---|---|---|---|---|---|
| SYSTEM | ITEM | QUANTITY | PER ITEM COST | TOTAL COST | NOTES | MILESTONE | EST. DATE |
| Structures | Nosecone | 1 | $104.99 | $104.99 | | Construction | Mar 2020 |
| | Fuselage tube | 2 | $302.25 | $604.50 | | Construction | Mar 2020 |
| | Coupler | 1 | $14.99 | $14.99 | | Construction | Mar 2020 |
| | Fins | 3 | $20.19 | $60.57 | | Construction | Mar 2020 |
| | Carbon fiber cloth | 6 | $18.99 | $113.94 | | Construction | Mar 2020 |
| | Motor mount tube | 1 | $206.25 | $206.25 | | Construction | Mar 2020 |
| | Centering ring | 3 | $7.29 | $21.87 | | Construction | Mar 2020 |
| | Payload compartment damping | 1 | TBD | - | | Construction | Mar 2020 |
| | Boilerplate spacecraft (mass simulator) | 1 | Custom | $30 | Standard payload if one isn't designed | Construction | Mar 2020 |
| | | | Subtotal: | $1,157.11 | | | |
| Propulsion | Aerotech Reloadable Motor System | 1 | $579.99 | $579.99 | 2 months lead time for ordering engine components due to shipping hazards | Construction | Mar 2020 |
| | Nozzle | 1 | $150.00 | $150.00 | | Construction | Mar 2020 |
| | Aero Pack 98mm Retainer (Flanged) | 1 | $68.89 | $68.89 | | Construction | Mar 2020 |
| | | | Subtotal: | $798.88 | | | |
| Recovery | Landing leg | 3 | Custom | - | | Construction | Mar 2020 |
| | Shear pins | 1 | $3.22 | $3.22 | | Construction | Mar 2020 |
| | Locking mechanism | 1 | Custom | - | | Construction | Mar 2020 |
| | Parachute | 1 | $285.00 | $285.00 | Substantial design changes due to Spring 2019 result | Construction | Mar 2020 |
| | Parachute harness/shock cords | 4 | $15.00 | $60.00 | | Construction | Mar 2020 |
| | Flame shield | 1 | $26.50 | $26.50 | | Construction | Mar 2020 |
| | Actuonix L12-R linear actuator | 1 | $70 | $70 | | Construction | Mar 2020 |
| | | | Subtotal: | $441.50 | | | |
| Avionics | Stratologger CF | 1 | $57.50 | $57.50 | | Construction | Mar 2020 |
| | BPS Signal R2 | 1 | $350.00 | $350.00 | | Construction | Mar 2020 |
| | Electronics Sled | 1 | $20.00 | $20.00 | | Construction | Mar 2020 |
| | Rocket launch remote control system | 1 | $45.00 | $45.00 | | Construction | Mar 2020 |
| | High-strength steel threaded rod | 2 | $7.58 | $15.16 | | Construction | Mar 2020 |
| | Hex nuts | 1 | $6.83 | $6.83 | | Construction | Mar 2020 |
| | | | Subtotal: | $494.49 | | | |
| Test and Launch | 10' T-slotted railing | 3 | $57.82 | $173.46 | | Testing | Apr 2020 |
| | 6' T-slotted railing | 2 | $36.99 | $73.98 | | Testing | Apr 2020 |
| | 3' T-slotted railing | 11 | $20.30 | $223.30 | | Testing | Apr 2020 |
| | Rail bolts | 99 | $2.38 | $235.62 | | Testing | Apr 2020 |
| | L-shaped connector | 20 | $3.56 | $71.20 | | Testing | Apr 2020 |
| | Corner bracket | 12 | $8.77 | $105.24 | | Testing | Apr 2020 |
| | ∠45° bracket | 4 | $11.99 | $47.96 | | Testing | Apr 2020 |
| | Steel launch rod | 1 | $3.71 | $3.71 | | Testing | Apr 2020 |
| | | | Subtotal: | $934.47 | | | |
| Pay-load | | | TBD | - | During the 2018-2019 school year, our MAXQ opted to just use a boilerplate payload. | Construction | Mar 2020 |
| | | | TBD | - | | Construction | Mar 2020 |
| | | | Subtotal: | TBD | | | |
| Compe-tition | Lodging | - | Varies | - | | Competition | Jun 2020 |
| | Vehicle and trailer rental | - | TBD | - | Non-US citizens will pay their own competition fees | Competition | Jun 2020 |
| | Competition fees | - | TBD | - | | Competition | May 2020 |
| | Food | - | Varies | - | | Competition | Jun 2020 |
| | | | Subtotal: | $3,500.00 | | | |
| Club | Madcow Rocketry 4" Super DX3 kit | 15 | $95.95 | $1,439.25 | | Club | May 2020 |
| | Cesaroni - P38-1G Classic (G46) motor | 15 | $30.74 | $461.10 | Club run in tandem with competition team | Club | May 2020 |
| | Sky Complete Launch System | 1 | $26.98 | $26.98 | | Club | May 2020 |
| | | | | | | Club | May 2020 |
| | | | Subtotal: | $1,927.33 | | | |
| Misc | Miscellaneous hardware | - | - | $50.00 | | | |
| | Welding expendables | TBD | TBD | - | | | |
| | | | TBD | - | | | |
| | | | TBD | - | | | |
| | | | Subtotal: | $50.00 | | | |

# Conclusions

The team's main goal for this project is to participate in the Intercollegiate Rocket Engineering Competition, in conjunction with the Spaceport America Cup. Our intent is for all systems to work in synchronization with each other as designed, fulfill all rules and regulations set forth by the competition and lastly successfully launch a safe rocket. The largest benefit of this project will be that the team members will become better team members and engineers, having gained extensive knowledge about rocketry and teamwork. Another huge benefactor will be the Idaho State Rocketry Club. Our work and success will be used as part of the legacy of the project. We hope to be able to hand a completed rocket to the next generation in the hopes of continuation and development of what we have started. We will meet these goals by meeting all deadlines for the competition as well as test launching the rocket before the competition to ensure a successful competition. We have documented our design and team process to the best of our abilities, and will continue to do so, to pass the legacy knowledge to the succeeding years team.

As stated earlier in this report, the COVID-19 pandemic has significantly impacted this project as well as the entire world economy and everyone's personal lives. This unforeseen event, however, didn't stop us from doing everything we could to ensure this project continues into the future. We have the majority of the parts for the rocket on site in storage, ready for the next year's team to take and build a great competition rocket. We have submitted a new grant to fund the future of this project, and ensure all those students at ISU that are interested in aerospace have a creative outlet to express their interest in rocketry.

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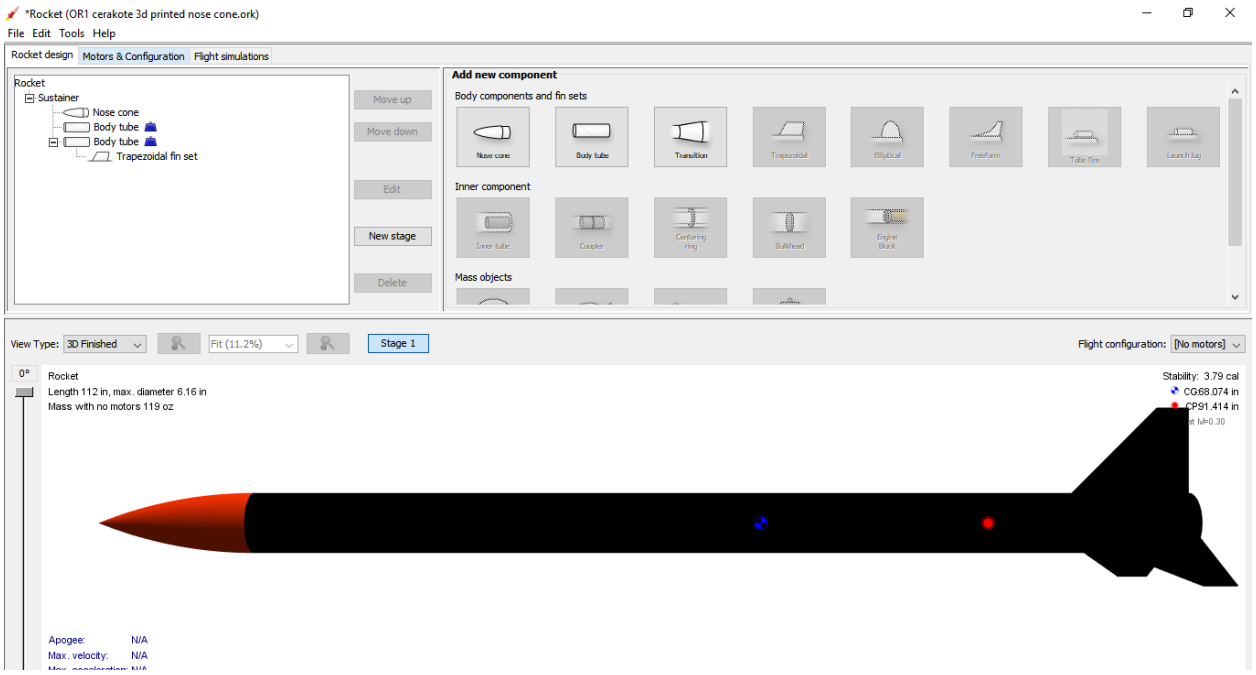
# Appendices

## I. Analysis of Components of the project




## II. Drawing/Software Development Package

*Structure 1 drag data*

| Component | Pressure $C_D$ | Base $C_D$ | Friction $C_D$ | Total $C_D$ |
|---|---|---|---|---|
| Nose cone | 0.00 (0%) | 0.00 (0%) | 0.03 (6%) | **0.03 (6%)** |
| Body tube | 0.00 (0%) | 0.00 (0%) | 0.09 (20%) | **0.09 (20%)** |
| Body tube | 0.00 (0%) | 0.13 (29%) | 0.09 (20%) | **0.23 (49%)** |
| Trapezoidal fin set | 0.06 (13%) | 0.00 (0%) | 0.05 (11%) | **0.11 (24%)** |
| **Total** | **0.06 (13%)** | **0.13 (29%)** | **0.26 (58%)** | **0.46 (100%)** |

*Structure 2 drag data*

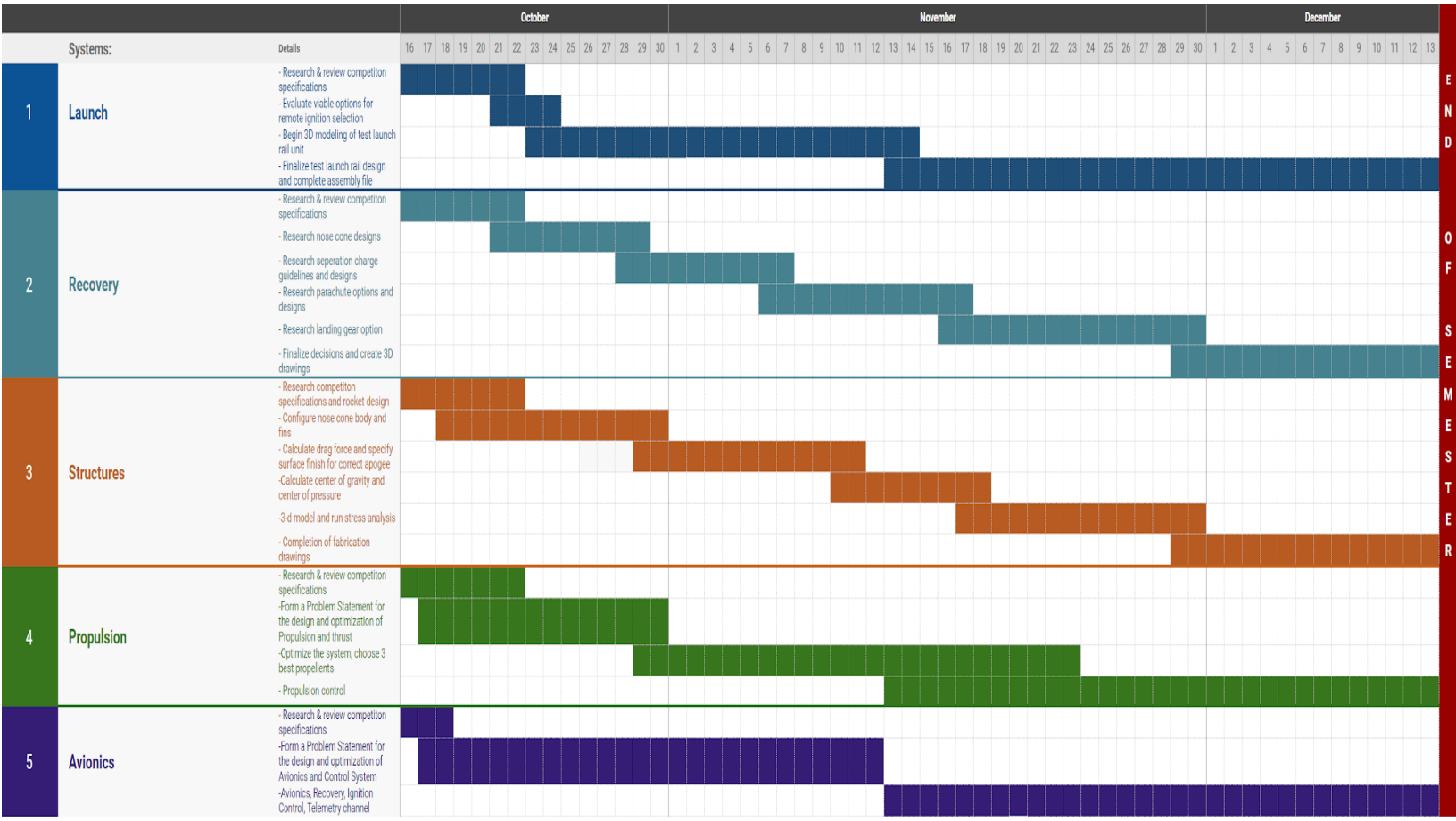
| Component | Pressure $C_D$ | Base $C_D$ | Friction $C_D$ | Total $C_D$ |
|---|---|---|---|---|
| Nose cone | 0.00 (0%) | 0.00 (0%) | 0.03 (6%) | **0.03 (6%)** |
| Body tube | 0.00 (0%) | 0.00 (0%) | 0.09 (20%) | **0.09 (20%)** |
| Body tube | 0.00 (0%) | 0.13 (29%) | 0.09 (20%) | **0.23 (49%)** |
| Trapezoidal fin set | 0.06 (13%) | 0.00 (0%) | 0.05 (11%) | **0.11 (24%)** |
| **Total** | **0.06 (13%)** | **0.13 (29%)** | **0.26 (58%)** | **0.46 (100%)** |

*Structure 3 drag data*

| Component | Pressure $C_D$ | Base $C_D$ | Friction $C_D$ | Total $C_D$ |
|---|---|---|---|---|
| Nose cone | 0.06 (11%) | 0.00 (0%) | 0.02 (4%) | **0.08 (15%)** |
| Body tube | 0.00 (0%) | 0.00 (0%) | 0.09 (18%) | **0.09 (18%)** |
| Body tube | 0.00 (0%) | 0.13 (26%) | 0.09 (18%) | **0.23 (45%)** |
| Trapezoidal fin set | 0.06 (12%) | 0.00 (0%) | 0.05 (10%) | **0.11 (22%)** |
| **Total** | **0.12 (23%)** | **0.13 (26%)** | **0.26 (51%)** | **0.50 (100%)** |

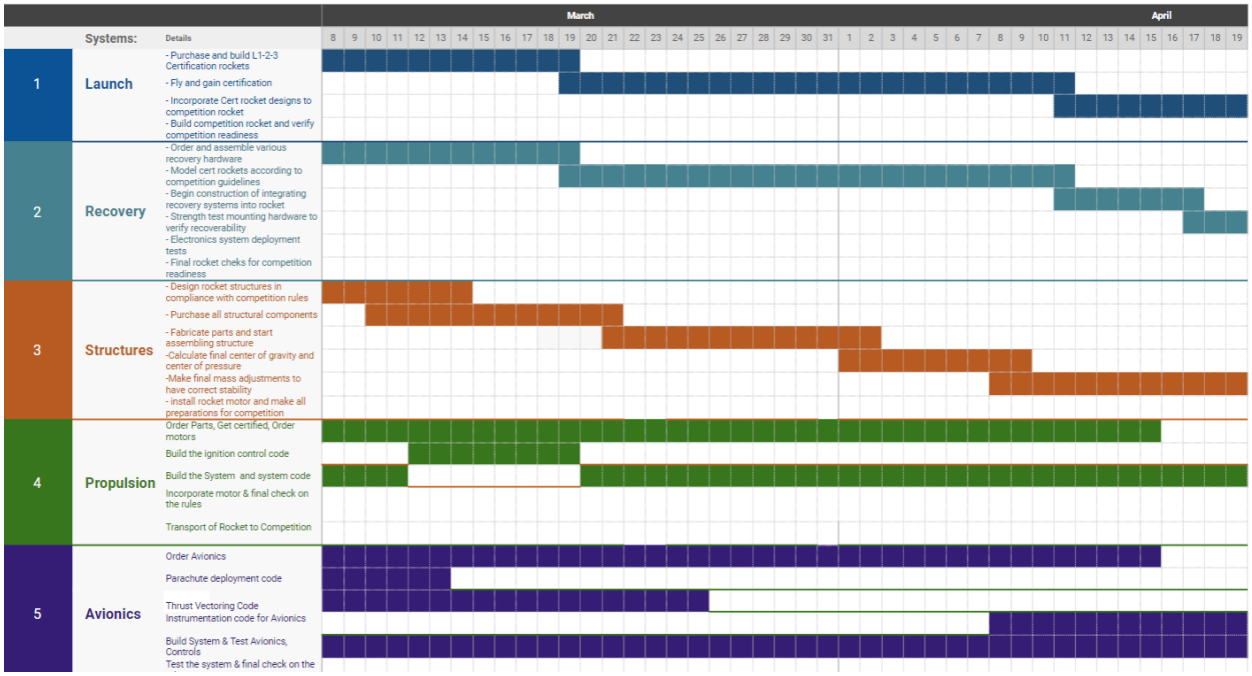
## III. Gantt Chart

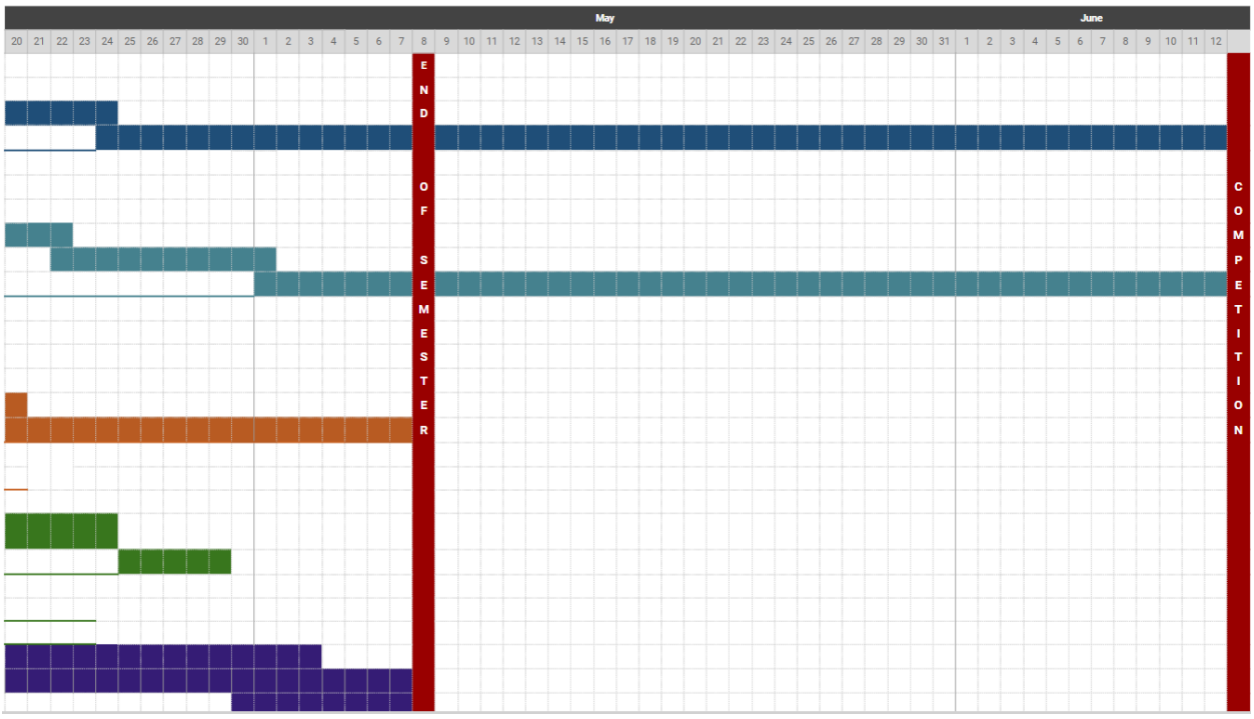
*Figure 9: Fall and spring Gantt chartst*



## MAXQ PROJECT TIMELINE

PROJECT TITLE MAXQ Rocket Project



IV. Project Updates (Meeting Minutes)

# ISRC/Senior Design

Team Meeting

**27 SEPTEMBER 2019** / 5:00 PM / Skype call

Attendees

Derrick Likes (Club President, Team Lead), Dr. Marco Schoen (Advisor), Kaius Tolman (Club Secretary), Brandon Evans (Club Member)

Absent

Shishir Khanal (excused - in class), Derek Anderson (excused - out of town)

Call to order

5:05 PM

Agenda

Last Meeting Follow-up

- None Yet

New Business

- ISR Club Update
    - Lots of new members
        - Lets create a club email list, or get everyone hooked into slack for updates?
    - Meeting for next week at MCERC on tuesday night? New opening social.
    - Possible club activities coming up? (movie night at MCERC?)

- Senior Design Update
    - We are presenting our first project update on October 14th.
        - 15 minutes in class
        - We need to have our systems detailed more, possibly some rough drawings

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

        - We need to have a detailed Gantt chart for the update
        - Any additional information?
    - Best way to incorporate club members into project tasks?

### Notes

- None Yet

### Action Items

- Everyone continue researching your systems and start prepping for first update presentation. (All)
- Start compiling data for your chosen systems. (All)
- Start doing some detailed drawings of your systems. (All)

### Next Meeting Agenda

- Introduction to MCERC.
    - Meeting at 5:00 PM at MCERC lab in Pocatello
    - Tour by Dr. Schoen and approval of workspace.
- Discuss proposals and challenges found through research for each of our systems.
- Discuss budget and coordination with NASA for grant guidelines and stipulations.
- Start working on update presentation. (specific slides for specific team members)

### Additional Minutes

- Summary of all discussions:
    - Derrick introduced club members to Dr. Schoen.
    - Derrick gave a brief overview of the project to the club.
    - Dr. Schoen told everyone about a space at the MCERC lab that we can use to work on our project and store any supplies we get for the project.
    - Derrick and Dr. Schoen discussed the finalized team, and action items moving forward with the project.
    - Discussion between Dr. Schoen and Derrick about possibly arranging a meeting with members of the Tripoli Rocketry Association to give everyone a better idea on how to build this rocket.

### Adjourned

5:40 PM

ISRC/Senior Design

Team Meeting

**1 October 2019** / 5:00 PM / mcerc conference room

### Attendees

Derrick Likes (Club President, Team Lead), Dr. Marco Schoen (Advisor), Shishir Khanal (Vice president), Derek Anderson (Treasurer)

### Absent

NA

### Call to order

5:05 PM

### Agenda

#### Last Meeting Follow-up

- Toured mcerc with Dr. Schoen

#### New Business

- The application deadline for the rocket is coming up so we need to gather the critical information for it.
- NASA grant entails promoting rocketry in K-12 grades so we need to plan that.

### Notes

- None Yet

### Action Items

- Send email to Dr. Schoen with bengal ID numbers to access the mcerc
- Dr. Schoen needs to sign mentor documents
- Contact ASME for meeting dates so that we can attend and ask for money for the project.
- Work on coming presentation.

### Next Meeting Agenda

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

- Gather more information for the application for the competition and get it submitted

### Additional Minutes

- Summary of all discussions:
    - Dr. Schoen gave a tour of the mcerc and discussed accessing the facility
    - Shishir brought up promoting rocketry in k-12 and ideas were discussed
    - Derek mentioned his wife teaches 4th grade so we could potentially engage with her.
    - Derrick discussed in depth the information needed for the application and its deadline

### Adjourned

5:40 PM

### ISRC/Senior Design

### Team Meeting

**12 October 2019** / 8:00 AM / Skype Call

### Attendees

Derrick Likes(President), Shishir Khanal(Vice-President), Derek Anderson(Secretary)

### Absent

Marco P. Schoen (Mentor)

### Call to order

5:05 PM

### Agenda

### Last Meeting Follow-up

- Talked with the Financial Accountant of CoSE about the entry fee payment process.

### New Business

- ISR Club Update
    - Discuss budget and coordination with NASA for grant guidelines and stipulations.

    - Opening Social on OCT 22.
    - Water Rocket for K-12 proposed for Nov-15
    - Dr. Schoen can pay the fees online through Travel Card.

- Senior Design Update
    - Discuss Points, Penalties Bonuses and Awards.
    - Start working on update presentation. (specific slides for specific team members)
    - Rehearse Sunday Evening

### Notes

- Points, Penalties Bonuses and Awards

### Action Items

- Derrick will talk with the competition contact staff about the concreteness of the entry form.
- Derek will contact the Teacher for K-12 Rocketry Activity.
- Complete the slides for Project Update Presentation.(ALL)

### Next Meeting Agenda

- Work on Submitting the Entry Form

### Additional Minutes

- Summary of all discussions:
- Group agreed on having a water rocket design competition for the K-12 project
- Group agreed to do a skype meeting on 10/16 to complete the entry form to the competition.

### Adjourned

9:05 AM

## Points, Penalties Bonuses and Awards
## Spaceport America Cup

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

| Total Points Possible - 1000 | |
|---|---|
| **Flight Performance -500** | **Accuracy of Launch Vehicle's apogee achieved relative to apogee - 350(0 pts for 7000 ft , 350 pts for 10000 ft)** |
| | **Successful Recovery -150 (pass/ fail basis)** |
| **Entry form and Progress Updates - 60** | **4 @ 15 pts each** |
| **Project Technical Report - 200** | **Correctness- 40 pts** |
| | **Completeness - 20 pts** |
| | **Analysis - 140 pts** |
| **Design Implementation - 240 pts (In the Poster Session through Interaction)** | **Competency of Design and Quality of Construction - 180 pts** |
| | **Strategic Design Decisions - 60 pts** |

| Penalties |
|---|
| **Unsafe or Unsportsmanlike conduct - (-20) each time** |
| **5 payload requirements in Section 2.2 in spirit or intent - (-100) each** |

| Bonuses |
|---|
| **Qualify for form factor exemption Sec 2.2.5.2, yet still adopt cubesat standard form factor - 50 pts** |
| **Efficient Launch Preparation**<br>**- Declared launch ready by the end of the field preparation day and flown by the end of the first launch day - 100 pts**<br>**- Declared launch ready and flown during first launch day - 50 pts**<br>**- Declared launch ready and flown during second launch day - 25 pts** |

| Awards | |
|---|---|
| **Judges Choice and Overall Winner Award** | **1 team among the first place award among 6** |

| | categories |
|---|---|
| **Technical Achievement Award(4 awards)** | **- Recognizing Technical Achievements<br>- 3-> Qualitative Assessments in Podium Session and launch Preparation day<br>- 1->to IREC team based on Flight Dynamics** |
| **Jim Furfaro Award for Technical Excellence** | **- If accepted into and participate in Podium session in Conference Day<br>- Project planning & execution, operation procedure, manufacturing process, iterative improvement, systems engineering methodology, robust design, etc.** |
| **Dr. GilMoore Award for Innovation** | **- If accepted into and participate in Podium session in Conference Day<br>- "Novel" features( analytic or operational processes & component or assemblies)** |
| **Charles Hoult Award for Modeling and Simulation** | **- If accepted into and participate in Podium session in Conference Day<br>- Excellence in Math Modeling and computational analyses** |
| **James Barrowman Award for Flight Dynamics** | **- Exquisite Trajectory Analysis<br>- % error between actual and predicted apogee** |
| **Team Conduct Awards** | **- Conduct exemplary goals and ideas held by event organizers<br>- Preserve, popularize, & advance science of Rocketry in a collaborative environment energized by friendly competition** |
| **Team Sportsmanship Award** | **Team that goes above and beyond to assist their fellow teams & event organizers to assure productive, safe and enjoyable experience.** |
| **Team Spirit Award** | **Arrive at competition with smiles on their face, a school flag in their hand and keeps both throughout the event** |

**Six Categories:**

- 10,000 ft AGL apogee with commercial-off-the-shelf (COTS) solid or hybrid rocket propulsion system
- 30,000 ft AGL apogee with COTS solid or hybrid propulsion system
- 10,000 ft AGL apogee with student researched and developed (SRAD) solid rocket propulsion system
- 30,000 ft AGL apogee with SRAD solid rocket propulsion system
- 10,000 ft AGL apogee with SRAD hybrid or liquid rocket propulsion system
- 30, 000 ft AGL apogee with SRAD hybrid or liquid rocket propulsion system

ISRC/Senior Design

Team Meeting

**16 OCTOBER 2019** / 8:15 AM / Skype call

Attendees

Derrick Likes (Club President, Team Lead), Shishir Khanal (Club VP), Derek Anderson (Club Treasurer)

Absent

Dr. Marco Schoen (excused - Teaching class)

Call to order

8:15 AM

Agenda

Last Meeting Follow-up

- Continued working on competition registration form.

New Business

- ISR Club Update
    - We need to officially plan and schedule an opening social.
        - We will have our next meeting at the MCERC and have a pizza party at 5 PM.

- Senior Design Update

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

    - Completed our design update in class.
    - We WILL complete our competition registration today!
    - Look down the road at our schedule to make sure were on track.

### Notes

- None

### Action Items

- Get complete club list from club secretary and set up a google email list to start updating club members about activities.
    - Specifically for the opening social
- Get club funds secured days before the event.
- Get on HeroX website and finish your portions of the entry form so we can be officially entered in the competition.

### Next Meeting Agenda

- Give a brief overview of the project to underclassmen to get them excited about the legacy project.
- Get to know the underclassmen
- Go over next steps in project timeline

### Additional Minutes

- Summary of all discussions:
    - Shishir was on his computer going over what fields we still needed to complete to be done with the entry form.
    - Derrick detailed emails he had received from HeroX every day about how many schools had entered the competition so far. The number was about 25 more schools per day. Only 150 teams will be accepted, so it is imperative that we get signed up.
    - Derek wondered if the data we used on the form was final, or if we could change it as our design process progressed.
        - Derrick emailed ESRA with that question.
        - They responded and said that they expect everyone's plans to evolve and that we can change our data in every one of our updates.
    - We planned to meet later today and complete our competition registration.

### Adjourned

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

8:45 AM

ISRC/Senior Design

Team Meeting

**03 NOVEMBER 2019** / 8:00 PM / Skype call

Attendees

Derrick Likes (Club President, Team Lead), Derek Anderson (Club Treasurer)

Absent

Dr. Marco Schoen (excused - unavailable), Shishir Khanal (excused - unavailable)

Call to order

8:00 PM

Agenda

Last Meeting Follow-up

- Need to schedule a club movie night.
    - Need to verify everything is in order for community outreach activity.

New Business

- ISR Club
    - Contact Bengal Theater and see when they will have Ad Astra showing and plan a movie night for the club.
    - Include underclassmen in the community outreach activity. (there was some interest at the last meeting)

- Senior Design
    - We received feedback from Dr. Wabrek & Mahar from our last presentation.
        - I emailed it out for review
    - We need to start preparing for our final presentation.
        - Specifically, we need to address the feedback from last presentation and make the necessary corrections.
        - We all need to make our decision matrices for all our critical components and have them in our presentation.

        - We essentially need to have all our final designs selected and any components priced out.

### Notes

- None

### Action Items

- Everyone go through your systems and select final components.
- Create decision matrix and add it to presentation.
- Consider doing a CAD drawing of select components and add that to your section of presentation.
- Don't forget about the ethics paper due this friday!

### Next Meeting Agenda

- Discuss details of community outreach program and get everything finalized.
- Get all remaining deadlines lined out for the rest of the semester.
    - ESRA
    - NASA
    - PROJECT DESIGN

### Additional Minutes

- Summary of all discussions:
    - Derek and Derrick went over the feedback that was emailed to us from our last presentation.
        - Also discussed final presentation schedule, and potentially practicing in person before actual presentation.
    - Discussed layout of final presentation slides and matrices.
    - Discussed plan for keeping track of all our materials and parts.
        - Starting a materials spreadsheet with prices and links to make everything easier to find next semester when we start purchasing everything.
    - Discussed plans on getting other mentors involved in the project to help us stay on track.
        - Have all future meetings planned out much further in advance to get everyone involved.

### Adjourned

8:40 PM

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

ISRC/Senior Design

Team Meeting

**17 NOVEMBER 2019** / 2:30 PM / Skype call

### Attendees

Derrick Likes (Club President, Team Lead), Derek Anderson (Club Treasurer), Shishir Khanal (Club Vice President)

### Absent

Dr. Marco Schoen (excused - unavailable),

### Call to order

2:30 PM

### Agenda

### Last Meeting Follow-up

- Outreach program was a success! Everyone had a great time and no one was injured!

### New Business

- ISR Club
    - Look into movie schedule for the next 6 weeks at Bengal Theater for a club movie night.
    - Look into having a closing social for this semester

- Senior Design
    - Make a post to the class social media accounts for an account of the outreach rocket program.
    - Look into booking lodging for the competition next

### Notes

- Shishir to research additional thruster controls for rocket stability.

### Action Items

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

- Everyone go through your systems and select final components.
- Create decision matrix and add it to presentation.
- Consider doing a CAD drawing of select components and add that to your section of presentation.

### Next Meeting Agenda

- Begin crafting final report for class. Due the week after Thanksgiving break.
    - Breakout various sections, get document set up and begin writing report.

### Additional Minutes

- Summary of all discussions:
    - Derek, Derrick, and Shishir discussed problems linking simulink to our Arduino boards for our several projects we are working on.
    - Shishir had an idea for controlling stability and orientation while the rocket is in flight. Adding a seperate heat exchanger that will generate heat from the engine to use superheated vapor to help control rocket in air.
    - Shishir is looking into rocket engines and pricing, so we can schedule a test launch for may.
    - Derek talked about the senior design presentation. All of us need to finish our decision matrices, and we will be printing out our nose cone.
    - Derek talked about calculating our drag force, and which components would help us have a great coefficient of drag for this project.

### Adjourned

3:00 PM

### ISRC/Senior Design

### Team Meeting

**23 January 2020** / 4:30 PM / Dr. Schoen's Office

### Attendees

Derrick Likes(President), Shishir Khanal(Vice-President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor)

### Absent

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

None

### Call to order

4:30 PM

### Agenda

### Last Meeting Follow-up

- None

### New Business

- ISR Club Update
    - Now that we are in the building phase of the rocket, we need to encourage club members to get involved and help us build. This will help build the club and get a solid team lined up for next year.
    - We need to plan at least one outreach event for this semester.

- Senior Design Update
    - We have feedback from HeroX on our rocket.
        - There are a few things we need to change/update.

### Action Items

- Derrick
    - Correct the errors for recovery parts mentioned from HeroX
    - Add parts to the master parts list
    - Get info about certification for motors from Tripoli Rocket Association
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything
- Derek
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything
- Shishir
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything

### Next Meeting Agenda

- Club activity
- Steps to certification
- Actually ordering parts/review budget
- Further discussions of competition attendance

### Additional Minutes

- Group talked about the competition, and steps to get the rocket built
- Discussed how to involve the underclassmen in the project
- Discussed how to get the other mentors involved
- Talked about getting a club event going

### Adjourned

5:00 PM

### ISRC/Senior Design

### Team Meeting

**30 January 2020** / 4:30 PM / Dr. Schoen's Office

### Attendees

Derrick Likes(President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor)

### Absent

Shishir Khanal(Vice-President)

### Call to order

4:30 PM

### Agenda

### Last Meeting Follow-up

- Derrick contacted the tripoli rocket association about needing a certification in order to purchase a large rocket motor and they indicated that we would not need a certification for the purchase of a class M motor.

### New Business

- ISR Club Update
    - Now that we are in the building phase of the rocket, we need to encourage club members to get involved and help us build. This will help build the club and get a solid team lined up for next year.
    - We need to plan at least one outreach event for this semester.

- Senior Design Update
    - We have feedback from HeroX on our rocket.
        - There are a few things we need to change/update.

### Action Items

- Derrick
    - Correct the errors for recovery parts mentioned from HeroX
    - Add parts to the master parts list
    - Get info about certification for motors from Tripoli Rocket Association
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything
- Derek
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything
- Shishir
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything

### Next Meeting Agenda

- Club activity
- Steps to certification
- Actually ordering parts/review budget
- Further discussions of competition attendance

### Additional Minutes

- Group talked about the competition, and steps to get the rocket built
- Discussed how to involve the underclassmen in the project
- Discussed how to get the other mentors involved
- Talked about getting a club event going

### Adjourned

5:00 PM

### ISRC/Senior Design

### Team Meeting

**20 February 2020** / 3:00 PM / Dr. Schoen's Office

### Attendees

Derrick Likes(President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor)

### Absent

Shishir Khanal(Vice-President) - Excused (In Class)

### Call to order

3:00 PM

### Agenda

### Last Meeting Follow-up

- Derrick and Shishir have been contacting the Boise chapter of the Tripoli Rocket Club in efforts to get a mentor who is certified to purchase our rocket motor, or to schedule a launch day so that we can get certified. All team members are focused on ordering parts for their delegated systems.

### New Business

- ISR Club Update
    - Next week we will have an official club meeting to sort through all of our hardware that has been ordered.

    - We will layout a schedule for regular club meetings, and activities that we will need club help from.

- Senior Design Update
    - Derek and Derrick have ordered a large list of parts for the rocket.
        - These parts will be arriving next week and will facilitate club building activities and to begin working out design parameters.
    - Derrick made contact with a rocket component supplier (Buddy "Rocketman" Michaelson) that is willing to help us build and troubleshoot any issues with our rocket construction project.

### Action Items

- Derrick
    - Add parts to the master parts list
    - Get info about certification for motors from Tripoli Rocket Association
    - Look over grant details for next year
- Derek
    - Look over grant details for next year
- Shishir
    - Look over grant details for next year
    - Finalize parts so we can start ordering everything

### Next Meeting Agenda

- Club activities
- Steps to certification
- Additional parts
- Further discussions of competition attendance

### Additional Minutes

- Group talked about the competition, and steps to get the rocket built
- Discussed how to involve the underclassmen in the project
- Discussed how to get the other mentors involved
- Talked about getting a club event going

Adjourned

3:30 PM

ISRC/Senior Design

Team Meeting

**20 February 2020** / 10:20 PM / Email

Attendees

Derrick Likes(President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor), Shishir Khanal (Vice President), Kellie Wilson (Advisor)

Absent

None

Call to order

10:30 PM

Agenda

Because of illness, this week's meeting was over email. This was the update:

Thu, Mar 5, 10:26 PM

Derrick Likes <likederr@isu.edu>

to Derek,
Kellie, Marco,

Shishir

Hey Everyone!

Ok, so here are the updated for this week.

Frank Ross called me a few days ago. He's a board member for the Tripoli Idaho Chapter of Tripoli Rocketry who Shishir and I have both contacted. I asked him a bunch of questions about getting certified. He said that Tripoli or NAR could do the certifications for us, and that is is pretty common for people to get their L1 and L2 certs in the same day. Basically, we just need to look at the schedule on their websites and contact them to get everything arranged for the launch day. If we let them know we are coming to get certified they will make sure there is a vendor in site to sell us the motors we need. So, we need to schedule all of that.

Later that night I was chatting with Buddy Michaelson about purchasing some rockets to get our certifications done. He said he sells fully ready to go rockets that are basically made for certification flights, so they are pretty foolproof! We would need to purchase one rocket kit that is good for L1&2 certs and another kit that is good for L3. He said that's really the most cost effective way it can be done because the L3 is too big to get an L1 cert, and the L1/2 is too small to accept an L3 motor. Anyway, that was the conclusion we came to. I asked him about cost and it would be roughly $280 for the L1/2 and $360 for the L3, not including motors. I was hoping we could get all of this stuff with our senior design money, but it's a little too much, but I think we figured something else out! In the grant, there's over $1500 set aside to purchase model rocket kits for the club/rocket project. We could use that money to buy everything we would need to get certified, including the motors on certification day!

Frank Ross also mentioned that for the L2 and L3 cert, our rockets would need to have dual deployment. I brought this up to Buddy and he suggested that we use all of the electronics we plan on using for our competition rocket in the certification rockets first. He said this would give us some good practice using the equipment and learning how to use it before we put it in our competition rocket. I think that is what we should do. He sells everything we would need for the

cert flights, and it would also work for the competition, and all of that money is also already budgeted.

So at this point, I think we need to order the two rocket kits and get it in our schedule to go get certified. Shishir, I think we should follow Buddy's suggestion and just get all the electronics from him so we know we have a flight package that will work. Let me know what you think.

As far as the budget goes, we are a little over on some of the systems, but way under in other areas. So, we are good on funding right now.

If anyone has any comments or questions, or suggestions let me know!

Thanks,

Derrick

ISRC/Senior Design

Team Meeting

**12 February 2020** / 4:30 PM / MCERC Conference Room

Attendees

Derrick Likes(President), Shishir Khanal(Vice-President), Dr. Marco Schoen(Advisor), Kellie Wilson (Advisor)

Absent

Derek Anderson - Excused (Illness)

Call to order

4:40 PM

Agenda

### Last Meeting Follow-up

- Derrick has a calendar of the cert launch dates through may. Dragonplate tubing has arrived. By next monday/tuesday the two model cert rockets should be here as well as all of the recovery hardware for the competition rocket. Shishir has ordered all of the avionics and they will be here hopefully next week as well.

### New Business

- ISR Club Update
    - For next week's meeting, we are thinking of inviting the club because we will have hardware to work on. We can see who is really interested to take this project on for next year

- Senior Design Update
    - Our next project update is on April 8th, 2020. Our update will primarily consist of our build report with pictures etc., and certification progress.

- Rocket Update
    - Our priority right now is to get all our parts and start building.
        - We also need to get certified. Who can be there for cert launch days?
            - NAR Launch Dates: 3/21/20, 4/18/20, 5/16-17/20
            - TIR Launch Dates: 3/21/20, 4/11/20, 5/2-3/20, 5/16/20
            - Possibly find some underclassmen who want to get certified and could go to New Mexico in the event we can't go?
    - Since we will have parts next week, we should plan on building Thursday nights after a brief meeting until this thing is done.
    - Buddy said if we have any construction issues, call him!
    - The updated grant for next year's project is due 3-18-20. Derrick is working on it.

### Action Items

- Derrick
    - Complete grant that is due next week
    - Confirm details for certification flight with NAR and TIR
    -
- Derek
    - Complete 3D drawings of the rocket.
- Shishir

    - Start interfacing the avionics and look at payload bay arrangement.

### Next Meeting Agenda

- Bring all hardware over to MCERC. Find suitable storage. Start putting everything together.
    - Pizzaaaaa

### Additional Minutes

- Everyone discussed topics from today's agenda. Derek inquired about tool and processing machines that are available at the MCERC for rocket construction. Derrick discussed the rocket budget. Kellie will network with the students in her rocket lab to get additional students to our meeting next week.

### Adjourned

5: 10 PM

### ISRC/Senior Design

### Team Meeting

**20 March 2020** / 3:48 PM / Email

### Attendees

Derrick Likes(President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor), Shishir Khanal (Vice President)

### Absent

None

### Call to order

3:48 PM

### Agenda

Because of COVID-19, this week's meeting was over email. This was the update:

Mar 20, 2020, 3:48 PM (11 days ago)

Hey everyone!

Lets just count this as our meeting for this week. As far as updates for the grant: I have it all done, I have all of the attachments I need from everyone so I can bind it all together and submit the whole package to Steve Wright. The grant deadline was extended to April 1st, Steve was happy to hear that because now he can look over it more before he submits it.

As for the rocket project, I think everything we've ordered is there on campus just waiting for us in the engineering office. But with everything being shut down, I'm not sure when we would be able to get down there and get stuff done. A lot of the certification flights have been cancelled or postponed because of the virus, so i'm touching base with NAR and TIR to see what their plans are for future flights.

HeroX has posted a few times regarding the competition. They haven't cancelled it yet, but are meeting weekly to discuss potentially cancelling it for this year. I guess we will have to see how bad the virus gets. I think right now there are quite a few

international teams that can't physically get here at this point. Between universities (like ISU) banning any school sponsored travel to foreign and domestic governments banning travel from specific areas, who knows if the competition will happen. But either way, we have the bulk of our parts here for this year and future years at ISU.

Thats all I really have right now.

Happy quarantine everyone!

DL

ISRC/Senior Design
Team Meeting

**04 April 2020** / 8:00 PM / Google Meet video call

Attendees

Derrick Likes(President), Derek Anderson(Secretary), Dr. Marco Schoen(Advisor), Kellie Wilson (mentor)

Absent

Shishir Khanal (Vice President) - excused - technical difficulties

Call to order

8:00 PM

Agenda

Last Meeting Follow-up

- Covit-19 updates

New Business

- ISR Club Update

    - We are gathering materials for next year's club. Since all activities have been halted, all materials and funds will be transferred to next year.
- Senior Design Update
    - We are continuing forward with the revised senior design schedule as set out by the course syllabus.

### Action Items

- Derrick
    - Complete the budget showing what items have already been purchased for this year and compare it to the grant.
- Derek
    - Aid Derrick in the budget.
- Shishir
    - Take all of the rocketry components to the MCERC to be safely stored.

### Next Meeting Agenda

- Discuss any relevant updates with the competition, senior design, or the grant feedback.

### Additional Minutes

- Derrick talked about what was happening with the competition and the grant for 2021. Derrick submitted the competition form stating that we want our place held for next year's Spaceport America Cup., rather than have those fees refunded. This will allow next year's team to bypass the gruelling, competitive application process.
- After the budget is reconciled, we will know how much more supplies we can purchase before the end of the year for next year's team.
- Derrick is working with Buddy Rocketman on ordering more model rockets for next year.

Authors: (1) Derrick Likes, (2) Shishir Khanal, (3) Derek Anderson

- Derrick submitted the grant to get funding for next year's team.

Adjourned

8:30 PM

ISRC/Senior Design

Team Meeting

**16 April 2020** / 8:00 PM / Email

Attendees

N/A

Absent

N/A

Call to order

8:00 PM

Agenda

Email from this week

- This week our meeting consisted of an email. Due to the COVID-19 shutdown, and the semester wrapping up, this was our update. The email was sent out to our team and advisors.

Hey everyone,

I didn't think there were enough updates to justify a meeting. The only update I have is that the Idaho Space Grant Consortium got back to me and said they are happy to see our application. They will be reviewing everything in the coming weeks and should have a response by mid May.

If anyone else has an update for this week, just respond here so we can all get the update.

Thanks everyone and have a good weekend!

DL

## V. Correspondence

Idaho State University

Derrick Likes <likederr@isu.edu>

**Idaho State University Rocket Team**
4 messages

**Derrick Likes** <likederr@isu.edu> Thu, Feb 20, 2020 at 11:31 AM
To: ky@the-rocketman.com

Hey Buddy!

This is Derrick Likes, we just chatted on the phone, So our basic dimensions are 10' long, 6" diemeter and between 45 and 60 lbs weight.

My paypal email is: PayPal.Me/derricklikes

Thank you so much for your help!!

**Rocketman Parachutes** <ky@the-rocketman.com> Thu, Feb 20, 2020 at 11:53 AM
To: Derrick Likes <likederr@isu.edu>

Hello Derrick,

That link isn't working for me, can you send me your personal email?

Thanks,
Buddy Michaelson

[Quoted text hidden]

**Derrick Likes** <likederr@isu.edu> Thu, Feb 20, 2020 at 11:54 AM
To: Rocketman Parachutes <ky@the-rocketman.com>

Sorry about that!

It's likesfam@icloud.com
[Quoted text hidden]

**Derrick Likes** <likederr@isu.edu> Thu, Feb 20, 2020 at 1:45 PM
To: Rocketman Parachutes <ky@the-rocketman.com>

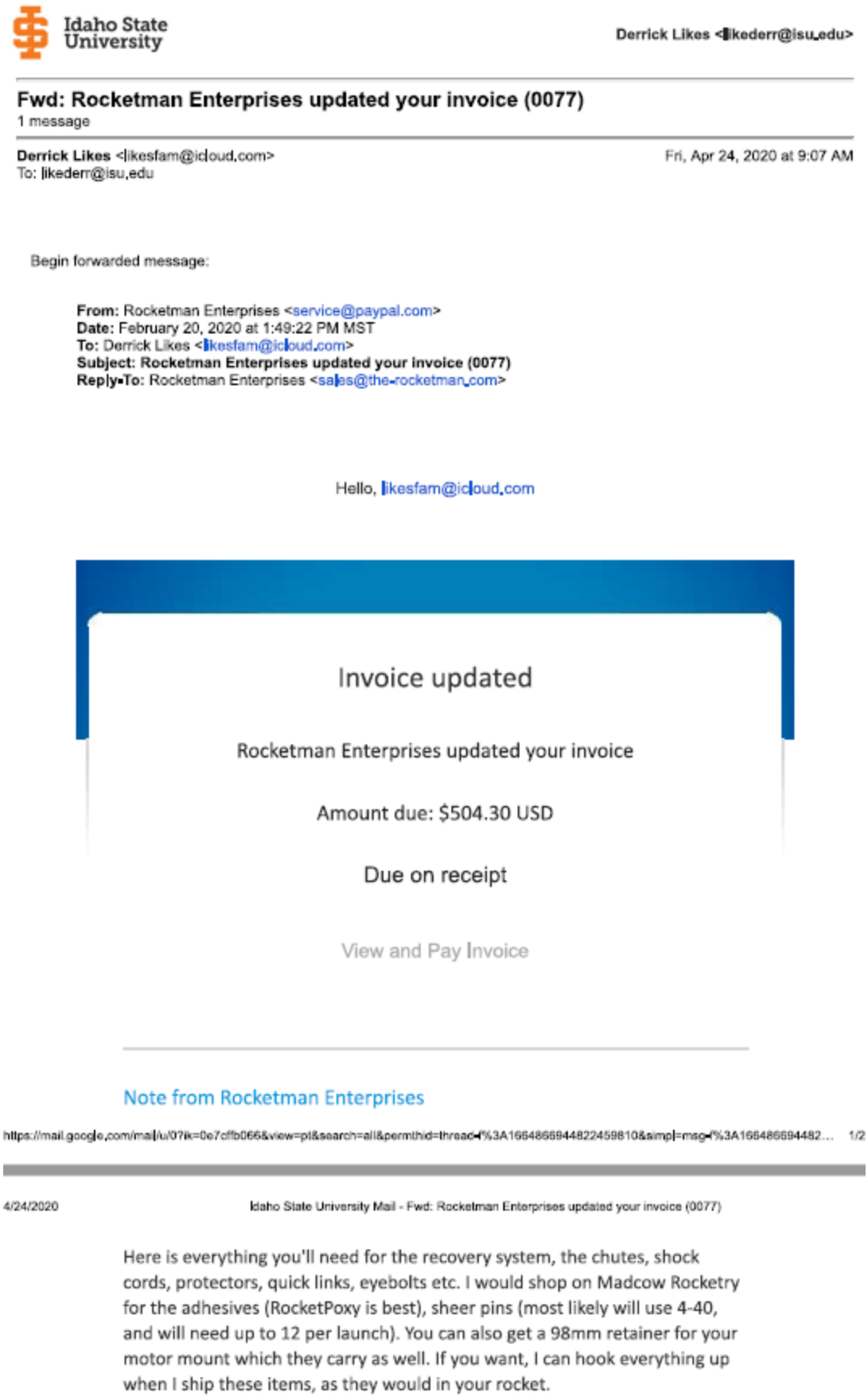
Hey Buddy!

Ok, the lady in our engineering department wants you to send the invoice to her email, and she can pay for it that way.

Her email is: bladlaur@isu.edu

She says she can pay it right now.

Thanks!



Idaho State University

Derrick Likes <likederr@isu.edu>

**Fwd: Rocketman Enterprises updated your invoice (0077)**

1 message

**Derrick Likes** <likesfam@icloud.com> Fri, Apr 24, 2020 at 9:07 AM
To: likederr@isu.edu

Begin forwarded message:

**From:** Rocketman Enterprises <service@paypal.com>
**Date:** February 20, 2020 at 1:49:22 PM MST
**To:** Derrick Likes <likesfam@icloud.com>
**Subject: Rocketman Enterprises updated your invoice (0077)**
**Reply-To:** Rocketman Enterprises <sales@the-rocketman.com>

Hello, likesfam@icloud.com

Invoice updated

Rocketman Enterprises updated your invoice

Amount due: $504.30 USD

Due on receipt

View and Pay Invoice

Note from Rocketman Enterprises

https://mail.google.com/mail/u/0?ik=0e7cffb066&view=pt&search=all&permthid=thread-f%3A1664866944822459810&simpl=msg-f%3A1664866944482... 1/2

4/24/2020 Idaho State University Mail - Fwd: Rocketman Enterprises updated your invoice (0077)

Here is everything you'll need for the recovery system, the chutes, shock cords, protectors, quick links, eyebolts etc. I would shop on Madcow Rocketry for the adhesives (RocketPoxy is best), sheer pins (most likely will use 4-40, and will need up to 12 per launch). You can also get a 98mm retainer for your motor mount which they carry as well. If you want, I can hook everything up when I ship these items, as they would in your rocket.

## VI. Statements of Capability

**Derrick Likes**

Growing up on a potato farm, Derrick has always utilized machines to get complicated jobs done. Doing so required him to learn how to service and maintain a wide variety of machines. Welding and fabrication are essential skills in this line of work. He spent many years learning how complicated mechanical systems interacted with each other to make heavy machinery do all the work. This experience, paired with several machine design and physics classes at ISU only enhanced this capability. During his time working as an infrastructure engineer, he further developed his leadership skills working with the United States Army Corps of Engineers, running daily production meetings, making sure everyone was on track to get the tasks completed on time. These leadership roles, coupled with his background in fabrication and retrofitting put him in the position of team lead.

The classes that most heavily impacted the design aspect of his role on this project are as follows:

- ME 1105 Solid Modelling
- ME 2220 Engineering DynamicsME 3320 Kinematics and Dynamics of Machinery
- ME 3323 Machine Design
- ME 3325 Advanced Machine Design
- CE 3341 Fluid Mechanics
- ME 4406 Measurement Systems Lab
- ME 4440 Vibration Analysis

**Shishir Khanal**

Shishir Khanal is an international student from Nepal. He is currently majoring in Mechanical Engineering and Physics and Minoring in Computer Science. He is currently working as a Tutor, Proctor, Grader and Outreach Assistant in the Department of Physics, ISU. His job deals with helping students understand the basic physics concepts and build tools to demonstrate the concepts. Similarly, he is currently the president of ISU Society of Physics Students, Vice-President of the Idaho State Rocketry Club, and Secretary/ Treasurer of the World Fusion Dance Club. He has taken a number of thermal fluid systems design, vibrations and controls classes and has completed a number of projects which makes him the best candidate for the responsibilities that he has undertaken on this project. In this report he is the author of ‘Propulsion’, ‘Avionics, Control System and Power’ and ‘Community Outreach’ sub-sections.

He has taken following classes has an important role in this project:

- ME 1105 Solid Modelling
- CHEM 1111 General Chemistry I
- ME 1165 Structured Programming
- CS 4499 Engineering Computation with C++
- EE 2240 Intro to Electrical Circuits
- PHYS 4461&4462 Intro to Mathematical Physics I & II
- CE 3341 Fluid Mechanics
- ME 4476 Heat Transfer
- ME 4451 Compressible Fluid Flow
- ME3323 Machine Design
- ME 4406 Measurement Systems Lab
- ME 4440 Vibration Analysis
- ME 4425 Mechatronics
- ME 4473 Mechanical Control Systems
- ME 4499 Intelligent Controls & ML
- CE 3361 Engineering Econ & Mgmt
- PHYS 2212 Engineering Physics II
- PHYS 4483 Theoretical Mechanics
- PHYS 4481 Classical Mechanics
- PHYS 4421 Electricity and Magnetism I*
- PHYS 4422 Electricity and Magnetism II(Spring 020)
- PHYS 4414 Electronics Instrumentation and Measurement(Spring 020)
- ME 4499 Adaptive Controls(Spring 020)

**Derek Anderson**

Derek Anderson is a mechanical engineering student at the Idaho Falls campus. He has worked in heavy industry as food processing maintenance mechanic for 3 years, where he solved issues with mechanical and electrical machinery in a timely manner to keep production moving. From this experience and ME 1105, he was employed for 3 years at Idaho Steel, designing the same type of equipment he had been repairing. Through these experiences and the classes at Idaho State University, Derek has learned how to effectively problem solve and attack design for a variety of problems. Derek has a great understanding for the design process, as well as the team player mentality that is necessary for success on a design team.

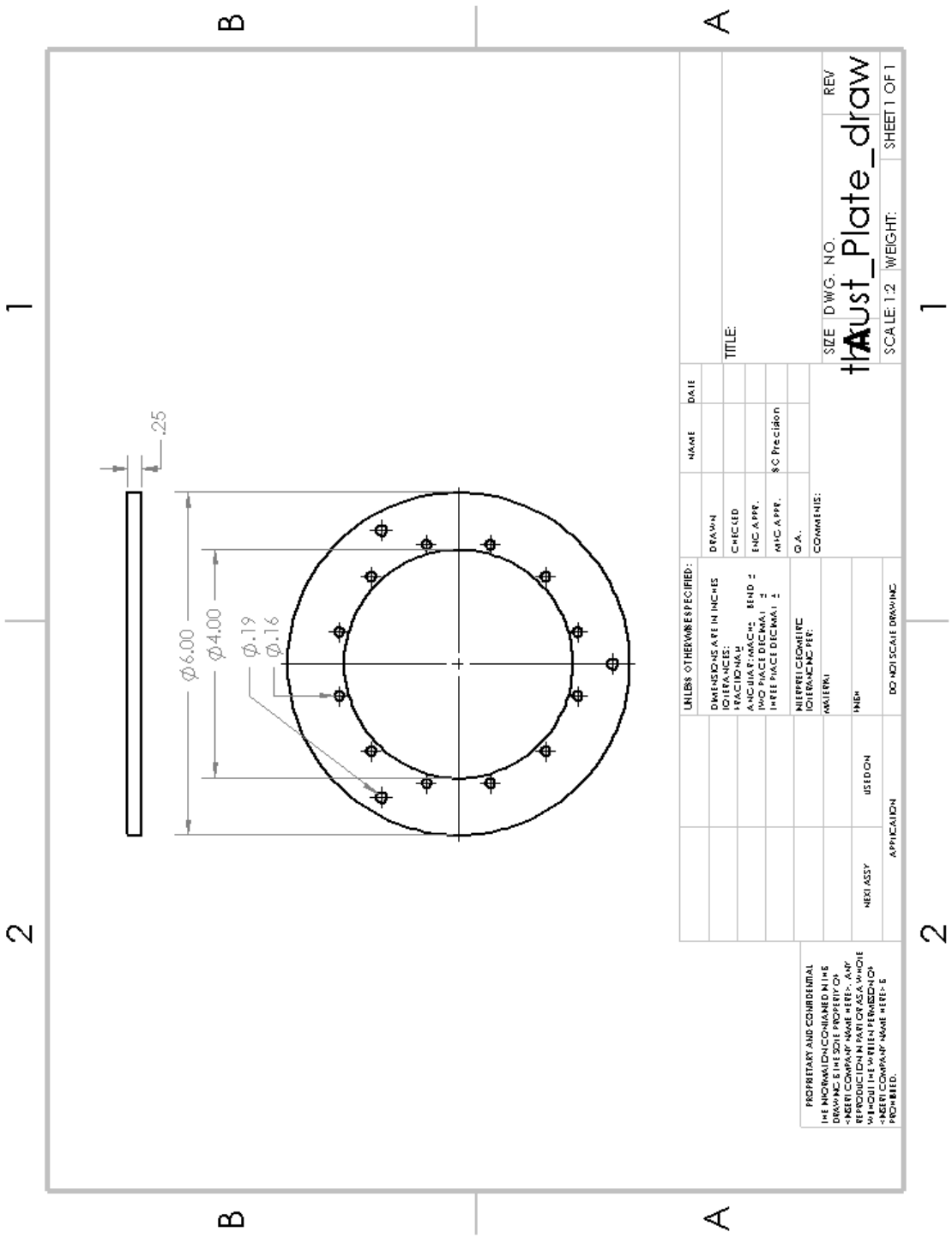
The following courses have qualified him for this project:

- ME 1105 Solid Modelling

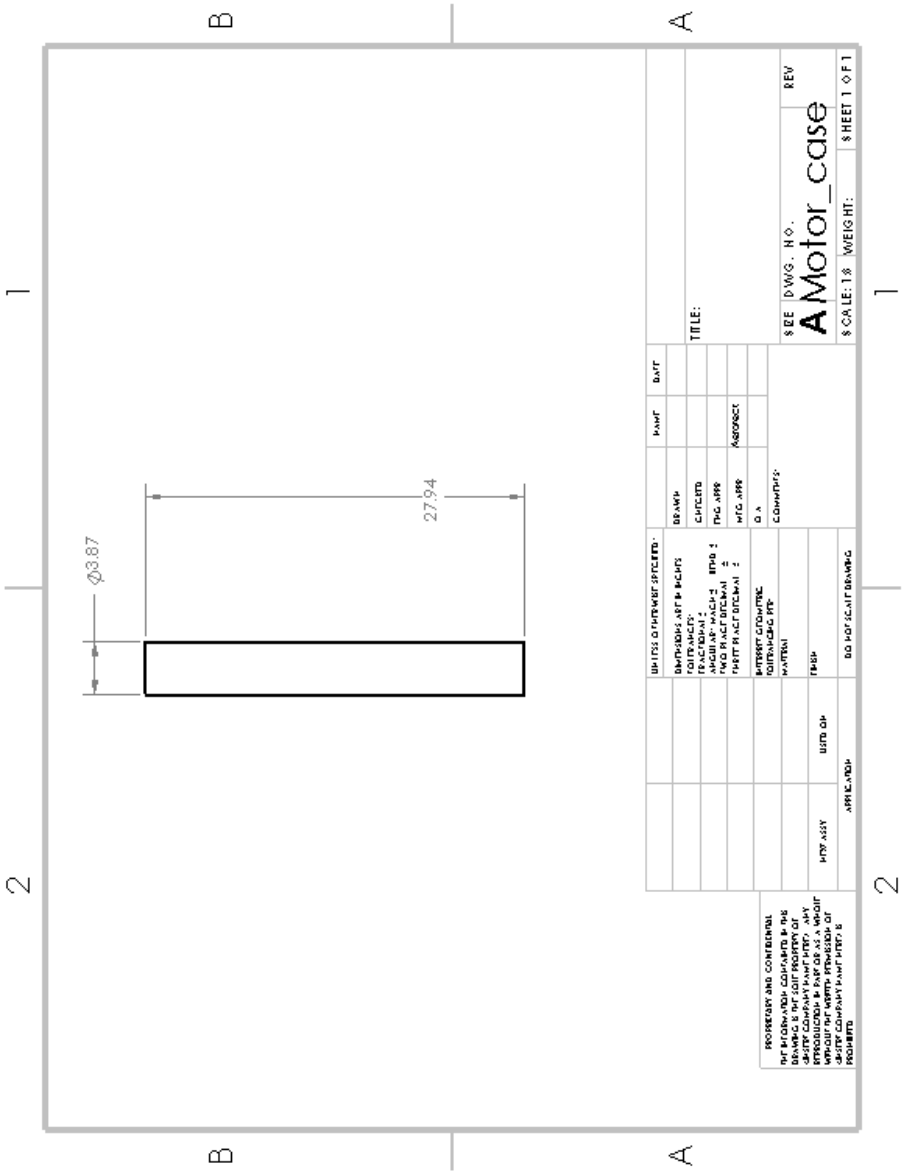
- ME 2220 Engineering Dynamics
- ME 3320 Kinematics and Dynamics of Machinery
- ME 3323 Machine Design
- ME 3341 Fluid Mechanics
- ME 4406 Measurement Systems Lab
- ME 4440 Vibration Analysis

# VII. Drawing files for the Propulsion System

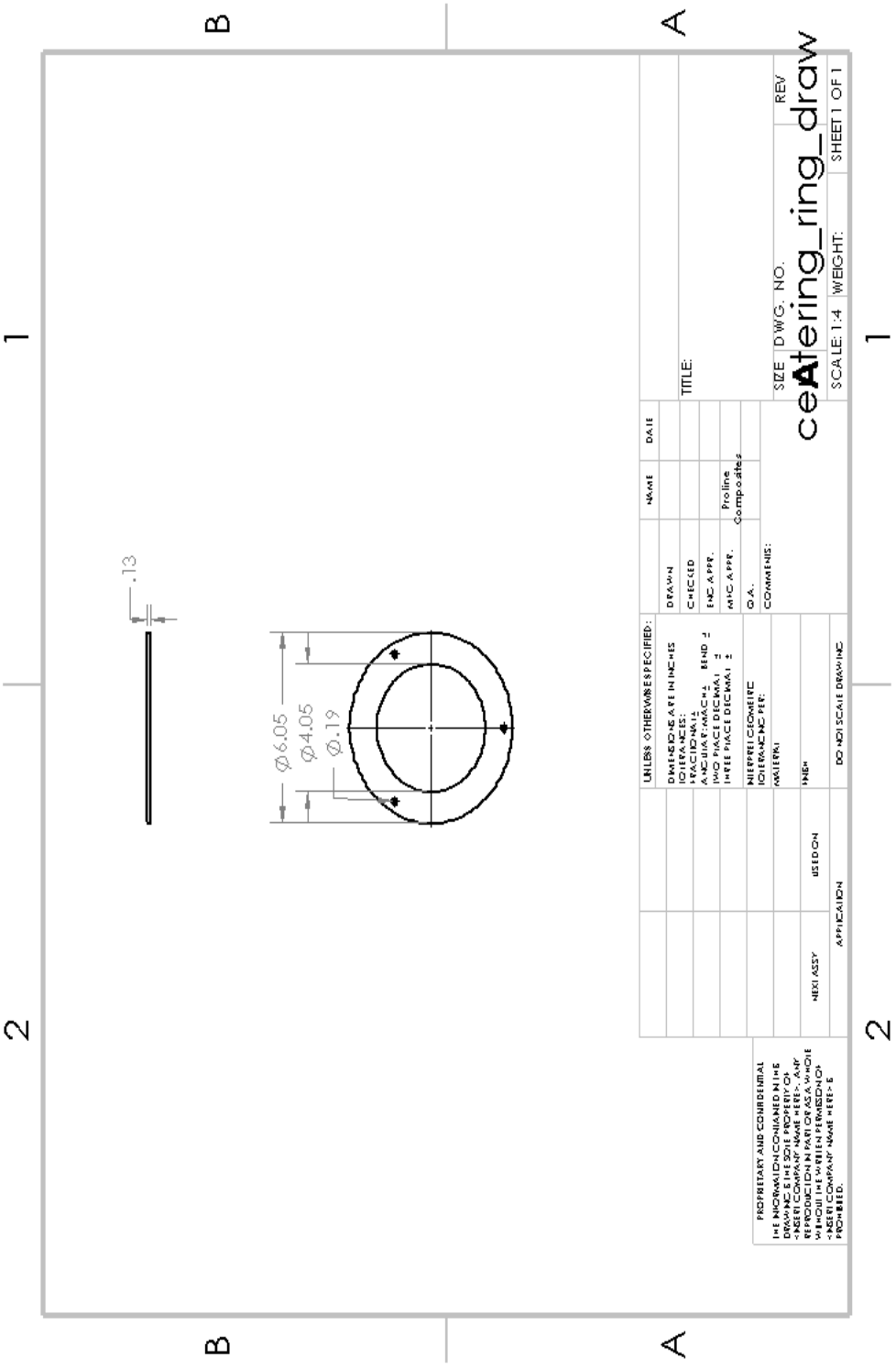
## A. Thrust Plate



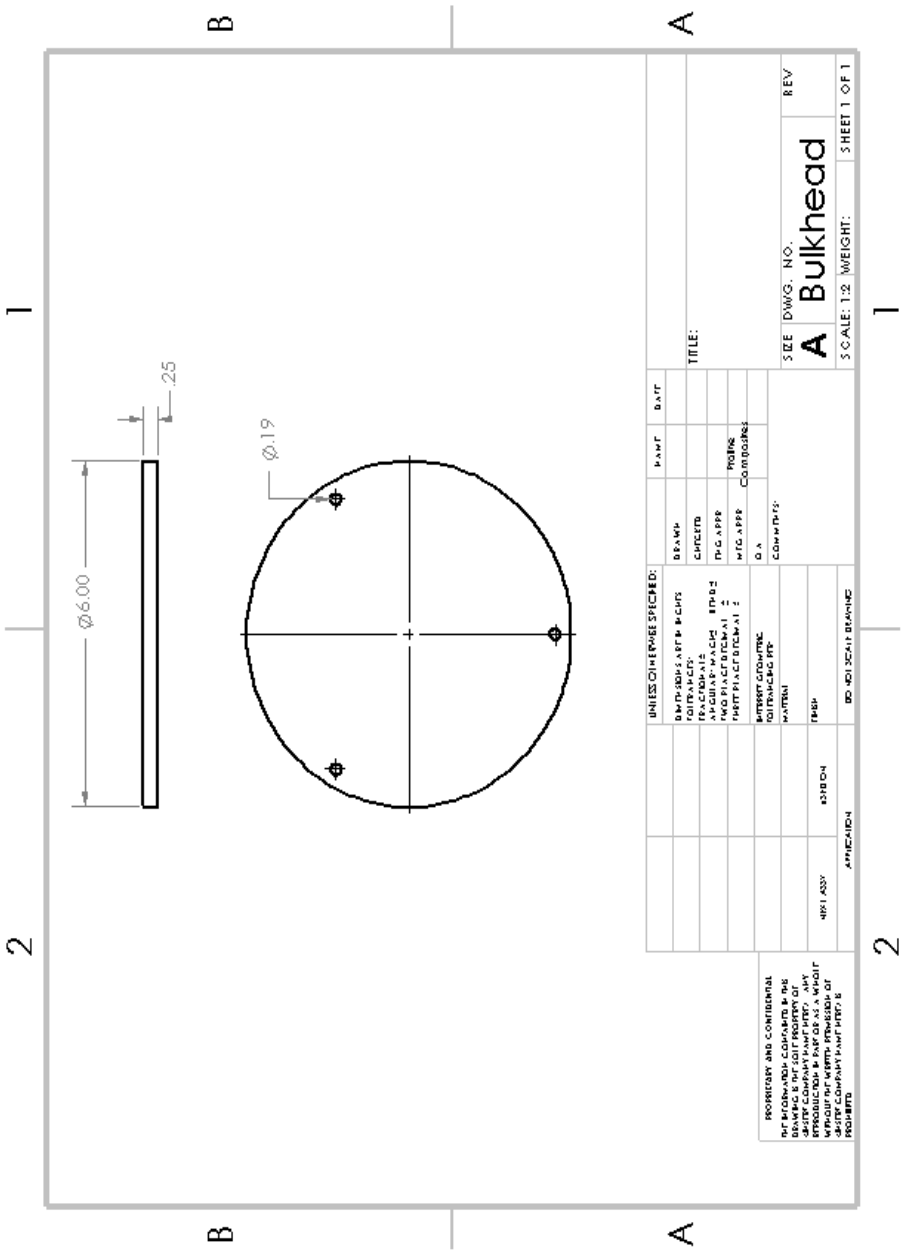
B. Motor Hardware



C. Centering Ring



D. Bulkhead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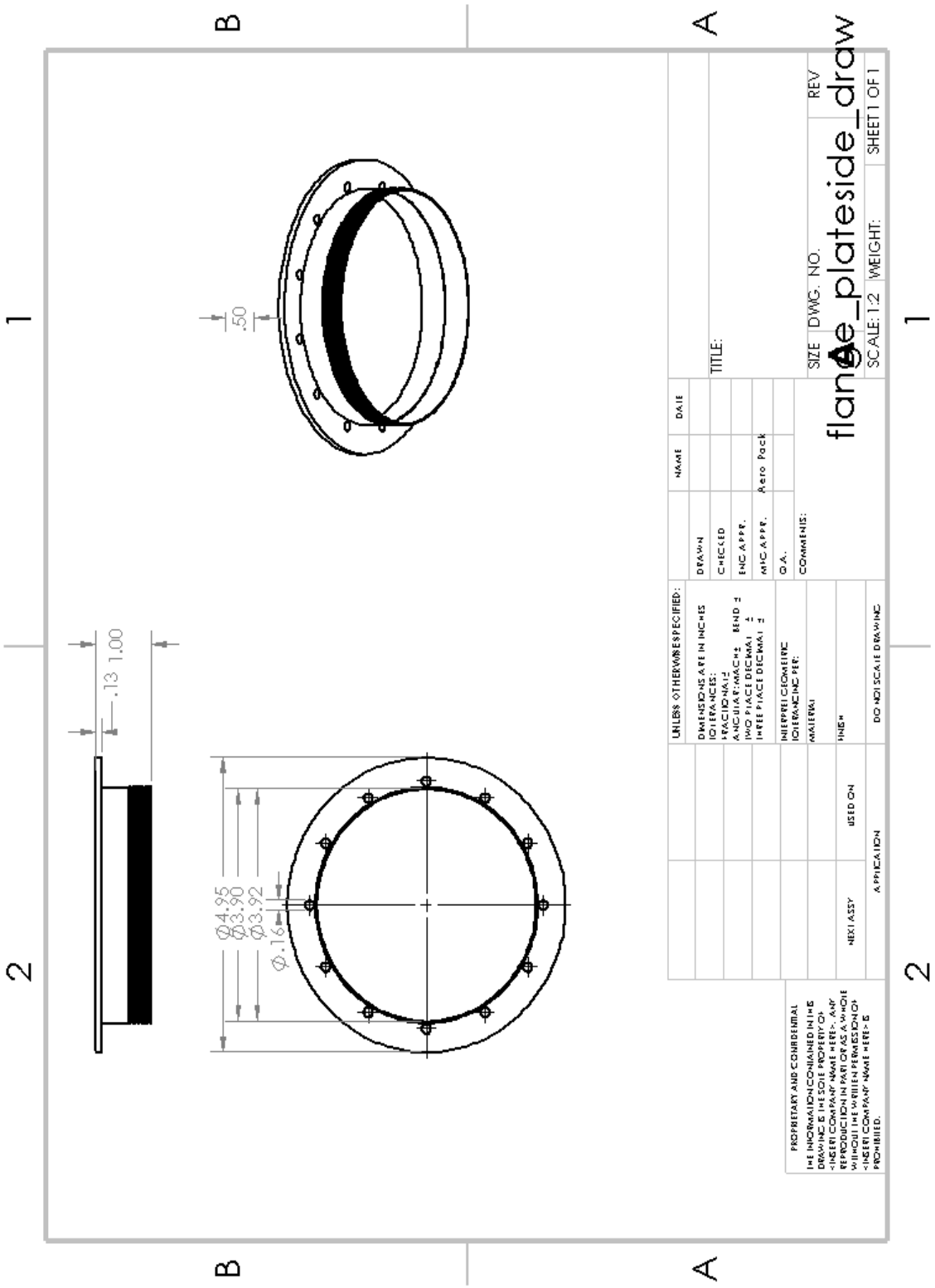
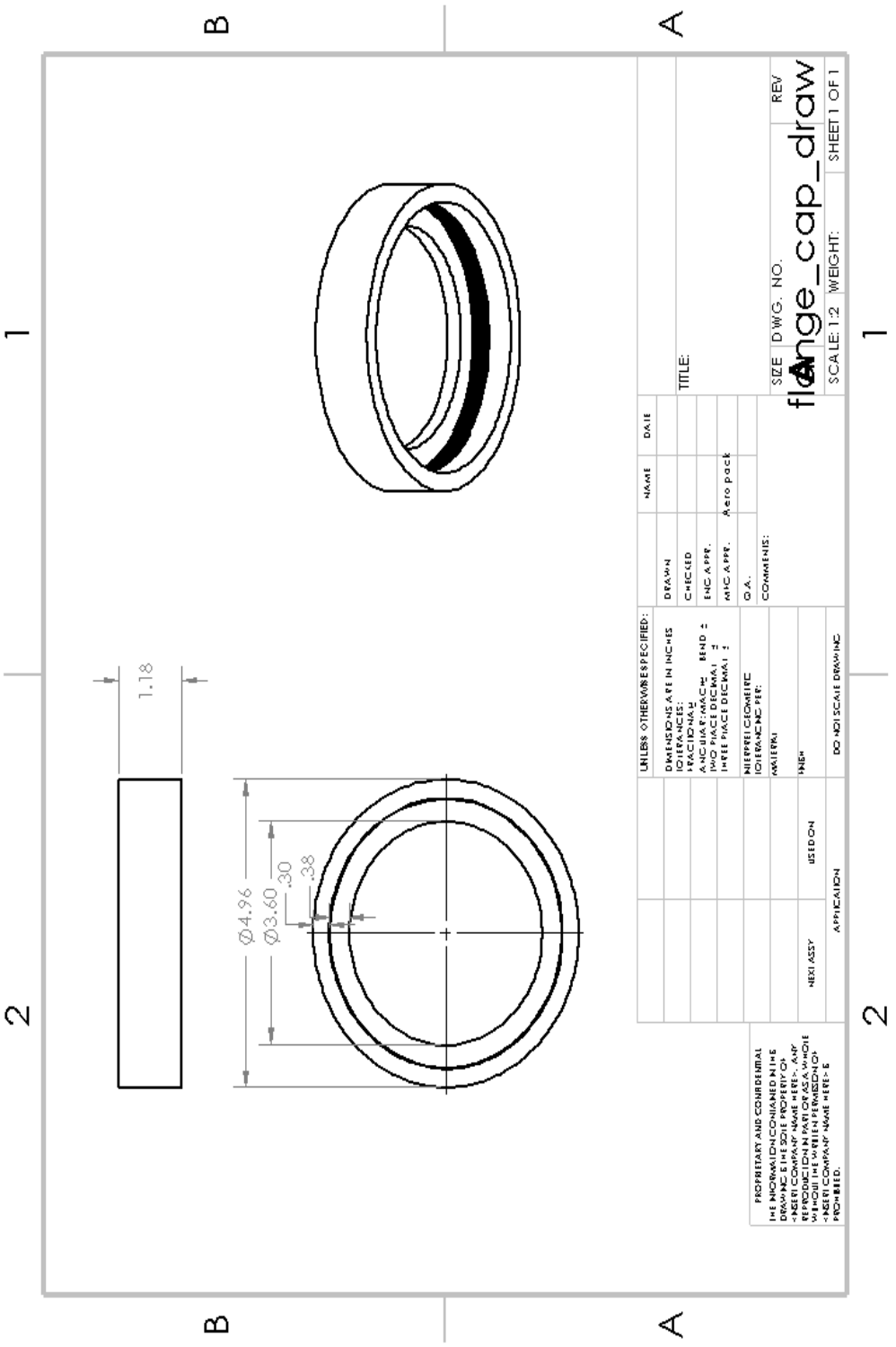
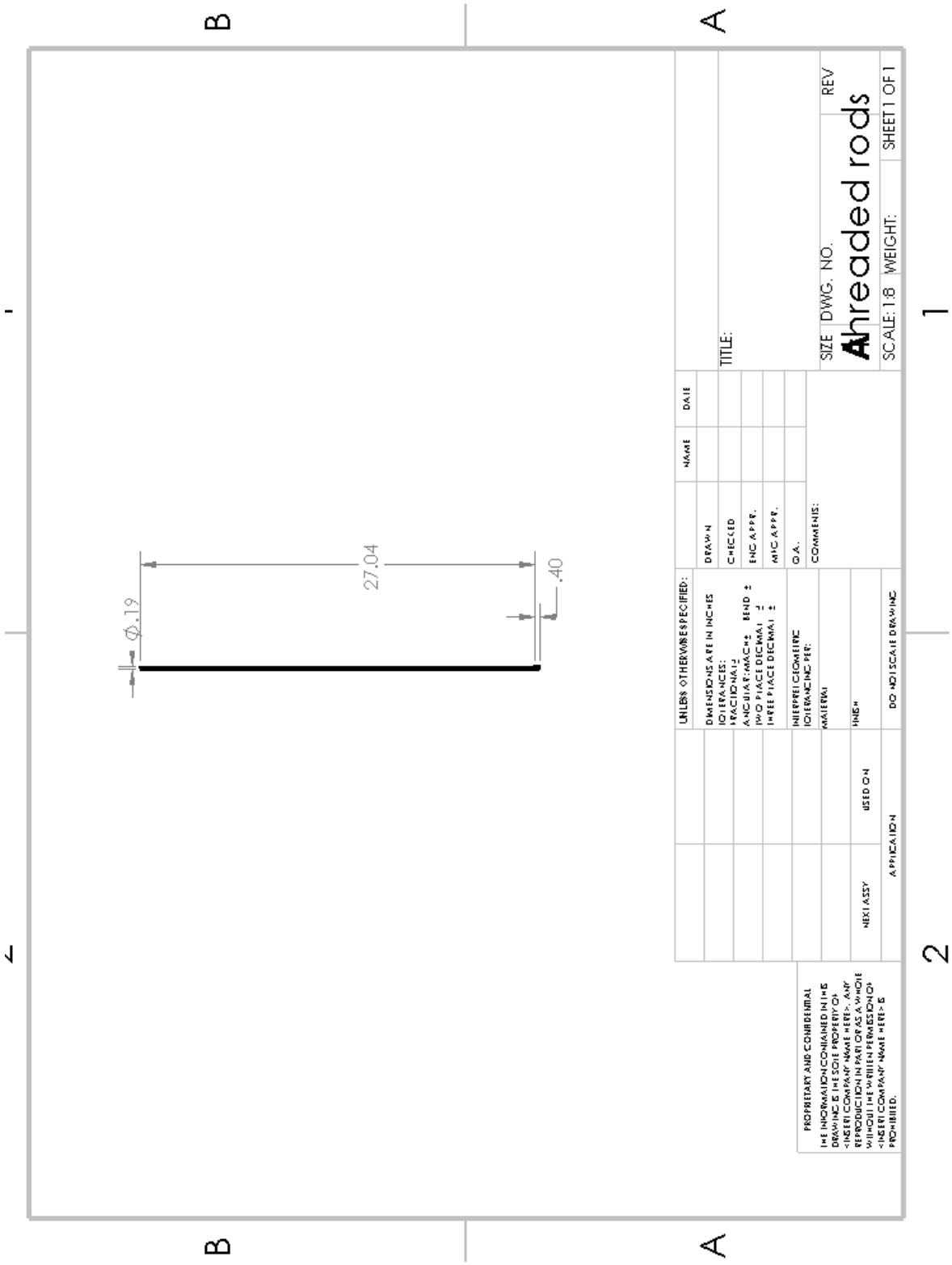
E. Flanged Retainer -Plateside



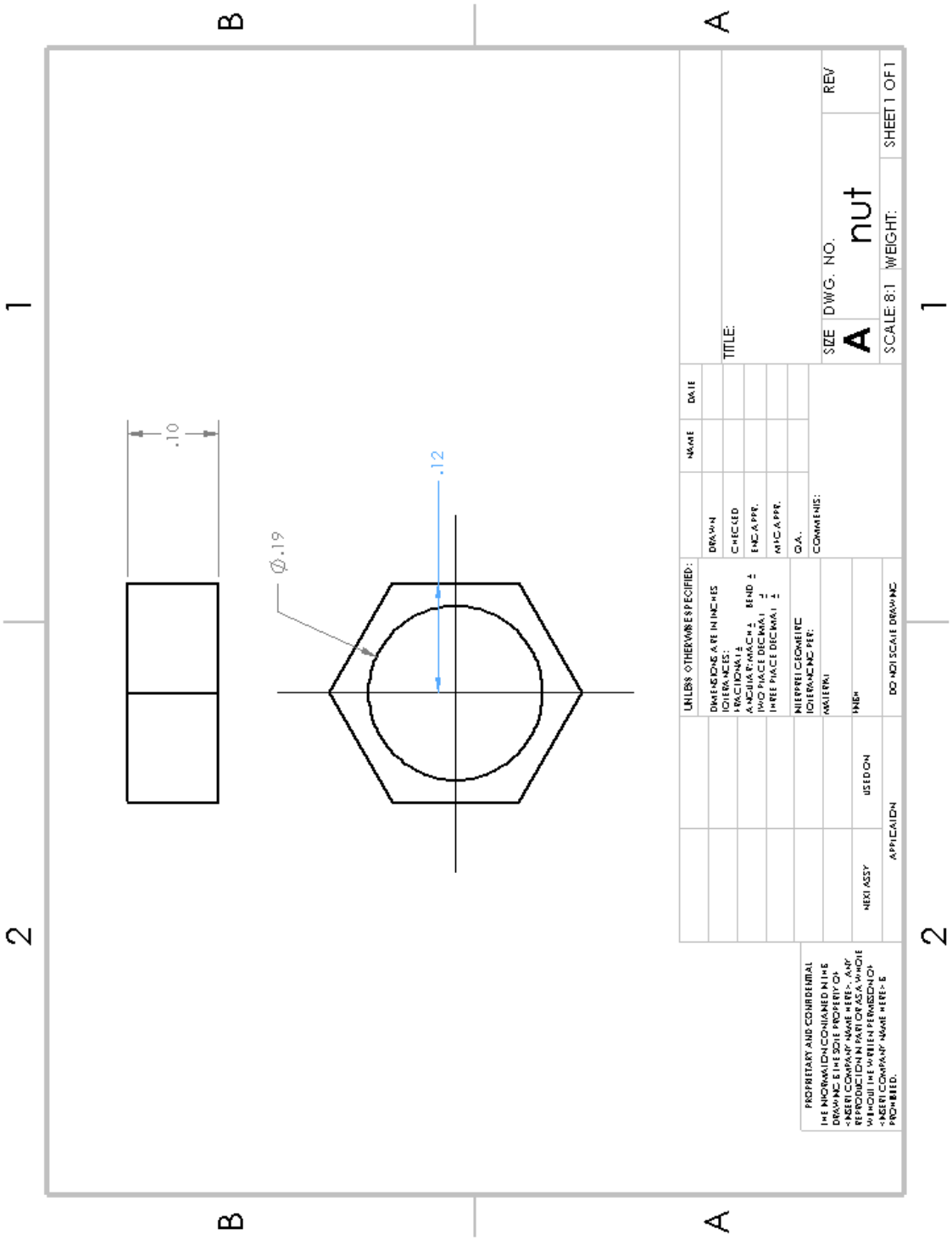
F. Flanged Retainer -Cap



G. Threaded Rod



H. Nut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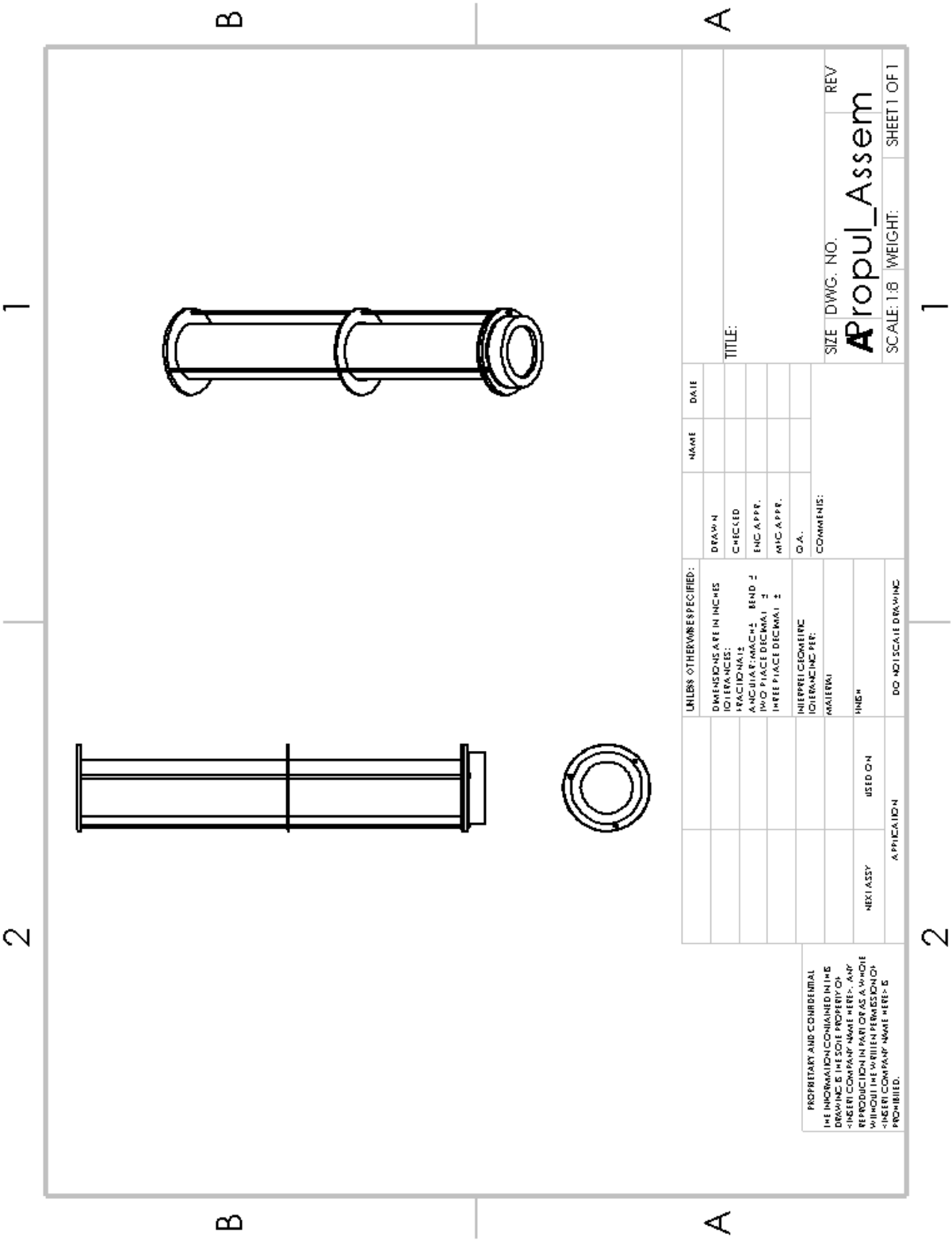
I. Propulsion Assembly



# VIII. Community Outreach Event

## Community Outreach

As a part of NASA Grant, an engineering focused school level outreach event was planned, designed, and executed through the Idaho State Rocketry(ISR) Club to the 4th grade of Riverview Elementary School located at Shelly, ID.

The outreach event - **'Water Rocket Design'** was designed by ISR Vice - President Shishir Khanal, the school search was done by ISR secretary Derek Andersen and the event-planning was done by ISR president Derrick Likes. The materials for the event was provided by the ISU Department of Physics Outreach through ISU professor and Outreach Coordinator Dr. Steven L. Shropshire.

A number of physics demonstrations were presented and design materials were provided to familiarize the students with the physical principles associated with the rocket design, provide exposure to the students with the design process and constraints. Appendix A1 contains the picture of the students of Riverview Elementary School with their rocket prototype.

*Figure 53: Fourth graders of Riverview Elementary School with their Rockets*

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