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# Final Design Review

# ME #4 - MAXQ

ME 4496 Project Design II

29 April 2020

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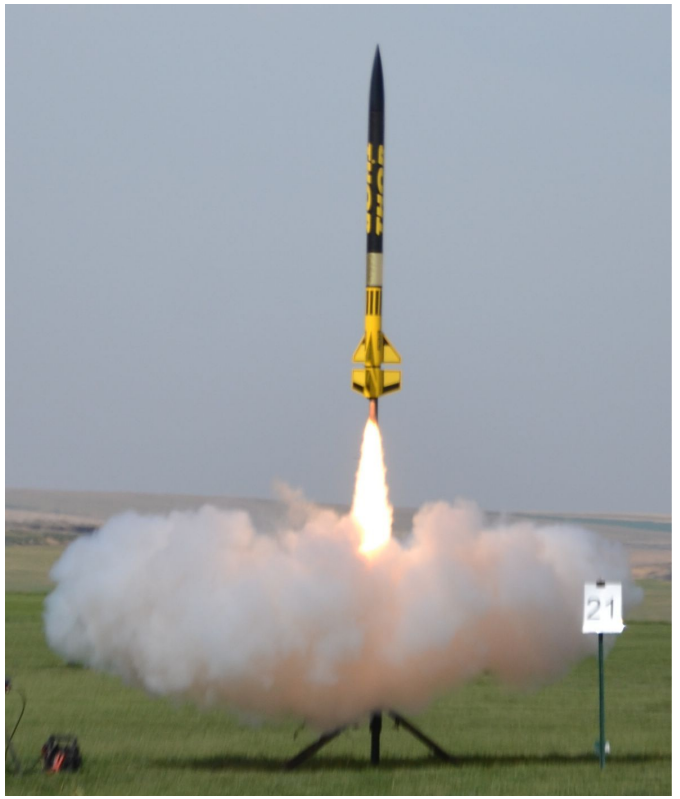
# Problem Statement

- Spaceport America Cup
  - Altitude: 10,000 ft
  - Solid Engine Class
  - Recoverable

- Fulfil all requirements for ME 4496A/B



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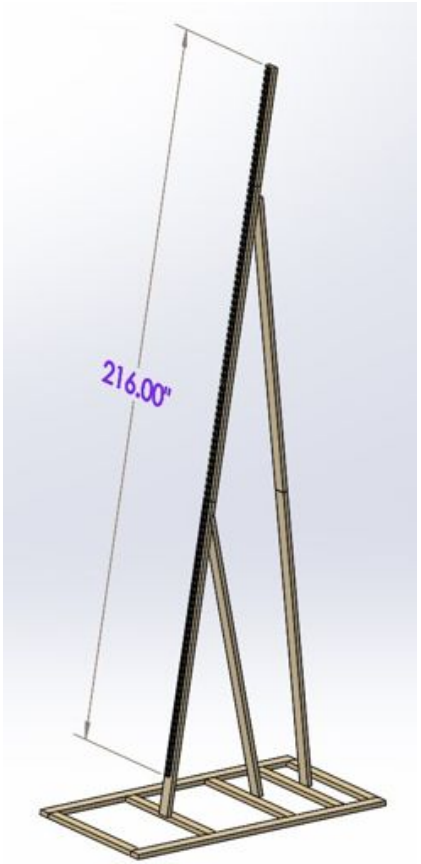
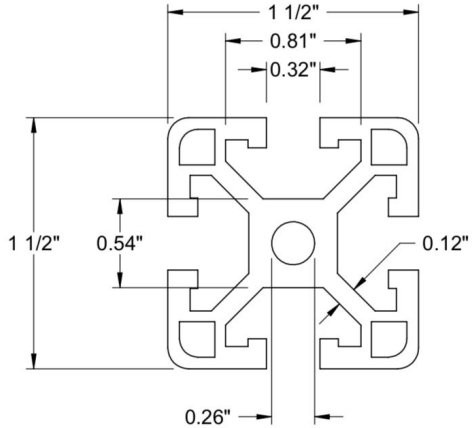
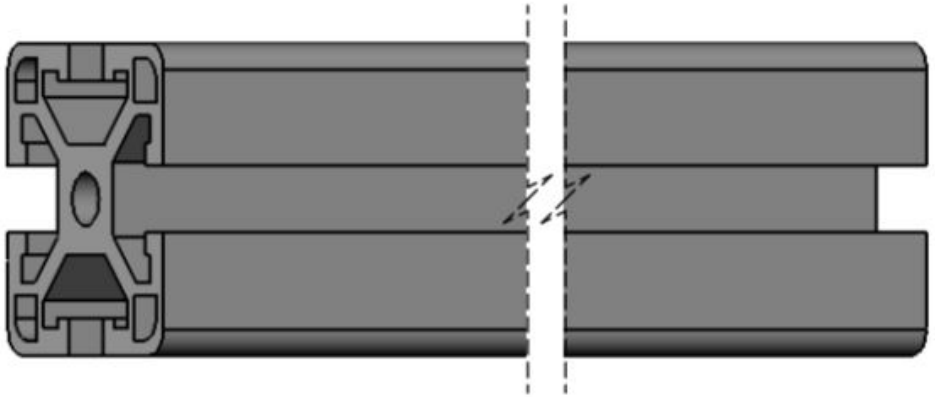
# Launch Components

- Launch Rail



- Launch Lugs

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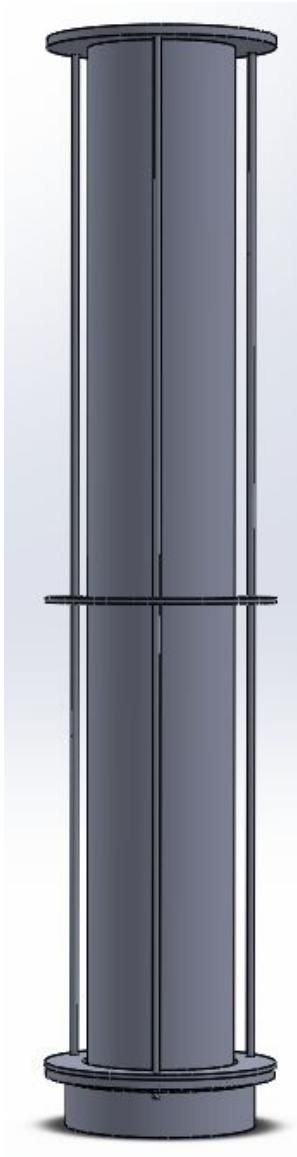
# Propulsion

- Objectives
  - Select a solid propellant motor
    - specific impulse of 9208 lbf-s
  - Select components and build the propulsion system
    - Motor
    - Thrust Plate
    - Centering Rings
    - Retainers
    - Rods and nuts



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# Propulsion Components

- Motor
  - Propellent
    - N-10000-VM-P
    - Weight: 7338 grams
    - Cost: $899.99(Aerotech N3300)
  - Hardware
    - Supplier: Aerotech
    - Weight: 6804 grams
    - Cost: $520

Fig: Aerotech Motor Hardware

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# Propulsion Components

- Thrust Plate
  - Supplier: SC Precision
  - Weight: 266 grams
  - Diameter: 6”
  - For: 98 mm motor
  - Cost: $67.45

Fig: Thrust Plate

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# Propulsion Components

- Centering Ring
  - Supplier: Proline Composites
  - Weight: 63.9 grams
  - Diameter: 6”
  - For: 98 mm motor
  - Cost: $39.9(for 2)


Fig: Centering Rings

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# Propulsion Components

- Bulkhead Disc
  - Supplier: Proline Composites
  - Weight: 135 grams
  - Diameter: 6”
  - Cost: $9.80

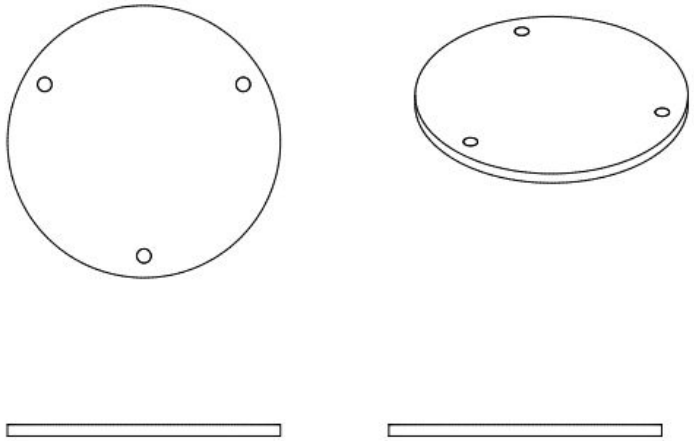

Fig: Bulkhead

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# Propulsion Components

- Flanged Retainer
  - Supplier: Aero Pack
  - Weight: 230 grams
  - For: 98 mm motor
  - Cost: $98.89

Fig: Flanged Retainer

# Propulsion Components

- Threaded Rods
  - Product #: LC.03401012.HD.DAR
  - Diameter ¾”
  - Cost: $67.5
- Nuts
  - Product #: 842176125206
  - Diameter ¾”
  - Cost: $48.45 (for 3)

Fig: Threaded Rods

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# Exploded View of Propulsion system

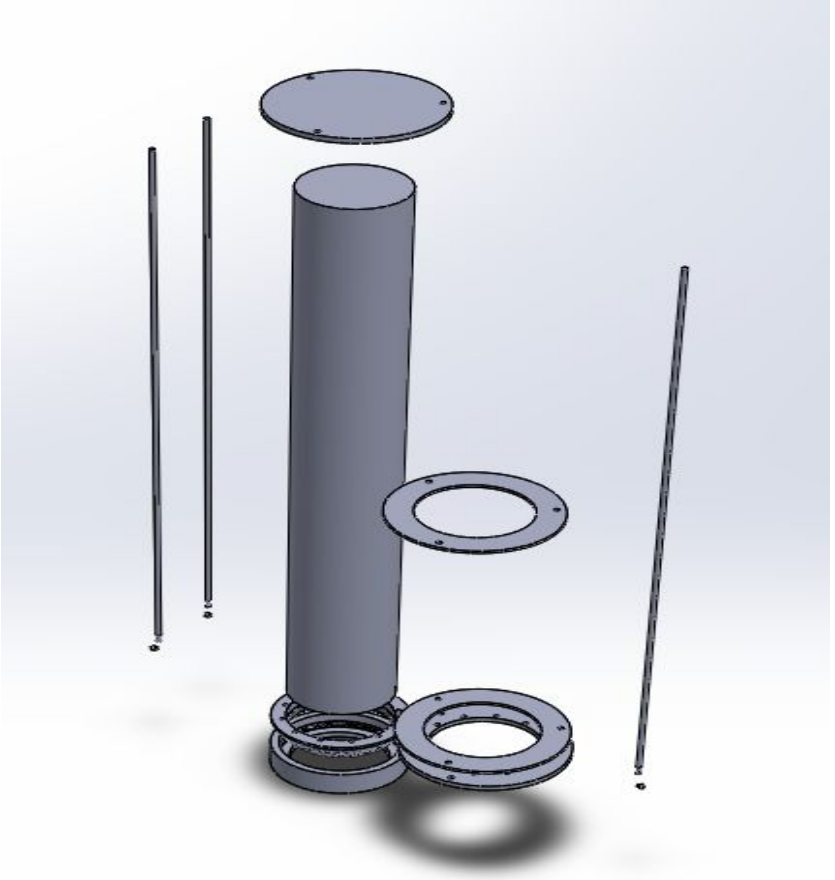
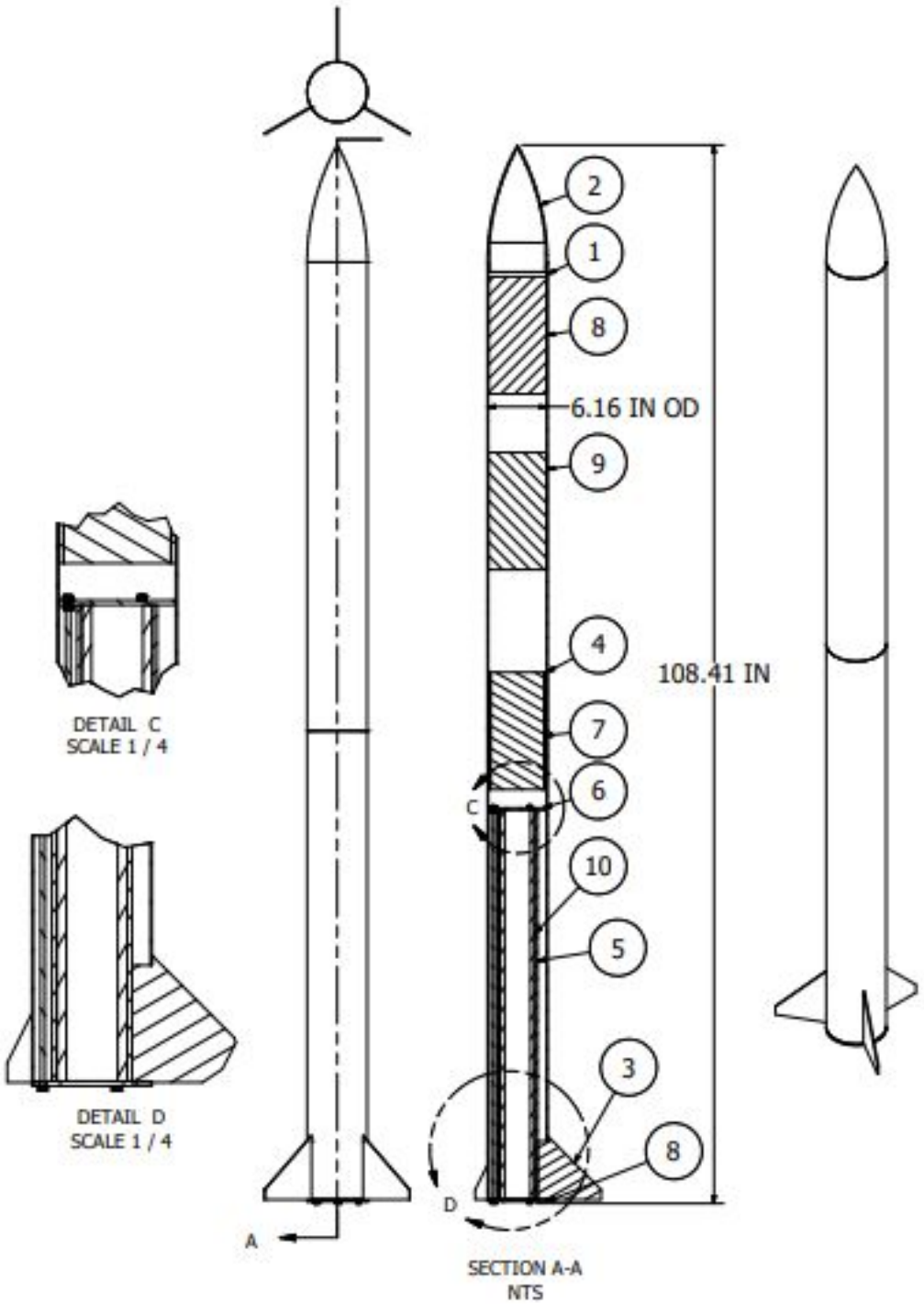


Fig: Exploded view of Propulsion system

# Structural Overview




| Bubble | Name | Material | Mass (LBM) |
|---|---|---|---|
| 1 | Fuselage | Carbon Fiber | 7.5 |
| 2 | Nose Cone | Nylon 6 (3DP) | 0.968 |
| 3 | Fins | Carbon Fiber | 0.519 |
| 4 | Coupler | Fiberglass | 0.063 |
| 5 | Motor coupler | Phenolic | 6.016 |
| 6 | Bulkhead | Aluminum | 0.684 |
| 7 | Parachute 1 | Nylon | 3.87 |
| 8 | Parachute 2 | Nylon | 2.36 |
| 9 | Electronics Bay | Various | 15.6 |
| 10 | Motor | Propellent | 21.875 |
| | | | 59.455 |

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# Structural Constraints

## Competition constraints

- PVC, PML, and stainless steel Prohibited for load bearing parts
- Joints must be “stiff”
- Joint must extend two body calibers past edge of adjoined sections
- Payload must be removable at weigh in and designed in units of CubeSat (10cmX10cmX10cm)

## Rocketry club constraints

- Design “legacy” rocket that can be re-implemented next year

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# Changes

- Fiberglass Coupler
- 3D printed nosecone finish Aerojet
- Through the wall fin design

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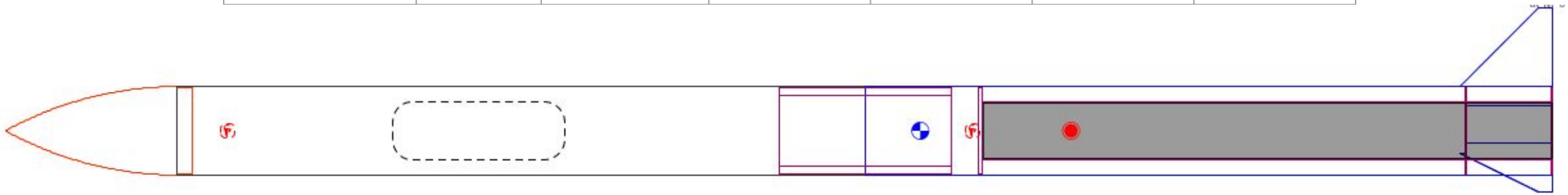
# Final Specifications

| 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 |



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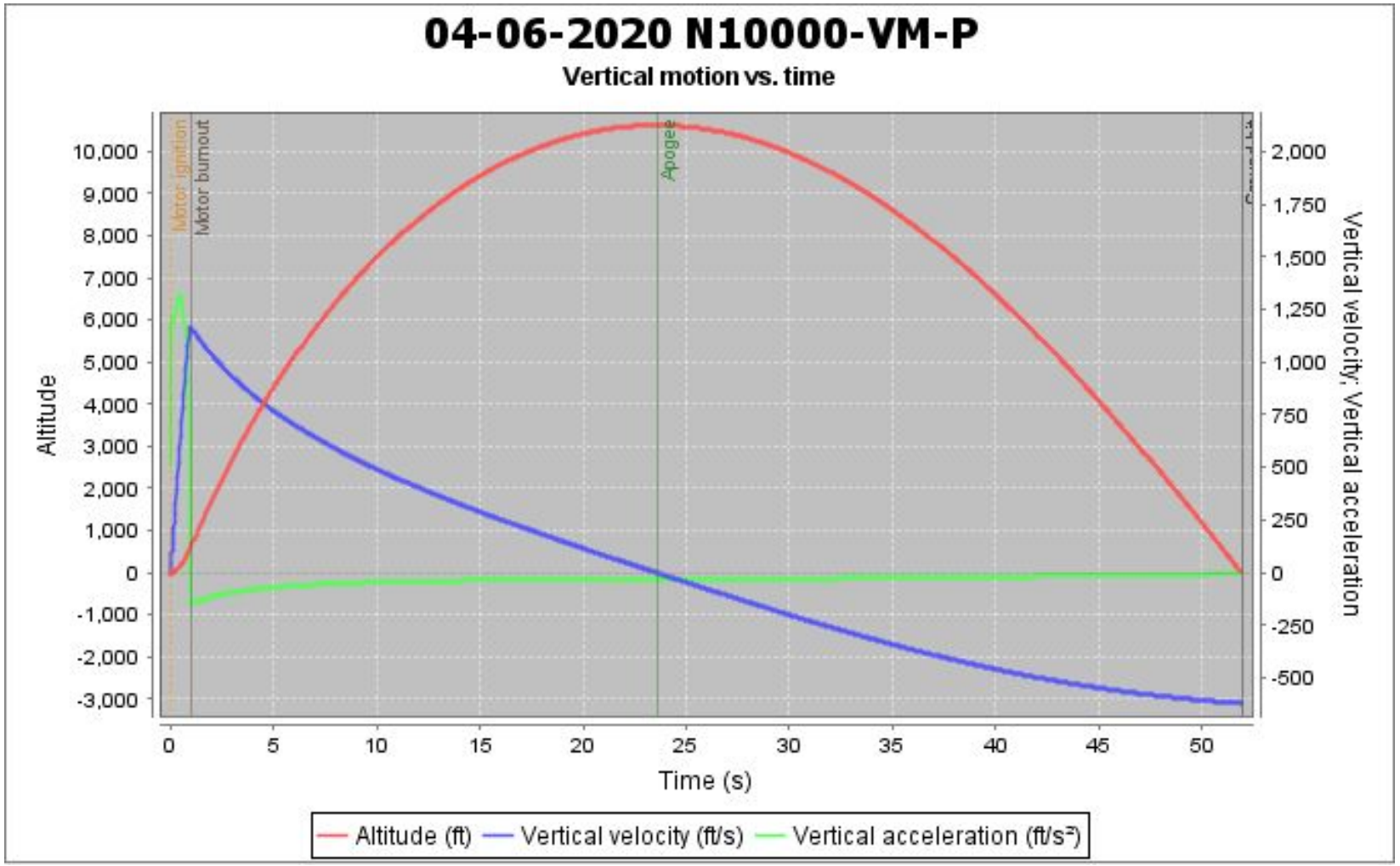
# Simulation Results



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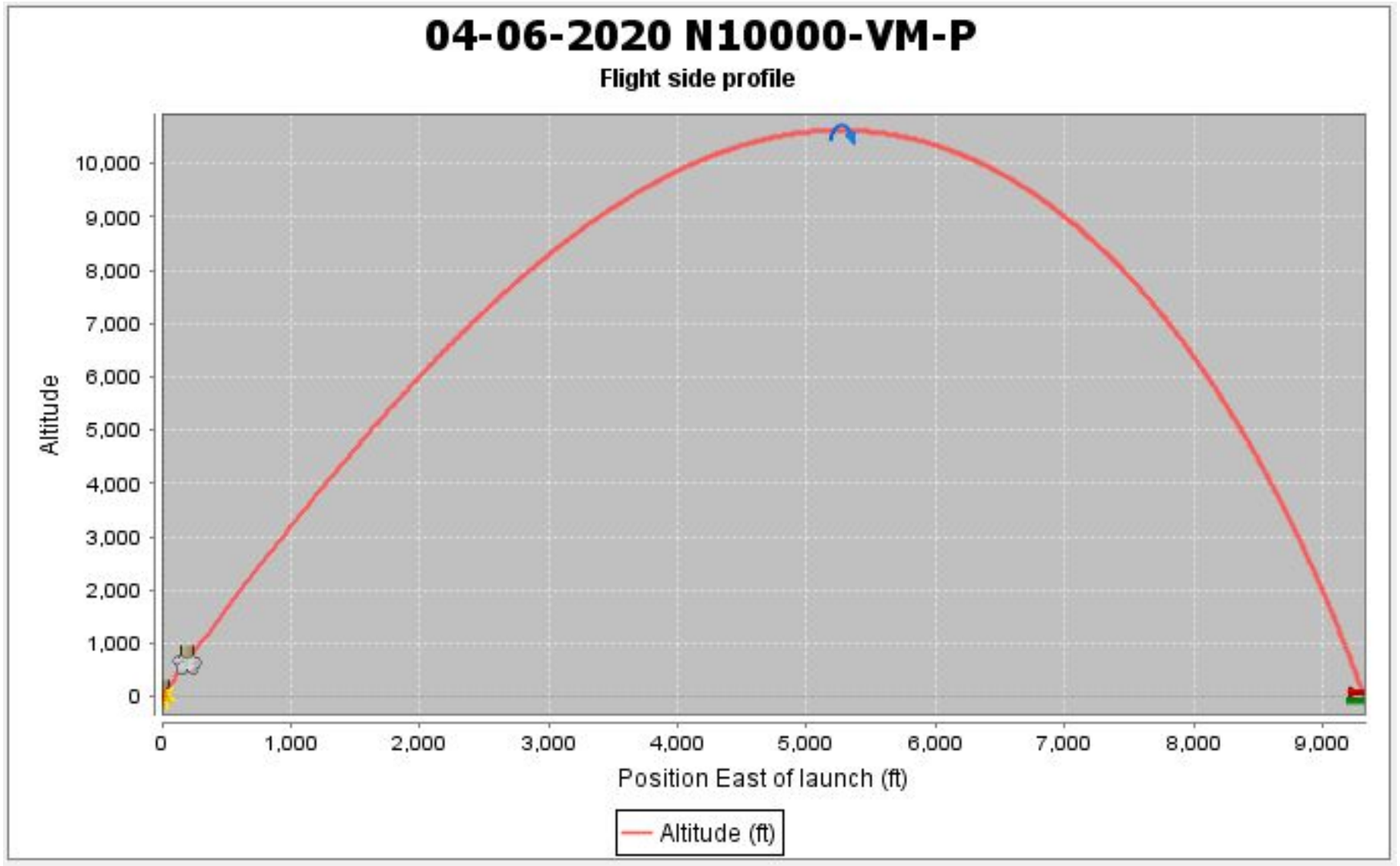
# Simulation Results



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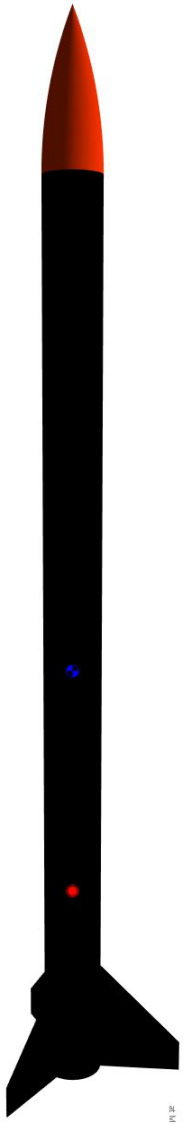
# Final Structure Specifications

- 3-d printed, Nylon 6, tangent ogive nose cone, 16” height
- Aerojet finish on nose cone
- 6” ID, 96” long carbon fiber fuselage, wall thickness 0.08"
- Total price $875.49
- Clipped Delta wings

| 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%)** |



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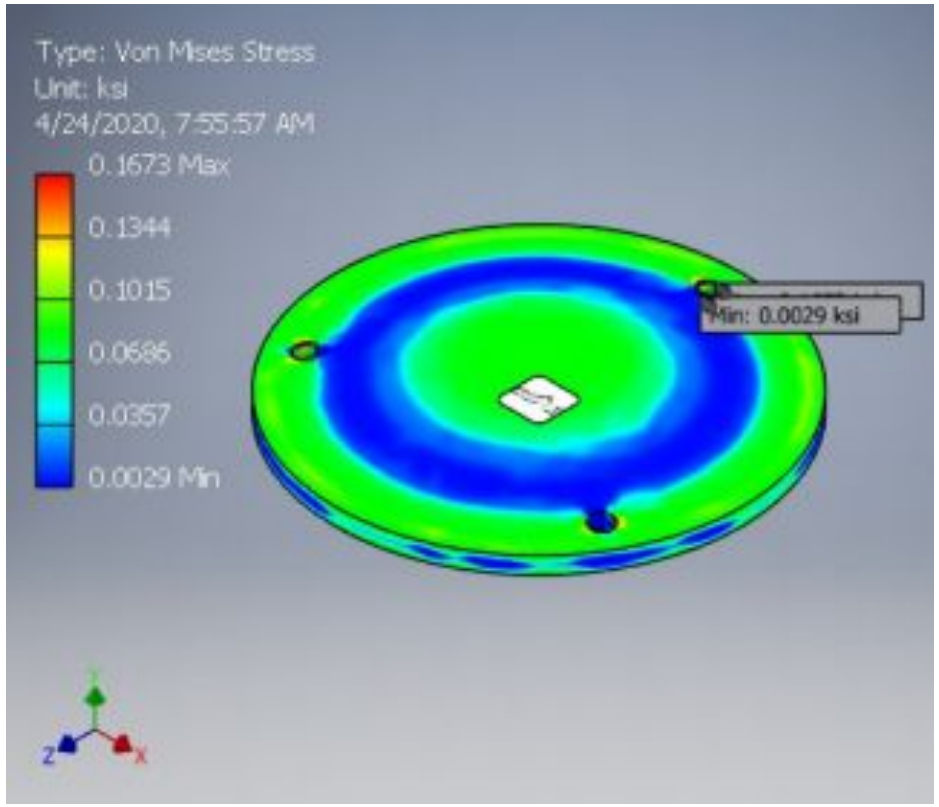
# Thrust Plate FEA Analysis




- Max thrust force = 2600 LBF
- Material: 6061 Aluminum plate ¼ IN
- Safety Factor: 15

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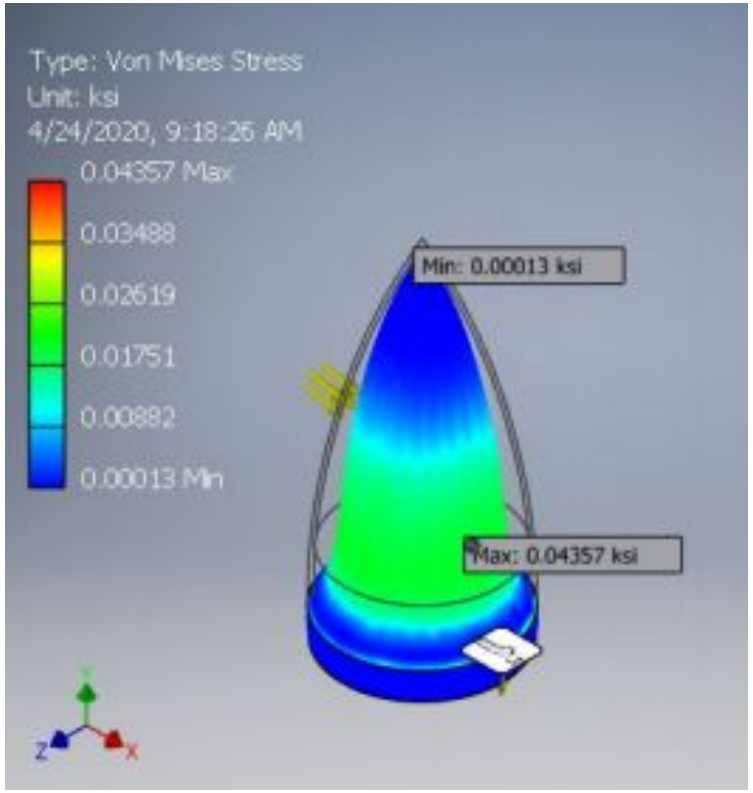
# Nosecone FEA Analysis




- Maximum Drag force = 202 LBF = 1.25 PSIG
- Material: Nylon 6, min thickness = .125 IN
- Safety Factor: 15

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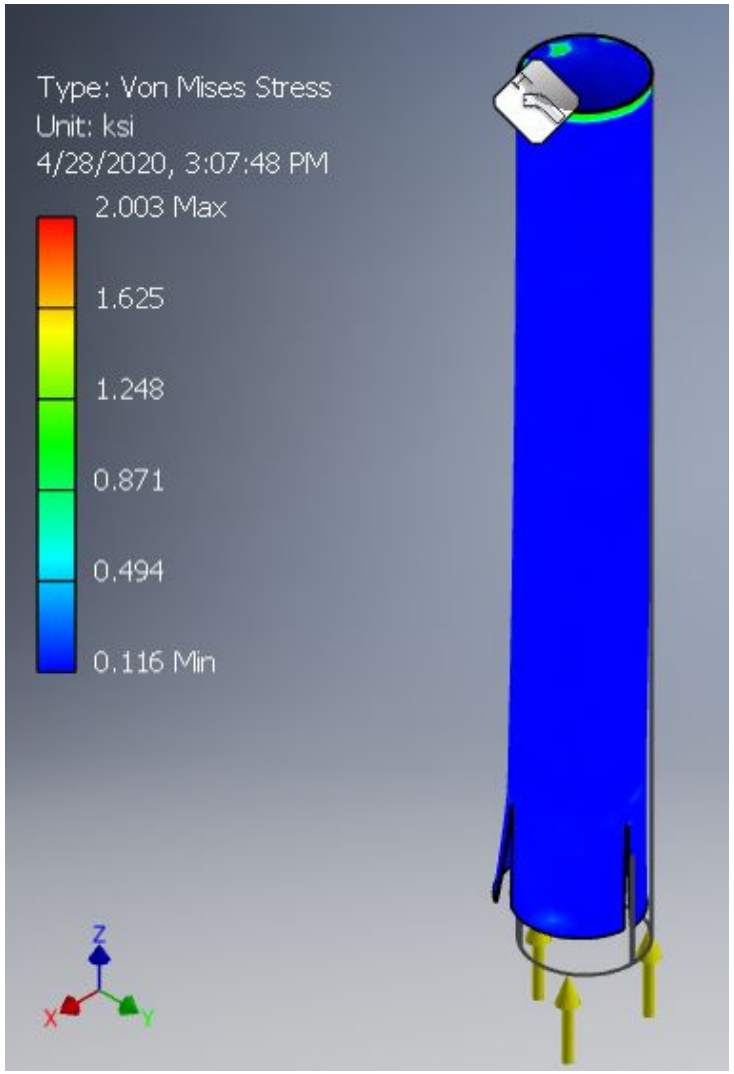
# Fuselage FEA Analysis




- Max thrust force = 2600 LBF
- Material: Carbon Fiber .080 in Wall Thickness
- Safety Factor: 15

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# Avionics & Controls

- Purpose:
  - Track the altitude and position of the Rocket
  - Achieve predictable height

- Avionics & System Controls
  - Ignition Control
  - Parachute Deployment Control

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# Avionics & Controls

- Avionics
  - Controllers
  - Main Avionics
  - Backup Avionics
  - Power

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# Avionics & Controls

- Controller
  - BeagleBoard
    - Cost: $125
    - Weight: 48 gms
    - Power: Max Power (P) = I*V = 3A*5V = 15 W
    - Power Camera
- Camera
  - Arducam Sony
    - Cost: $64.99
    - Clairity: 8 MP
    - Weight: 54 gms
    - Power: Max Power (P) = I*V =  0.02 A* 5V = 0.1 W

Fig: BeagleBoard


Fig: Arducam

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# Avionics & Controls

- Main Avionics
  - GPS/RTx System
    - Cost: $259.95
    - Power: Max Power (P) = I*V =  0.07 A* 9V = 0.00047 W
    - Telemetry using receiver in the LCD Screen
    - Real Time-flight parameters in the DAQ software

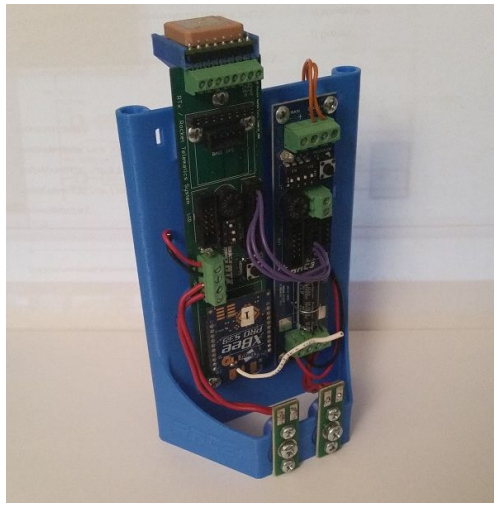

Fig: GPS & Altimeter System

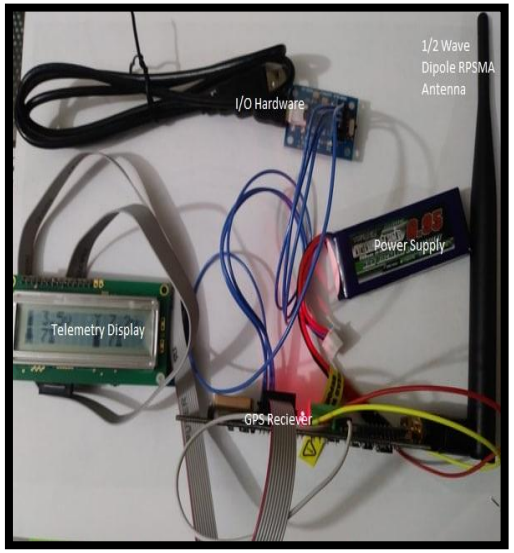


Fig: Receiver System

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# Avionics & Controls

- Power

| 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 |

# Avionics & Controls

- Controls
  - Ignition Control
    - $58.13
    - Connected externally to the rocket
    - Detaches during launch

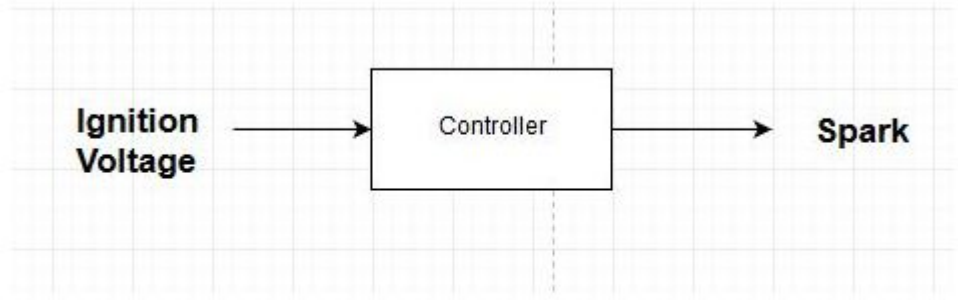


Fig: Block Diagram Ignition Control

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# Avionics & Controls

- Controls
  - Parachute Deployment Control
    - Black Powder
      - $5.64/2 oz
      - The ignition of black powder can be induced by a charge

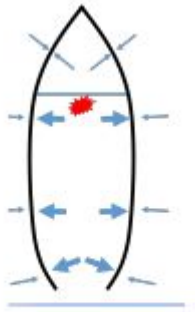

Fig: Black Powder Mechanism

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# Recovery

- Drogue Parachute
  - Weight: 7.7 oz
  - Descent rate: ~90 ft/sec
- Main Parachute
  - Weight: 32 oz oz
  - Descent rate: 17 ft/sec

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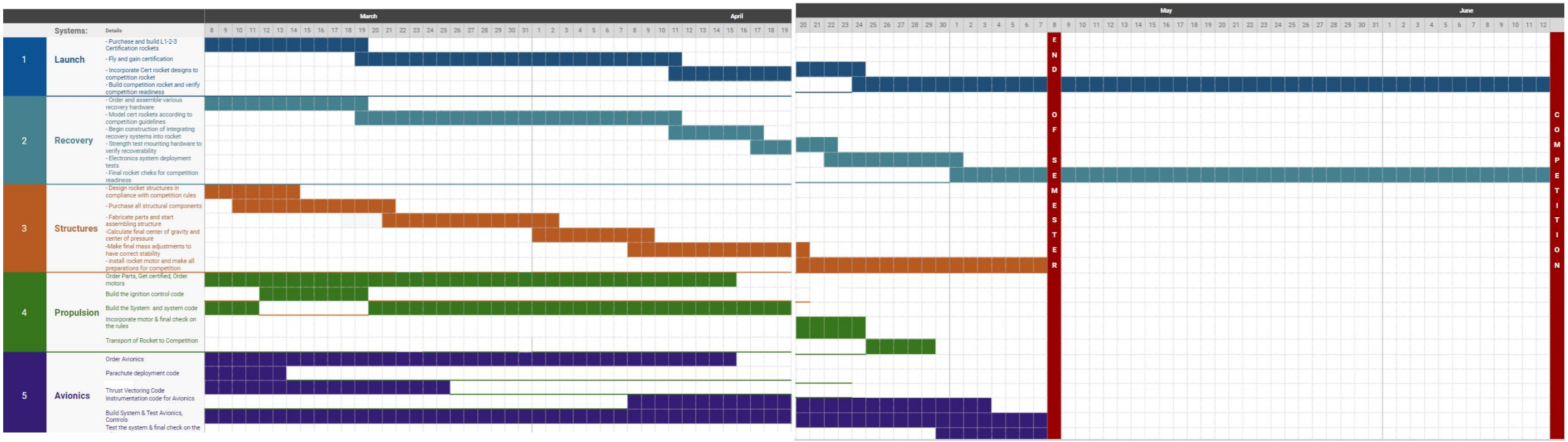
# Project Timeline

## MAXQ PROJECT TIMELINE

PROJECT TITLE MAXQ Rocket Project



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# COVID-19 Complications

- Because of the virus, the 2020 competition was cancelled.
- Certification flights were also cancelled.
- The organizers let teams reserve their spots for next year.
- Our grant is still in place.
- We are stocking up supplies for next year’s team and the rocketry club.

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# Questions?

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# References


- Launch Lugs: apogeerockets.com
- Launch Rail: 2019 MAXQ Design Team, mcmastercarr.com
- Descent Control: https://the-rocketman.com/chutes-html/
- Blue Tube: https://www.apogeerockets.com/Building_Supplies/Body_Tubes/Blue_Tubes/6in_Blue_Tube?cPath=42_43_56&
- Competition Rules : http://www.soundingrocket.org/uploads/9/0/6/4/9064598/sa_cup_irec-design_test___evaluation_guide_20191118__rev_c_final_.pdf
- Radax Joint: http://www.patentbuddy.com/Patent/8607705
- Cubesat Image: https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwj9oIXjgPflAhUjCjQIHQyxDQEQjRx6BAgBEAQ&url=https%3A%2F%2Fwww.isispace.nl%2Fproducts%2Fcubesat-structures%2F&psig=AOvVaw3I9cKNqorp4VwGq3_ajAJa&ust=1574278011007606
- Igniter Idea: https://www.youtube.com/watch?v=tSRbmpiaQKY
- PID Controller Picture: https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwja3u33jfflAhXoITQIHS9SC4sQjRx6BAgBEAQ&url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FPID_controller&psig=AOvVaw0Df5OvzvnEPpAHiMnbafbJ&ust=1574281553395060
- ANFIS Picture:https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwjG9frJj_flAhU1Ln0KHbKNDecQjRx6BAgBEAQ&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FAdaptive-Neuro-Fuzzy-Inference-System-ANFIS-structure-with-two-inputs-and-three_fig2_334398541&psig=AOvVaw2Kj1ODpjSeu8zkBVCIEZ2V&ust=1574281986924675
- Fuzzy Picture:https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwihkajuj_flAhX2JTQIHcl6BsIQjRx6BAgBEAQ&url=http%3A%2F%2Flipas.uwasa.fi%2F~TAU%2FICAT3080%2Fslides.php%3FMode%3DNoFrame%26File%3D9000Links.txt%26Page%3D-1%26MicroExam%3DOff%26Images%3DOn%26Menu%3DOff%26Brother%3DBig%26Whiteboard%3DOff%26TRACE%3DOff&psig=AOvVaw1d80eQ-1l1wrJGY_GjAeuZ&ust=1574282070344997
- Nose Cone Cap Picture:https://www.google.com/aclk?sa=l&ai=DChcSEwizm8LOk_flAhUPquwKHU-4DIQYABAPGgJwag&sig=AOD64_2kq4YRo_ghXUWZEHsuQZTGktVX0Q&ctype=5&q=&ved=0ahUKEwixibzOk_flAhURt54KHbPcA5oQ1CkI0QI&adurl=

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# References


- Servo Motor: https://www.adafruit.com/product/2307?gclid=EAIaIQobChMIzta3mJT35QIVkqDsCh1HnwOFEAkYBiABEgJMP_D_BwE
- Fin Control Image: **https://www.youtube.com/watch?v=lb3gqGsuEHI**
- **Solid Rocket Motor: https://www.researchgate.net/figure/A-typical-solid-propellant-rocket-motor-Whitfield-and-Keller-1970_fig1_270703058**
- **Aerospike Nozzle: https://en.wikipedia.org/wiki/Aerospike_engine#/media/File:Aerospikeprincipliediagram.svg**
- **Bell Shaped Nozzle Image: https://en.wikipedia.org/wiki/Bell_nozzle**
- **Open Rocket:**http://openrocket.info/