TYMAD
Tripoli L3 Certification

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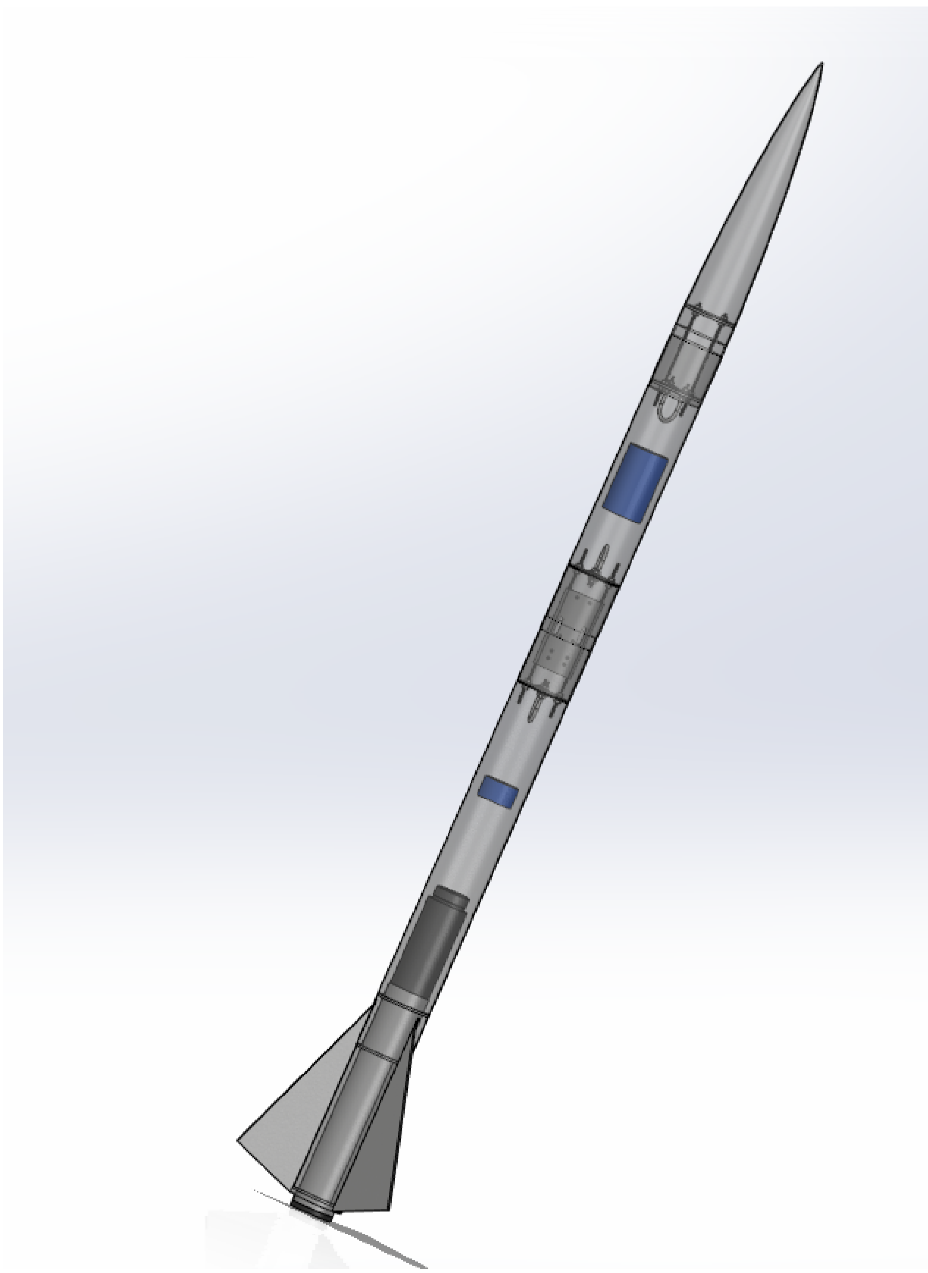

Contents

I. Design Overview

This overview is meant to be a very brief description of the different core components of the rocket. Specifically the Airframe, Recovery, and Electronics. More details on specific implementation and construction can be found later in the Design Modifications and Manufacturing sections.

A. Airframe

The airframe will be constructed using the Competitor 4 kit from Wildman Rocketry. This kit is a 4" diameter all fiberglass kit that contains a 44" booster, and 22" payload. The electronics bay is made up of a 9" coupler with 1" switch band. The 75mm motor mount tube all made from filament wound fiberglass. It also contains a 6-1 Von Karman nosecone with coupler also constructed with filament wound fiberglass. Finally the centering rings, bulkheads, and fins were also all constructed out of 3/16" G10 fiberglass.

This kit was chosen due to it's size being capable of flying not only on 75mm motors, but also on a reasonable amount of 54mm motors using the Aeropack motor adapter system. Due to this decision, it was also chosen for an aeropack retainer to be put on the aft end of the motor mount to be able to utilize this system.

Other airframe components were also chosen to fit this model. The rail buttons are 1515 for use of 1515 rails at the launch site. Then there is also a camera shroud designed to go on the side of the airframe for a RunCam 2. It is undetermined at this moment if the camera will fly for the certification attempt and will be a day of flight decision depending on flight conditions.

B. Recovery

The recovery system for this rocket is a standard dual deploy configuration. At apogee, a separation charge will open up the booster payload bay to deploy a 2ft, 0.97Cd drogue parachute attached to the Electronics Bay and a forged eyebolt on the forward closure of the motor casing. The shock cord will be a 25 foot long 3/8" Kevlar harness from OneBadHawk to ensure the two halves will stay together. Also, all attachment points between the shock cord, parachute, and airframe will feature a 5/16" 2,540lb quick link. These quick links will allow for replacement of the shock cord or parachute while still maintaining that the rocket will stay together.

At 1200 feet, a second ejection charge will occur in the main payload section. This ejection charge will deploy the main parachute, a 6 foot, 2.2Cd high performance parachute from Rocketman Parachutes. It will use a 30 foot long 3/8" OneBadHawk harness with a similar mounting strategy on both ends to ensure the rocket stays in one piece.

As a final measure of safety, all of the parachutes will be packed into Kevlar parachute bags. This will greatly reduce the chance of any singeing occurring from the ejection charge and ensure a long life-span to the parachute. It also ensures that the parachute will be able to escape from any potential tangles on any other airframe components during recovery.

C. Electronics

The electronics for this flight will be an Altus Metrum Telemega as the primary flight computer. This specific flight computer was chosen as it is what I am familiar with and a product I already own. I have also used Altus Metrum products on enough occasions to know their reliability. This specific Telemega was also used on my Level 2 Certification Flight. This flight computer will be running on a single battery configuration with a MissileWorks screw switch. It will be programmed to set off the apogee charge at apogee, with the main charge at 1200 feet. The live telemetry will also help in recovery of the rocket with GPS location.

The backup flight computer will be an Altus Metrum EasyMini. Like the Telemega it was also chosen due to experience with the Altus Metrum ecosystem. However, the EasyMini itself was chosen as a backup due to it's simple nature. There are not a lot of things that can go wrong with it as opposed to more complex units and they have been proven to be reliable backups in the past. It will also be in a single battery configuration with a MissileWorks screw switch just like the Telemega. It will be programmed to set off the apogee charge at apogee + 2 seconds and the main at 1,000 feet. These values were chosen to ensure that each charge would have adequate amount of time to ignite and de-pressurize before the backup fires.

II. Calculations and Modeling

A. Openrocket Model

The first step I always take for any rocket is to model it in OpenRocket. I originally took a file from the kit manufacturer's website, but once I received the kit I found it to have some issues. I believe I may have just ended up with an outdated version of the file. Regardless, once the kit arrived I updated the OpenRocket to re-run the simulations.

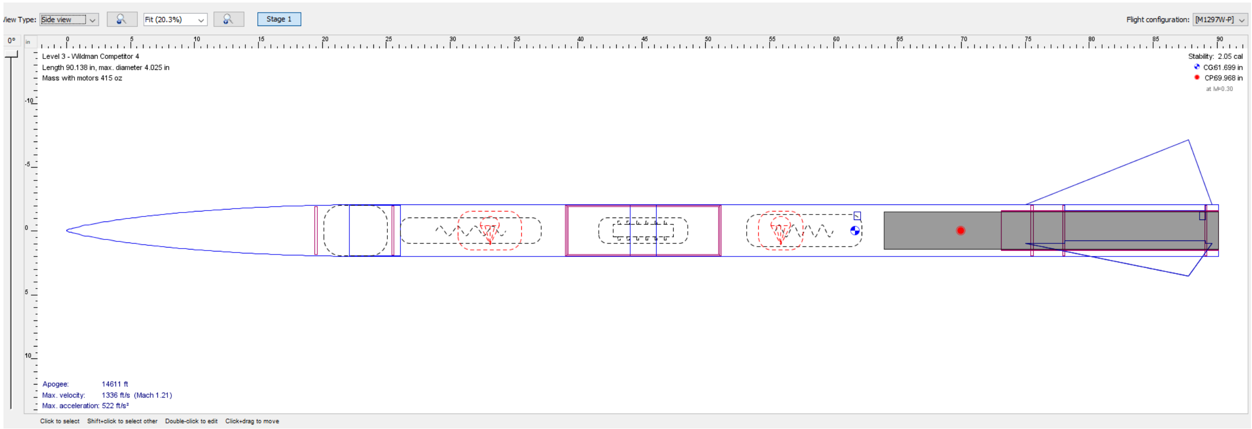

Figure 1 Screenshot of the OpenRocket model.

As I constructed the kit I kept modifying the amount of ballast weight needed in the nosecone to keep a stability of about 2 cal. After completion of painting the required weight was 750g of nose weight to reach that goal. This exact amount will be measured and balanced out the day of flight to ensure the right amount is set.

The final flight simulation profile will be attached in the pre-flight details section.

B. Solidworks Model

Once the Openrocket model was updated the Solidworks model was also updated. This was done to be able to create models for different jigs or custom parts and make sure they fit properly in the rest of the assembly. This was especially useful for the modifications for the nosecone and the electronics bay sled. I was also able to utilize features from Solidworks CAM to CNC out the custom G10 components.

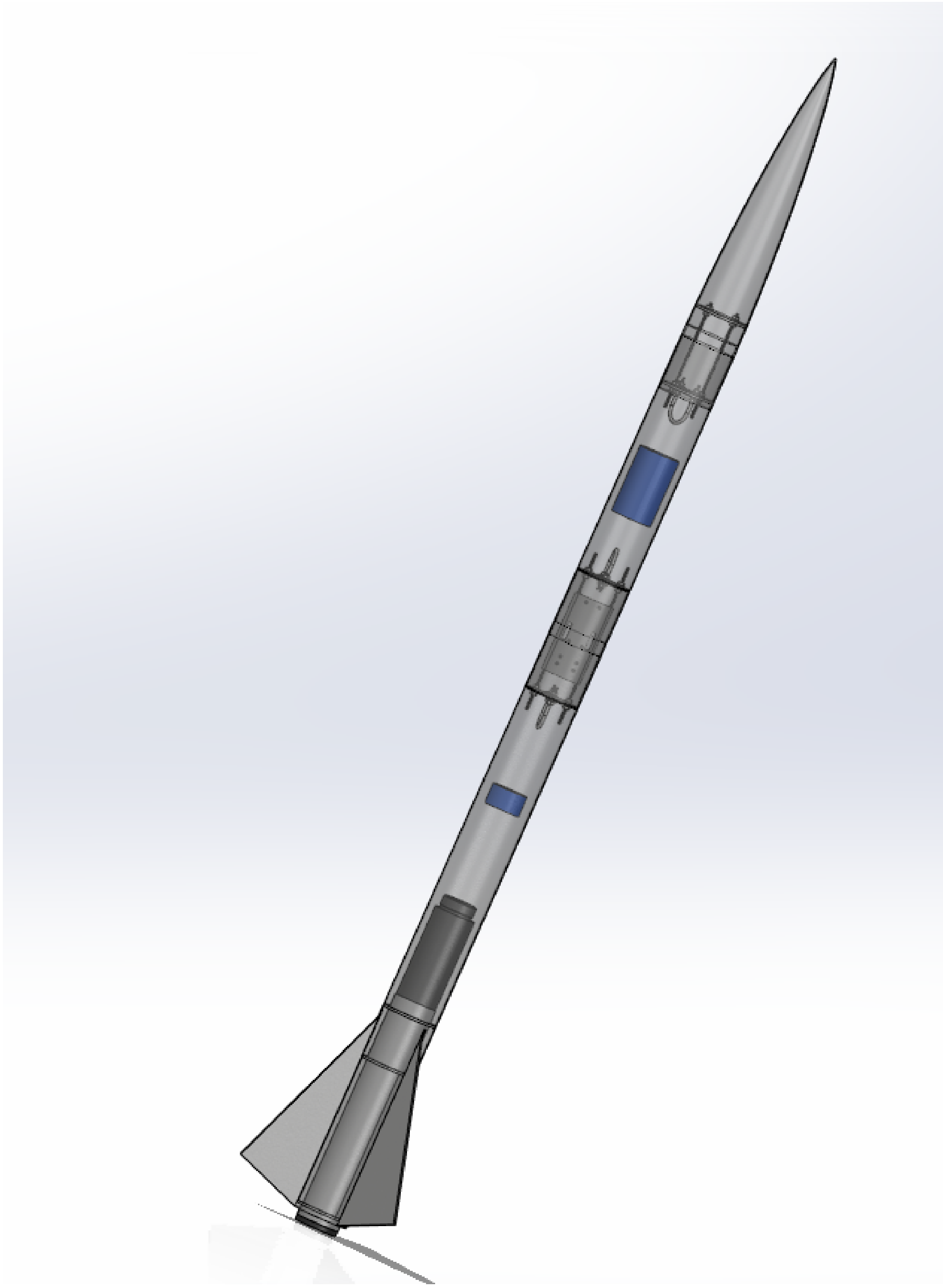

Figure 2 Solidworks Full Rocket Assembly.

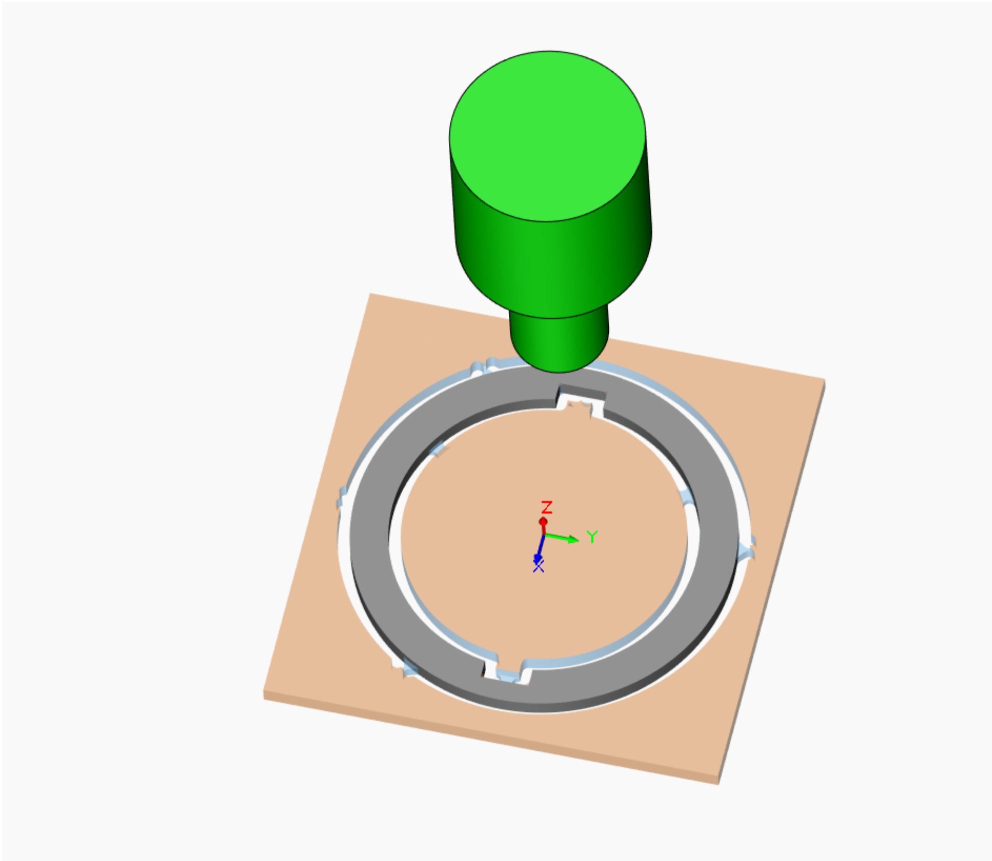

Figure 3 Solidworks CAM for a centering ring.

III. Bill of Materials

Component	Vendor	Description	Quantity
Nosecone	Wildman Rocketry	6-1 VK Nosecone	1
Nosecone Coupler	Wildman Rocketry	8" Coupler FWFG	1
Payload Tube	Wildman Rocketry	22" Body FWFG	1
Electronics Bay	Wildman Rocketry	9" Coupler FWFG	1
Switchband	Wildman Rocketry	1" Switchband FWFG	1
Lower Body Tube	Wildman Rocketry	44" Body FWFG	1
Motor Mount Tube	Wildman Rocketry	17" MMT FWFG	1
Fins	Wildman Rocketry	3/16" G10 Fiberglass	3
EBay Bulkheads	Wildman Rocketry	3/16" G10 Fiberglass Bulkhead	2
Rocketpoxy	Wildman Rocketry	Rocketpoxy 2 Pint	1
Threaded Rods	McMaster Carr	98957A801 1/4-20 X 2’ Hardened Steel	2
UBolts	McMaster Carr	3043T618 1/4-20 2" Zinc Plated Steel	3
Forward Nosecone Bulkhead	Custom	3/16" G10 Fiberglass Bulkhead	1
Aft Nosecone Bulkhead	Custom	3/16" G10 Fiberglass Bulkhead	1
Centering Rings	Custom	3/16" G10 Fiberglass Centering Ring	3
75mm Aeropack	Wildman Rocketry	75mm Aeropack Motor Retainer	1

Rail Guides	Wildman Rocketry	2052-LG Rail Guides	2
Shock Cords	Wildman Rocketry	4" OneBadHawk Harness	1
Drogue Parachute	Rocketman Parachutes	24" 0.97Cd	1
Main Parachute	Rocketman Parachutes	72" 2.2Cd	1
Main Deployment Bag	Rocketman Parachutes	4" X 12" With Pilot	1
Drogue Deployment Bag	Rocketman Parachutes	3" X 8" With Pilot	1
Quick Links	Menards	5/16" Quick Links	6
Quick Links	Menards	1/8" Quick Links	2
Telemega	Altus Metrum	Primary Flight Computer	1
EasyMini	Altus Metrum	Backup Flight Computer	1
Screw Switch	Missileworks	Flight Computer Screw Switches	2
Electronics Sled	Custom	3D Printed Electronics Sled	1
Fillet Fiberglass	Owned	9oz Fiberglass	1
Fillet Epoxy	US Composites	615 Epoxy	1
Motor	Wildman Rocketry	Aerotech M1297	1
Motor Casing	Wildcat Rocketry	Aerotech 75-2560	1

IV. Electronics

The Electronics Bay will hold all of the electronics necessary for the successful operation of this flight. This includes parachute deployment, GPS tracking, and flight statistics logging. Due to the need for safety the parachute deployment and flight logging will have two independent systems running for redundancy.

The primary flight computer is an Altus Metrum Telemega. This flight computer has been used on past flights and has had extensive ground and range testing completed on it. It will have a single 850mAh 3.7V LiPo battery from Altus Metrum in the battery terminal and the Pyro / LiPo channels jumped together. The battery connector will then be hot glued in to protect it from coming loose in flight. It will also have 2 wires coming out to a MissileWorks screw switch to allow for easy enabling at the pad. This flight computer will also be responsible for GPS tracking. This data will be transmitted to a ground receiver and displayed both on a laptop that it is wired into and a phone over Bluetooth connection.

The backup flight computer is an Altus Metrum EasyMini. This specific unit has not been flown, but has been tested on the ground to test basic functionality. This flight computer will also have the same independent power delivery system as the primary flight computer with it's own 850mAh 3.7V LiPo and MissileWorks screw switch.

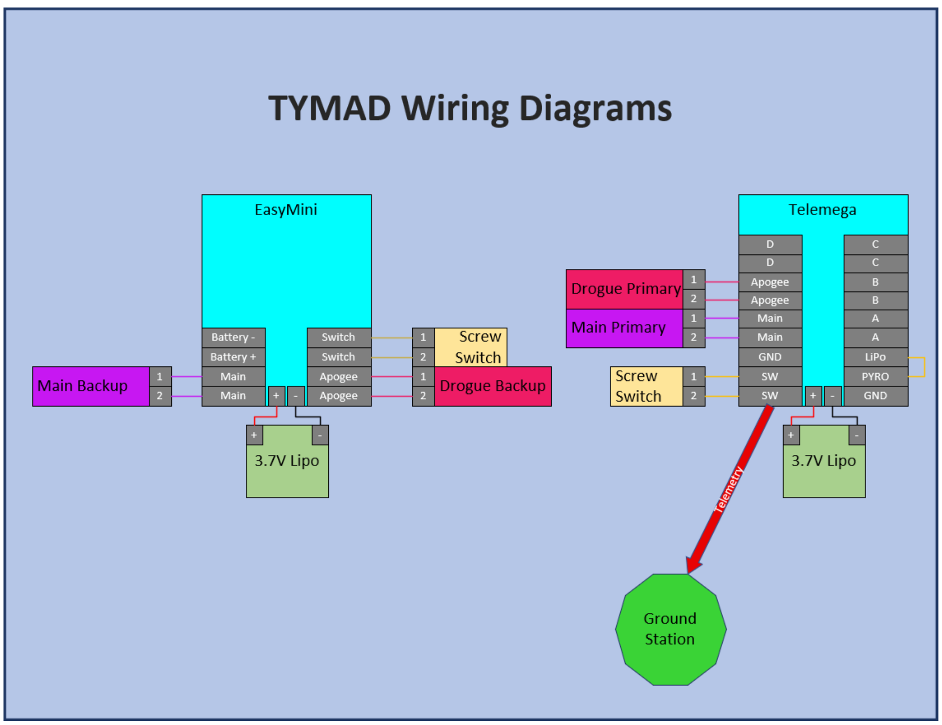

Figure 4 Visio Block Diagram of Electronics Wiring.

V. Design Modifications

A. Nosecone

The first major design modification was done in an effort to support multiple different motors without the need for permanent changes to the airframe. Specifically, a variable stability system was designed to be able to add or remove excess nose weight to adjust the vehicle stability for any given motor.

This design was first modeled in Solidworks along with the rest of the rocket design. To start, the goal was to make something that could be varied between about 0 and 2Kg to give a significant mass adjustment. Also, this was to be done without hindering parachute ejection or attachment points. The design was a mixture between using a permanent bulkhead, and standard electronics bay design. At the front of the nosecone, a bulkhead was added that would be permanently affixed with 2 threaded rods coming out the bottom. Then, a second bulkhead would go onto the threaded rods just like with an electronics bay and bolt on. With this it created a space that could be made larger or smaller by moving the bulkhead up or down. This in turn limits the maximum amount of material that could be added to get exactly the amount desired without any potential movement in the space.

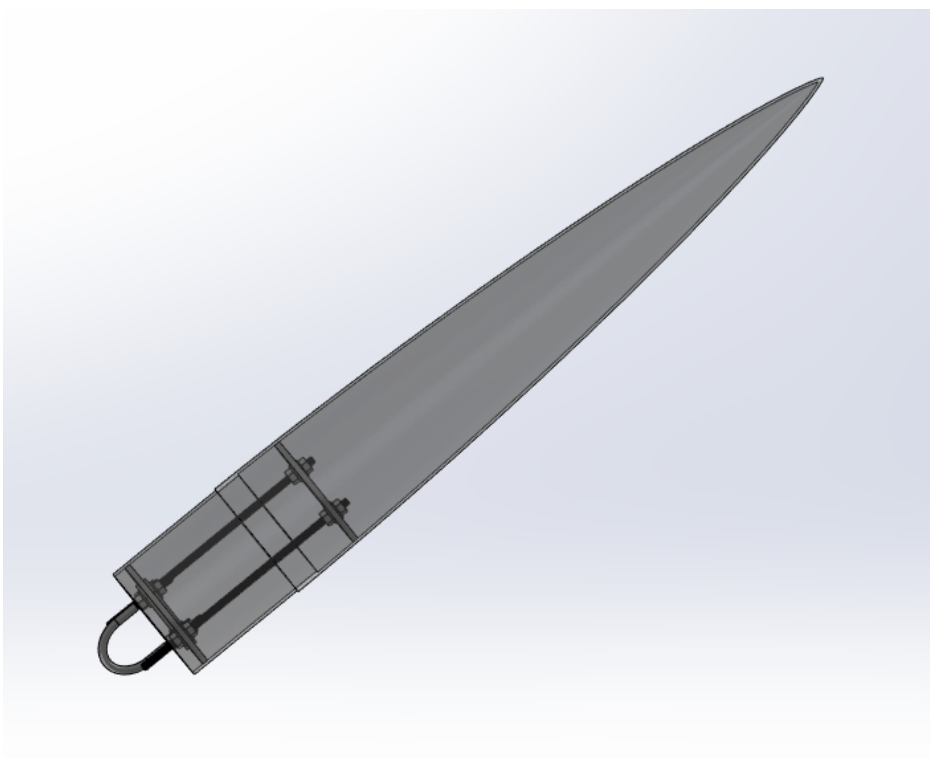

Figure 5 Solidworks model of the nosecone modifications.

B. Electronics Bay

The electronics bay did not have any major structural changes from how the kit itself is designed. However, it did get a custom electronics sled. This sled was designed to easily mount both flight computers, batteries, and screw switches. The model for this can be seen below.

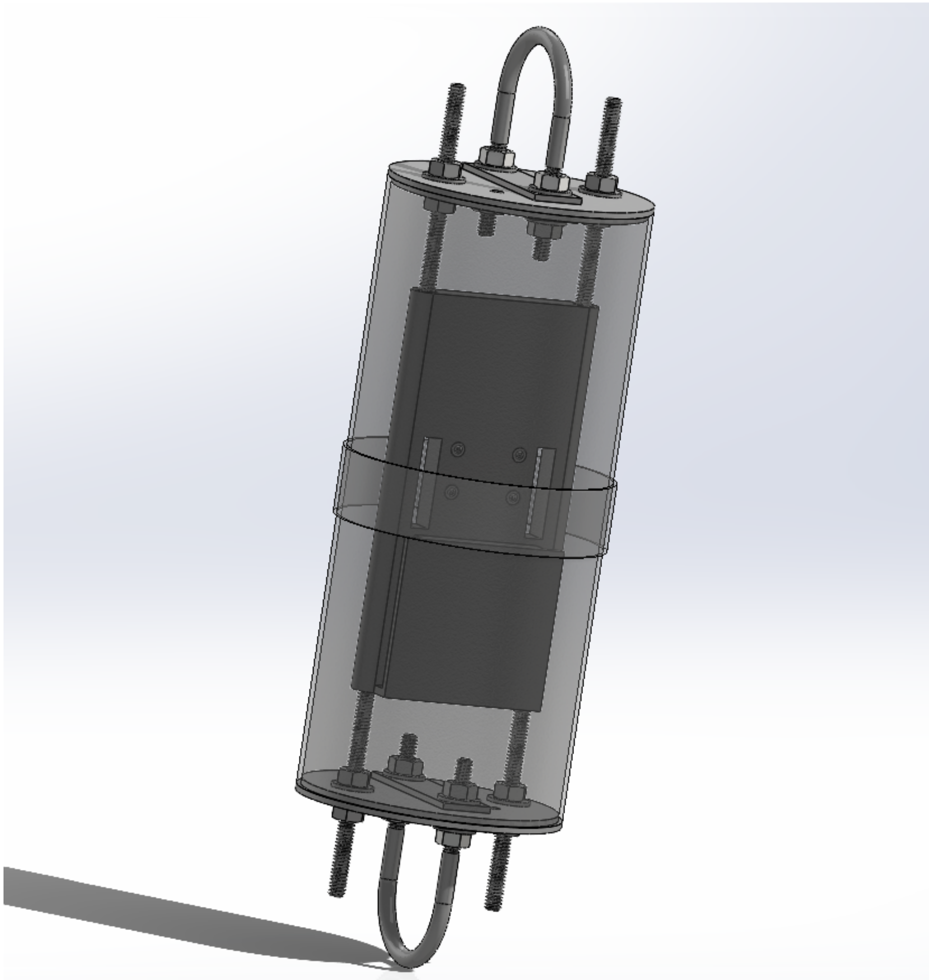

Figure 6   Electronics Bay Model.

C. Lower Body

The lower body had two major changes. One internal, and the other external. For the internal change when the kit arrived I decided to remachine the fiberglass centering rings. This was done to just have thicker stronger centering rings as opposed to the ones that came with the kit. With this then a bit of extra sanding was required to get the fit for the motor mount assembly and retainer.

The second major change was the addition of tip to tip fiberglass fin fillets. These fillets have been done on many rockets I have worked on in an effort to reduce any potential fin fluttering. Given the odd shape of these fins and the speed of the rocket this was a no-brainer decision. Also, it allowed for some extra practice with this construction technique.

VI. Manufacturing

This section describes and shows the manufacturing steps taken to build TYMAD. This section is not necessarily in chronological order.

A. Pre-work

The first thing that was done when the kit arrived was to take everything out, inspect, and inventory the parts. Upon inspection there were no issues found with any of the components for the airframe. Next, I took all of the fiberglass components out and washed them in a bath of hot soapy water. This was done to clean off any excess mold release or fiberglass dust residue that ended up on these components. I then took and remeasured and reweighed everything to update both my solidworks and openrocket models. After that everything was dry fit together to make sure it all fit together.

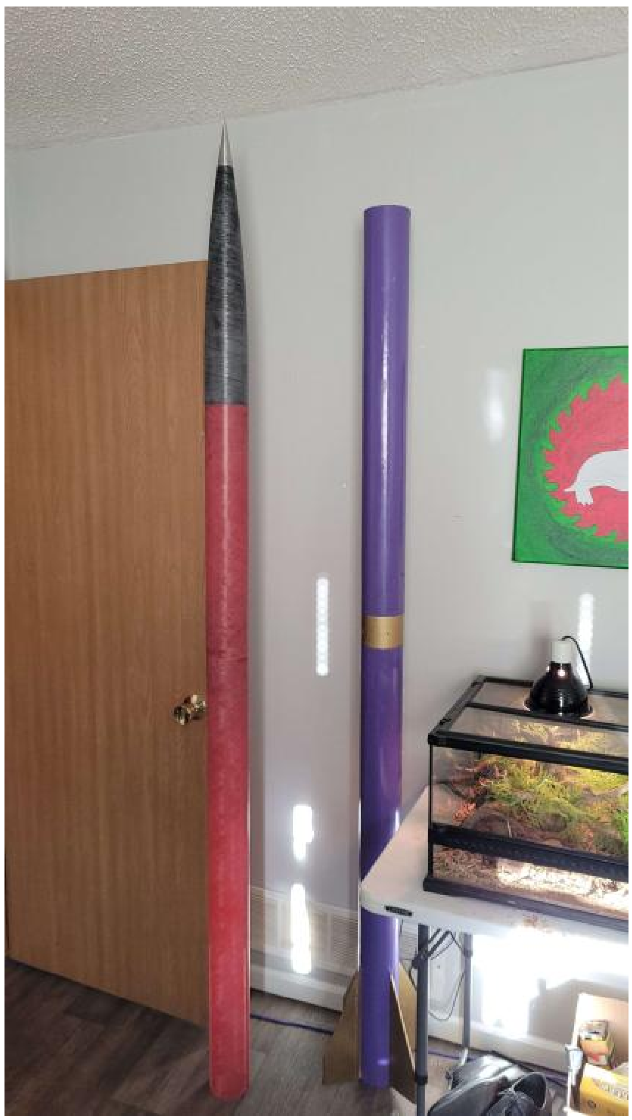

Figure 7 First dry fit with no fins.

B. Nosecone

The first work done on the nosecone was to design the variable mass payload section. To do this I opened up solidworks and created two bulkheads where one could be permanently affixed and the second be attached via two threaded rods that could be positioned up or down as needed. This model change was then sent off and approved for construction.

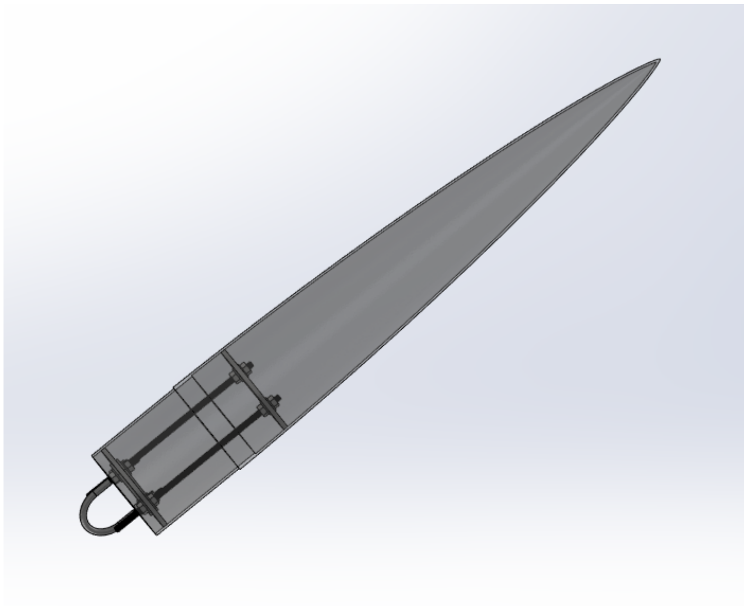

Figure 8 Solidworks model of the nosecone modifications.

After it was approved I then took and CNC'd out the components from 3/16" G10 stock material that I had stashed away from a previous project. After it was cut it was removed from the stock, sanded, cleaned up, and dry fit into the nosecone coupler with the other components.

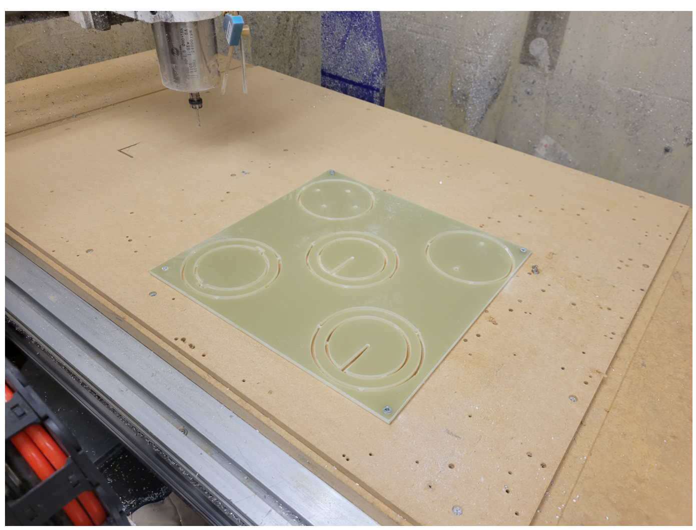

Figure 9 CNCd Bulkheads and Centering Rings.

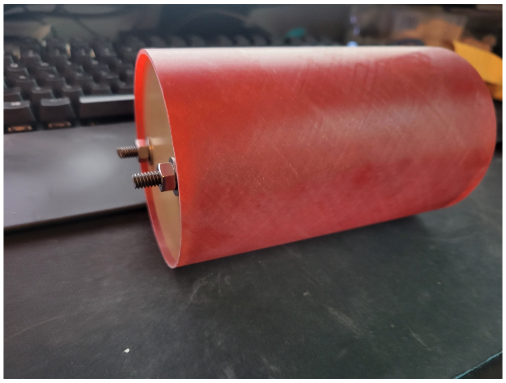

Figure 10 Forward end of the coupler dry fit.

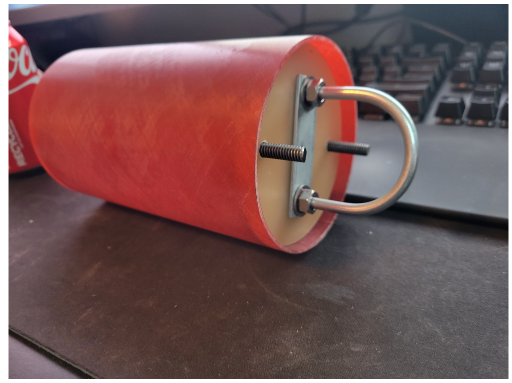

Figure 11 Aft end of the coupler dry fit.

After confirming a solid fit and doing a few mechanical checks to make sure everything moved the way I wanted it to I sanded the inside of the coupler and the outside of the bulkhead to get a better adhesive surface. After that I used red thread locker onto the nuts holding the threaded rods onto the permanent bulkhead and then used rocketpoxy to set the bulkhead. While it was setting the aft bulkhead was attached in so that it would hold the proper alignment. A bit of extra rocketpoxy was also put on the permanent nuts to make sure they stayed in place.

Figure 12 Epoxying of the forward bulkhead into the nosecone coupler.

After letting the nosecone coupler set and cure, it was sanded and prepared to be inserted into the nosecone. The inside surface of the nosecone was also sanded for this same purpose. A hole was drilled into the top of the permanent bulkhead to allow pressure to escape when inserting into the nosecone. The tip was then threadlocked on and received a generous amount of rocketpoxy on the back end. Next, the inside of the nosecone was lined with rocketpoxy and the nosecone coupler was inserted and twisted around to make sure the epoxy spread to get a good adhesion. Once the nosecone coupler was fully set into the nosecone the small pressure relief hole was refilled with rocketpoxy to make sure none of the variable mass material would be able to get through it.

Figure 13 Inserted nosecone coupler into the nosecone.

C. Upper Body

The upper body for this rocket did not take much mentionable work during construction. The only things done to it were sanding the edges to flatten them out. Sanding the outside to make the paint adhere a bit better. Finally then holes drilled into it for shear pins and steel screws.

D. Electronics Bay

The first work done on the electronics bay was the put on the switch band. 4" from each edge were measured out on the coupler which left 1" in the center. This area was then sanded for good adhesion along with the inside of the switchband. Then tape was added on the ouside of where the switchband was and rocketpoxy was applied to the center ring. Next, the switchand was slid on and rotated to spread the epoxy around the inside. The tape was later removed and everything was left to cure.

Figure 14 Mounted switch band onto the Electronics Bay.

Next the internals of the electronics bay were modeled. Being a similar size of electronics bay to my L2 and using the same components I was able to take my L2 sled model and make some modifications to be slightly simpler. It was then 3D printed and had all of the components test fit onto it.

While the electronics bay internals were being done, a jig was printed to mark and cut bulkhead holes. For the attachment points each one got a 2" UBolt with mount plates to distribute the load when pulled on. Then they were mounted together using 1/4" threaded rods that went the whole length of the EBay.

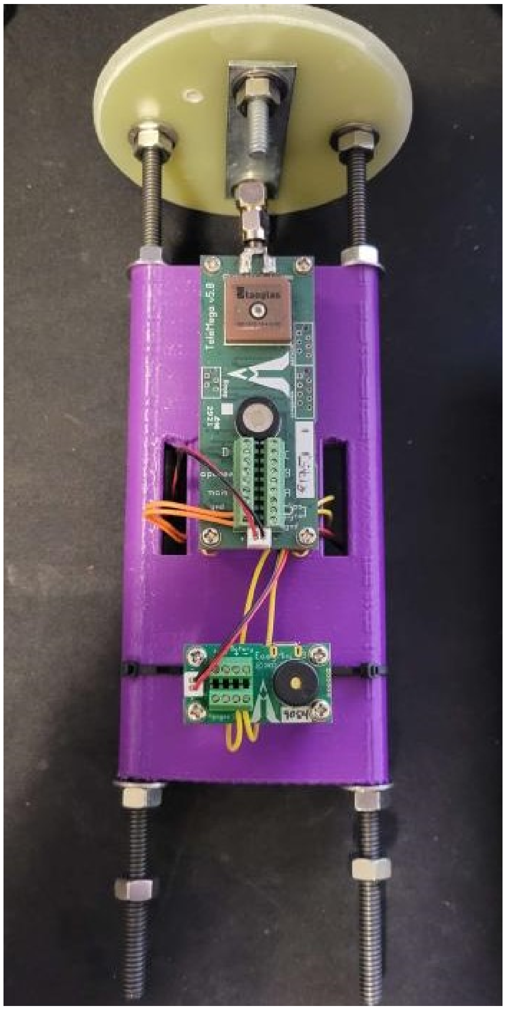

Figure 15 Electronics Side of EBay.

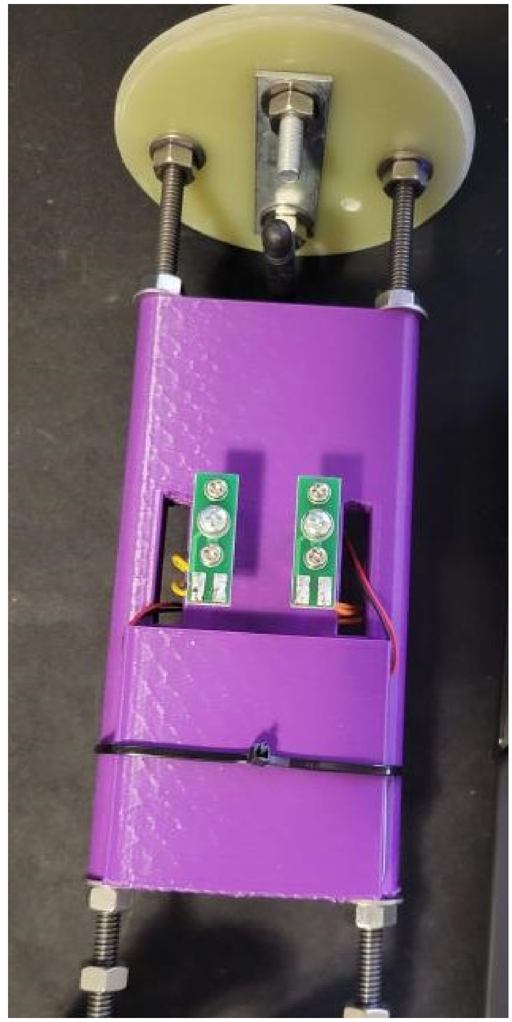

Figure 16 Switch / Battery Side of the EBay.

Figure 17 All of the bulkheads assembled together.

Once everything was test fit the nuts on the bolts holding on the UBolts were red threadlocked to ensure they stay together, and so were the nuts on one of the bulkheads for the threaded rods. This ensures that it stays tight permanently affixed to one side but being dismantleable for flight preparation. In-flight the nuts on the other side will receive removable blue threadlock. Everything was then put together to create the single unit capsule.

Figure 18   Electronics Bay Capsule assembled.

E. Lower Body

This section on the lower body will be split up into multiple subsections. This is because it is where the majority of the work went in and has the most complex features. These will be the fin can assembly, lower body assembly, and fin fillets.

1. Fin Can Assembly

To start off it was chosen early on to assemble the entire fin can outside of the rocket and then extend the fin slots so that it could slide right inside. This method was chosen as I believe it to be easier to do and is just my preferred method.

The first thing I did was to take and measure all of the parts and create a jig that would be able to align all of the fins with the motor mount tube and centering rings. This jig was then 3D printed and had all of the components dry fit into it to ensure everything was right.

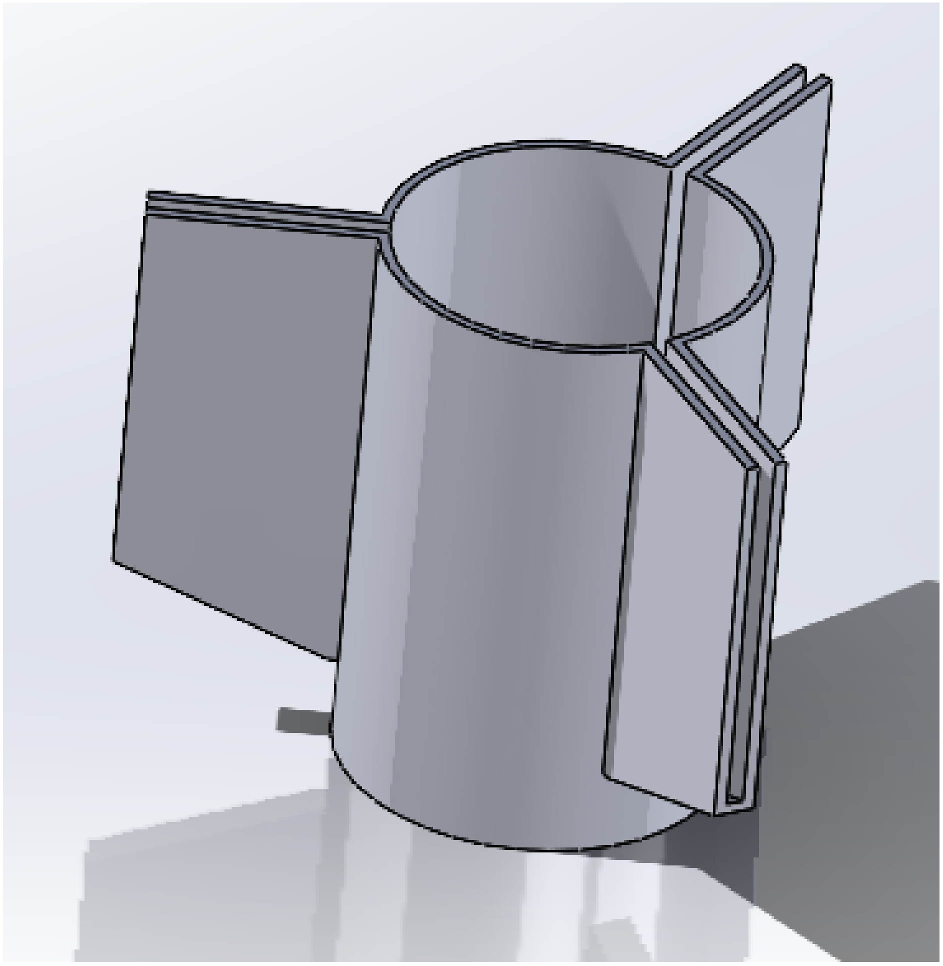

Figure 19   Fin alignment jig in solidworks.

Next, the motor mount tube was marked and sanded for creating better adhesion surfaces where the fins and centering rings would mount. Then the lower centering ring got tacked on alone with 5 minute epoxy. Once that centering ring was set, the fins and other centering rings were also tacked on with 5 minute epoxy. This also partially includes the Kevlar shock cord attachment point, but that was just with a bit of excess.

Figure 20 Fin can tacked together with 5 minute epoxy.

After the 5 minute epoxy set, the fin can was removed from the jig and inspected. Once it was cleared the surfaces were again sanded and internal rocketpoxy fillets were done. These were done between each fin and the motor mount, the motor mount and centering rings, the centering rings and fins, and the motor mount and shock cord harness.

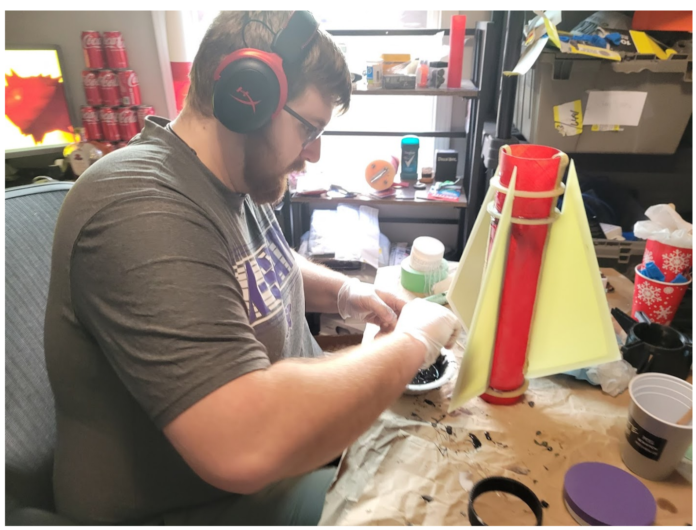

Figure 21 Rocketpoxying on the fins and centering rings of the fin can.

It is important to note that in some places on this step I used painters tape and in others I did not. This was done as a personal experiment to see how much it improves the line quality and the answer was significant. Either way, the look of these lines are not incredibly important as it is for the internals of this project.

As a final step on the fin can I took and signed it and wrote a few notes to myself that I hopefully will never see again.

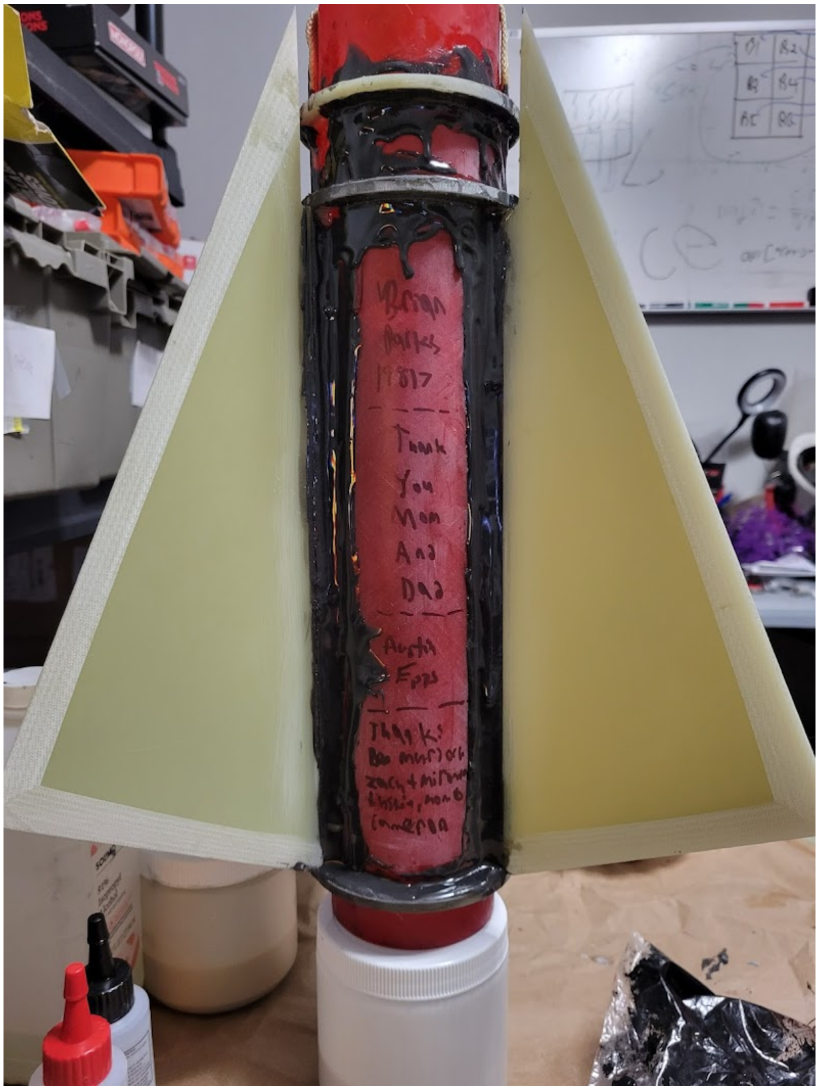

Figure 22 Final photo of the fin can with signatures.

2. Lower Body Assembly

The first thing I noticed while dry fitting were that the fin slots were significantly too long. The fin slots had been cut out to be the whole length of the fin and not just the tab. To fix this I took one of the couplers, wrapped it in mylar, and used rocketpoxy to fill the gap in the fin slot. This worked significantly better than I originally thought it would and made the correction incredibly easy.

Next, the fin slots were extended to the bottom of the body to allow for the easy insertion of the fin can. This was completed with a dremel cutting wheel. After the fin slots were extended a line was marked and the first of the rail guides were inserted. This was done as it would be impossible to access after the fin can was assembled and inserted.

Figure 23   Filling the extra space on the fin slots.

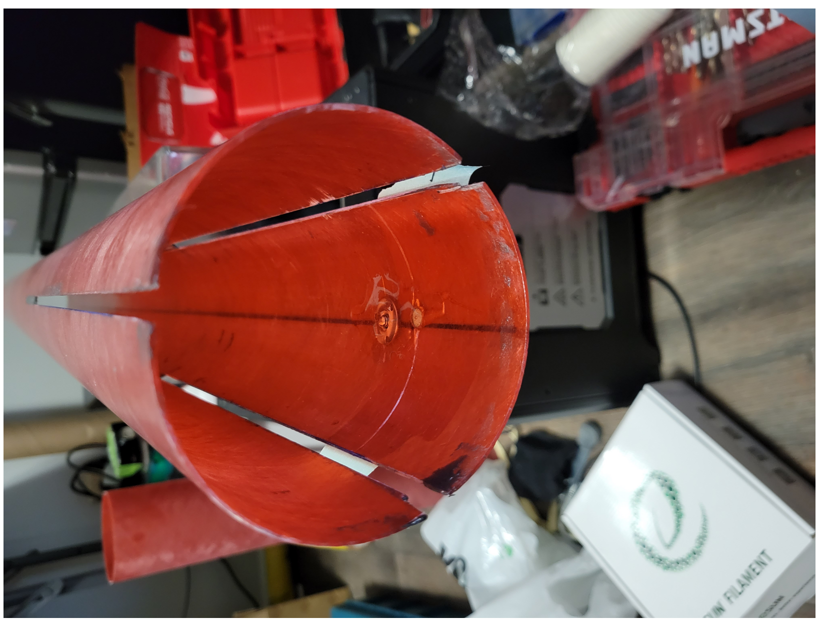

Figure 24   Lengthened fin slots and inserted rail guide.

Once the fin can was complete and the rail guide was cured in, it was time to insert the fin can. To do this the insides where the centering rings would be were sanded where possible to allow for a better bond. Then, a dowel rod was used to smear epoxy in those locations. Once that was ready the fin can was inserted into the body allowing the epoxy to smear and adhere the two components together. Extra rocketpoxy was also added below the lower centering ring and onto the motor retainer as it was attached. It was then clamped together and left to cure overnight.

Figure 25   Fin can inserted, epoxied, and clamped together.

3. Fin Fillets

After the fin can had been inserted into the lower body tube it was time to begin the external fin fillets. The first type of fin fillet done were rocketpoxy fin fillets. To do this the surrounding areas around the fins were bond prepped with sandpaper and then taped with painters tape. A thick amount of rocketpoxy was mixed and then laid in the fillet and curved with the edge of the popsicle stick. After about 3 hours the tape would be removed to create clean lines around the fillet. This process was repeated a total of 3 times. One for each fin.

Figure 26   External rocketpoxy fin fillets.

Once all of the rocketpoxy fillets were completed it was time to begin the fiberglass tip to tip fillets. To do this the fin profile was measured out and a cardboard stencil was made to be able to cut out the shape for the layup. The same was also done for the required peel ply.

Figure 27   Fiberglass with fin fillet template.

After the fin fillet fiberglass was ready, the surface was again prepped with sandpaper to create a good bonding surface. After the surface was ready it was cleaned off and the layup began. To do the layup the first step was to mix the 3:1 US Composites 635 Epoxy. It was then painted onto the surface to completely coat where the fiberglass fillet would go. Next the first fiberglass sheet was laid down where it was then also painted over. This process was then repeated for the second layer. Finally, after both layers were down the peel ply sheet was brought over and set onto it. This pulled up some of the excess epoxy while also being able to work out any extra bubbles of creases in the layup. After letting it cure for over 8 hours the peel ply was removed and the fin fillet was inspected. This was repeated a total of 3 times, one for each fin.

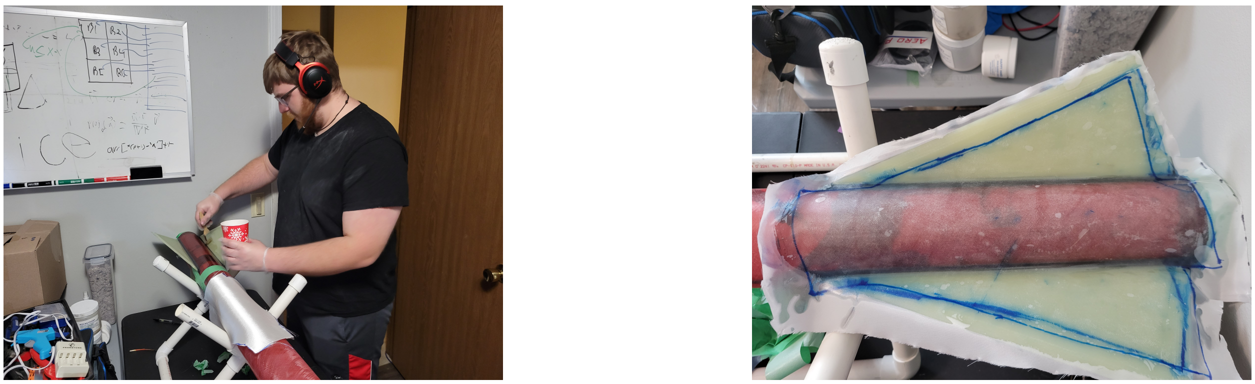

Figure 28 Fin fillet process.

Once all of the fin fillets had been completed the next step was to sand the fillet out smooth. This was done with a mix of sandpapers ranging in grits from 80 to 400.

F. Painting

Once all of the body construction was completed all external surfaces were again hit with another round of sanding. This time to create a good surface for the paint to adhere to. All components with couplers were taped up to ensure not paint would get into places that it was not needed. The first layer done on all parts was a white primer that was then sanded down and reapplied for a total of two coats. This helped with some of the surface finish before the color coats were added.

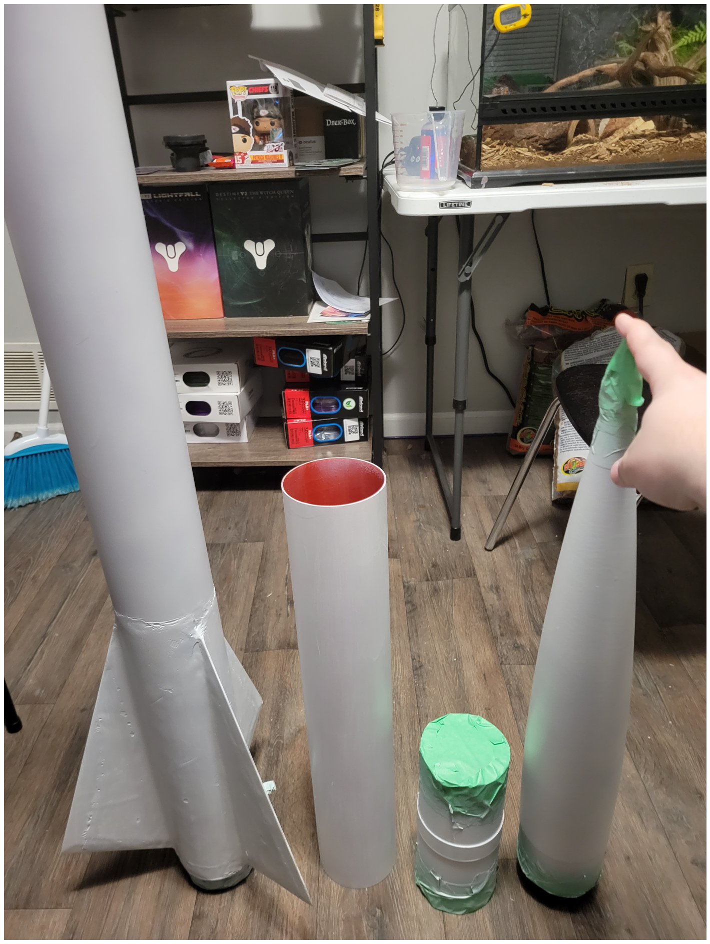

Figure 29 Primer Coats.

After the primer coats were completed the color coats began. The colors of green and red were chosen with the main body being green and the accent colors being the red. With this the nosecone and switch-band each got 2 coats of red and were then set aside.

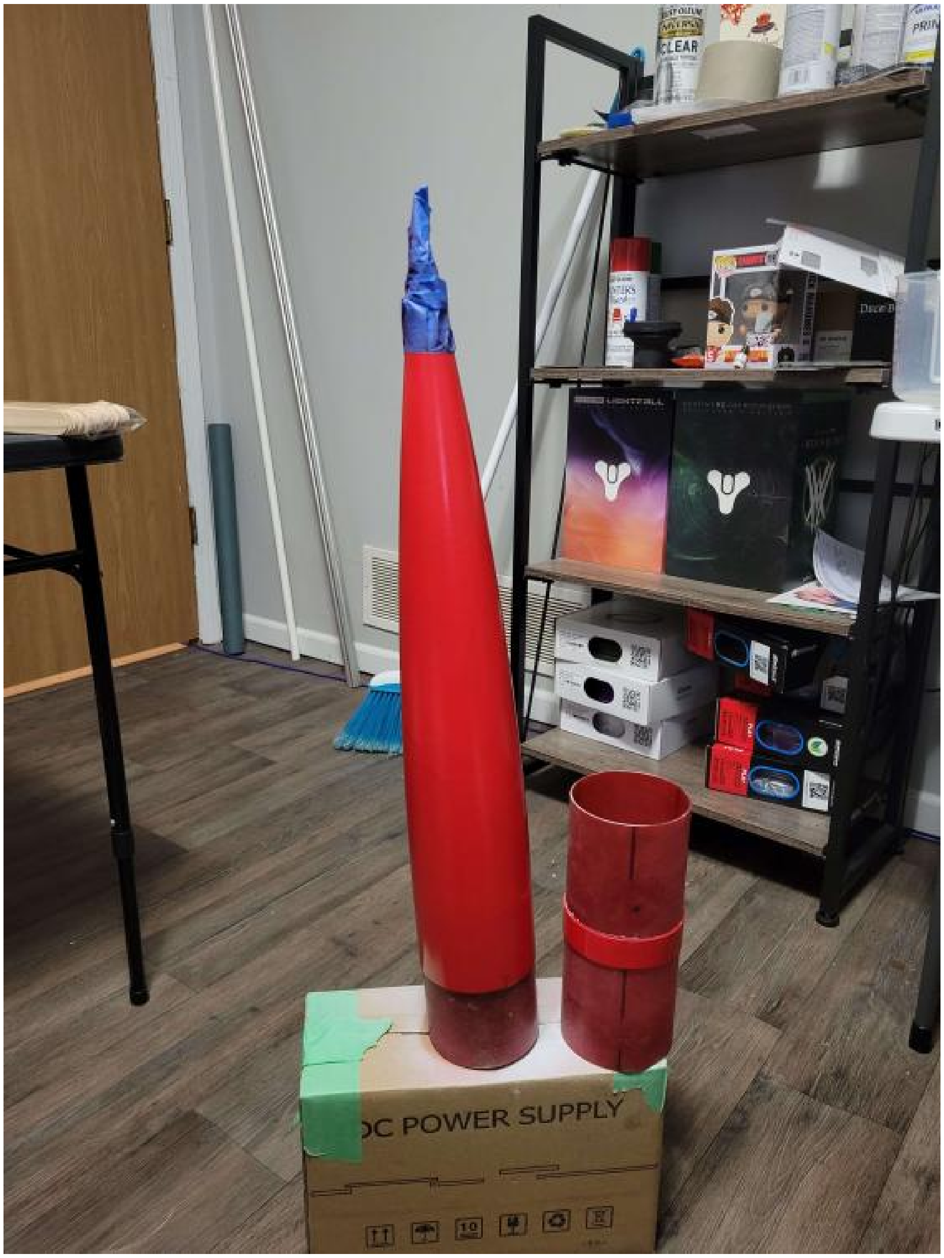

Figure 30 Nosecone and Switchband painted coats.

The upper body tube was painted entirely green and received 3 coats. Each of them with a light sanding in between due to imperfections in the paint application process.

Figure 31   Upper Body Tube Painted.

For the lower body tube it was decided to paint the fins red first and then the main body green afterwards. To do this the body was covered with a mixture of green tape and a trash bag to create a clean transition into the red. The fins were then painted, sanded, and painted again before the tape was removed and then the fins got taped up. Once those fins were taped up the main body received it's 3 coats of green paint. Finally, the tape on the fins was removed leaving us with the final paint job.

Figure 32   Lower Body Tube Painted.

Once all of the painting was done the decals were applied. The decals were made by Miranda Deibert and spelled out the name of the rocket. Once these were on the rocket then received a clear coat protector and was left to cure.

G. Final Work

Once all of the decoration was complete a few more thing had to be done. For one the holes for shear pins, steel screws, Electronics switches, and ventilation had to be drilled. Once all of the holes were drilled the recovery harnesses were pulled out and put together to make sure everything packed together properly.

Figure 33 Drogue Recovery harness.

Figure 34 Main Recovery harness.

H. Ejection tests

To size my ejection charges I use an online calculator to get a general estimate, then test it and adjust it based off of the results of those tests. For the drogue parachute, I decided to use 3 2-56 shear pins between the lower body and the electronics bay, and for the main I decided to use 3 4-40 shear pins between the nosecone and the upper body.

It took a few attempts to get the deployments where I wanted them to be at. A few of the early attempts were too small, and then I had one that I overcompensated the correction on the main parachute and it had to be tuned back down. Through all of my testing I was able to get my ejection charge values of:

- Main Primary: 5.5 grams
- Drogue Primary: 4.2 grams
- Main Backup: 7 grams
- Drogue Backup: 5.25 grams

My actual procedure was to mount everything like it would be in-flight, and test to get as close to the real situation as I could. The first step was to check all of the quick links and parachutes. Then, the parachutes were loaded into their deployment bags. After that the charges were made, loaded, and had a continuity check before the electronics bay was closed up. Once the electronics bay was closed up the charge was inserted into the body tube, a thick layer of cellulose insulation was added, then the parachute in the deployment bag, then the end connector for that section. Finally the shear pins and steel screws were added in all relevant locations

Once all sections were closed up, the airframe was taken outside to a safe section of field and the charges were remotely detonated. This allowed for accurate and safe tests to be performed.

VII. Flight Preparation

A. Simulation Data

Openrocket Launch Profile:

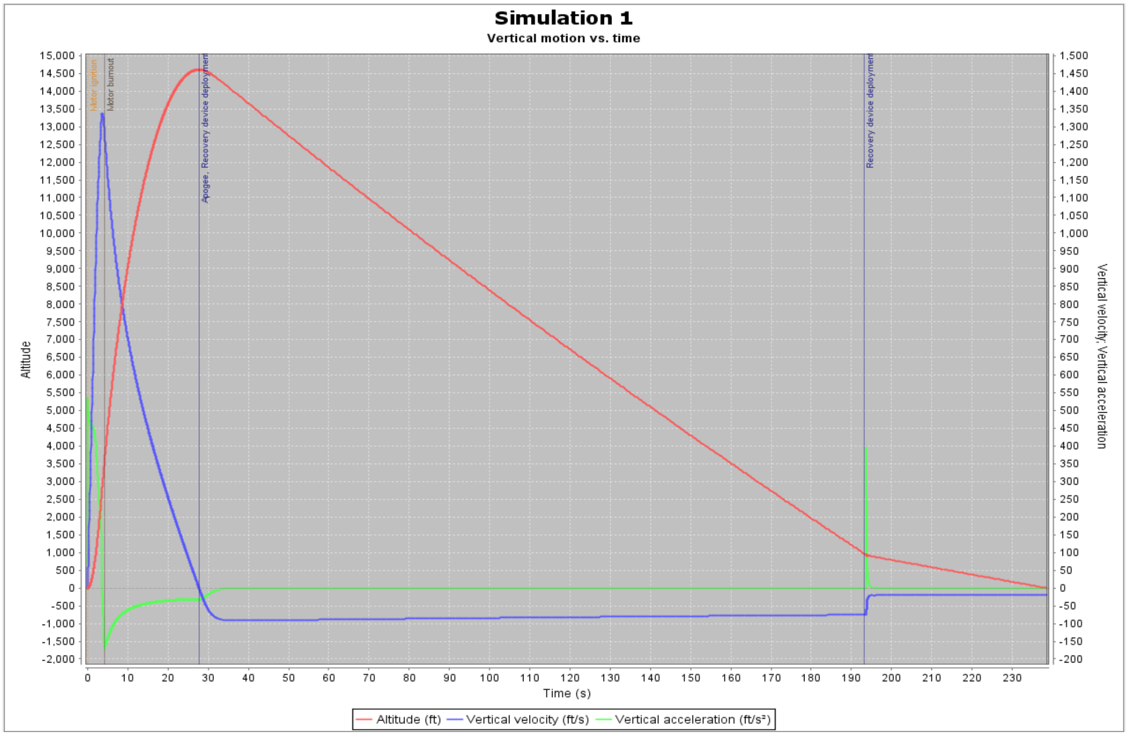

Figure 35 Openrocket Launch Profile.

Rod Exit Velocity: 112 ft/s

Apogee: 14,606 ft

Max Velocity: 1336 ft/s

Max Acceleration: 535 ft/s^2

Time at Apogee: 27.7 seconds

Flight Time: 251 seconds

Ground Hit Velocity: 16.2 ft/s

B. Pre-flight Data Capture

Tripoli Advisor Panel Pre-Flight Data Capture Form

TRIPOLI ROCKETRY ASSOCIATION, INC.

NAME: Brian Parks	ADDRESS: 5828 Norest Street	PHONE #: (913) 609-5556
TRA #: 19817	LAUNCH LOCATION: Argonia Kansas	DATE: 3/12/2022
ROCKET SOURCE: KIT ☑ SCRATCH ☐	ROCKET NAME: TYMAD	DECENT RATE AT LANDING: 15.8 ft/s
ROCKET DIAMETER: 4"	ROCKET LENGTH: 90.138"	ROCKET WEIGHT LOADED: 25.94lbs
AVIONICS DESCRIPTION: 1: Altus Metrum Telemega 1: Altus Metrum EasyMini	MOTOR TYPE: M1297	THRUST TO WEIGHT RATIO: 11.28:1
LAUNCHER REQUIREMENTS:	LENGTH: 12' 1515 rail	
CENTER OF PRESSURE: 69.968" From Tip	HOW CALCULATED: OpenRocket	
CENTER OF GRAVITY: 61.699" From Tip	HOW CALCULATED: OpenRocket	
MAXIMUM VELOCITY: 1336 ft/s	HOW CALCULATED: OpenRocket	
MAXIMUM ALTITUDE: 14,609 ft	HOW CALCULATED: OpenRocket	
WAS FLIGHT SUCCESSFUL:	YES: ☐	NO: ☐
TAP NAME:	Bob Brown	
TAP NAME:	Jay Bailey	
TAP NAME:		

Figure 36 Preflight Data Capture Form.

C. Packing List

1. Airframe

- Nosecone
- Upper Body
- Electronics Bay
- Lower Body
- Motor Retainer
- Main Parachute
- Drogue Parachute
- Main Shock Cord
- Drogue Shock Cord
- Camera Shroud
- Main Parachute Deployment Bag
- Drogue Parachute Deployment Bag
- 5/16" Quick Links X6

2. Electronics

- Telemega
- EasyMini
- Screw Switches
- AltusMetrum battery X3
- Laptop with AltOS
- Laptop Charger
- Car battery charger
- Runcam 2

3. Pyrotechnics

- Ammo Can
- Scissors
- Mounting Putty
- 4F Black Powder
- EMatches
- Gloves
- Small Zipties
- Electrical Tape
- Blue Tape

- 75-5120 Aerotech Casing
- 75mm Forward Seal Disk
- 75mm Plugged Forward Closure (Tapped)
- 75mm Aft Closure
- Aerotech M1297 Rocket Motor Reload Kit
- Aerotech M1297 Propellant Graints X4
- Aerotech M1297 Phelonic Liner
- Aerotech Ignitors
- Superlube Grease
- 2-56 Shear Pins
- 4-40 Shear Pins

4. Other

- Rocket Stands
- All documentation
- Table
- Chairs
- Lunch
- Water
- Drill
- Drill Bits
- Dremel Tool
- Multimeter
- Screwdriver Set
- Other Assorted Tools

D. Launch-1 Checklist

1) Pull together all items, make sure everything is in good condition.
2) Go grocery shopping.
3) Start charging all batteries while packing.
4) Check flight computer programming.
5) Hot glue in power connectors.
6) Finish packing everything away into the car for launch.
7) Head to launch, setup camp, and sleep.

E. Assembly Checklist

1) Wake up.

2) Find Bob and Jay have them look over the launch vehicle. Make sure you are good to go to prepare the vehicle.
3) Assemble ejection charges. Set aside in ammo can for later use.
4) Assemble the motor per manufacturer instructions.
5) Attach the motor casing to the recovery system, and insert the motor into the airframe.
6) Attach motor retainer, ensure a snug fit.
7) Tape ignitor to the side of the airframe.
8) Ensure all electronics are turned off.
9) Turn on flight computers and verify the proper programming, battery levels, and connection to the ground receiver.
10) Turn off all flight computers.
11) Run primary and backup ejection charge through bulkhead to the Telemega and EasyMini respectively for main parachute.
12) Run primary and backup ejection charge through bulkhead to the Telemega and EasyMini respectively for drogue parachute.
13) Close up holes in bulkheads using mounting putty.
14) Test continuity of ejection charges through the flight computers.
15) Close up electronics bay, ensure continuity is still positive.
16) Apply blue threadlock onto the nuts of the electronics bay.
17) Measure out the amount of nose weight needed and insert it into the nosecone.
18) Close up the nosecone bulkhead, and threadlock on the nuts.
19) Pull out recovery system and lay it out. Inspect for tangles or damage.
20) Verify all hardware is tightly secured.
21) Fold parachutes into their deployment bags
22) Insert parachutes into body tubes.
23) OPTIONAL: Insert RunCam 2 into camera shroud.

F. Final Assembly Checks

1) Check ejection charge wrapping is secure.
2) Ensure all nuts on recovery mount points are secure.
3) Connect body tubes and couplers together.
4) Insert 3 steel screws between the upper body electronics bay.
5) Insert 3 4-40 shear pins between upper body and electronics bay.
6) Insert 2 2-56 shear pins between the lower body and electronics bay.
7) Verify motor retainer is secure.
8) Present vehicle to RSO and TAPs

G. Launch Checks

1) Confirm the following tools are ready: Blue Tape, Electronics Screwdriver, AltOS Laptop and Reciever, Extra shear pins, Dowel rod, 12’ 1515 rail.
2) Transport the rocket to the pad.
3) Lay down the launch rail.
4) Slide rocket onto the rail.
5) Lift launch rail back up while supporting the vehicle.
6) Optional: Turn on RunCam.
7) Turn on Telemega and EasyMini.
8) Confirm connection to the ground station from the Telemega.
9) Install ignitor in the motor.
10) Check ignitor continuity.
11) Return to RSO table.
12) Verify flight witnesses.
13) Indicate ready for flight to RSO.

H. Post Flight Checks

1) Find the rocket.
2) Verify all ejection charges are safe. Cut line by line if they are not.
3) Turn off flight computers.
4) Present vehicle to TAPs for flight and recovery verification.

VIII. Acknowledgements

I would like to take this time to acknowledge a few people who have helped me along my path for this project.

To Zach Deibert: It is thanks to a random visit to campus where I came by to see you working on stuff for Wildcat Rocketry, Final Frontier Aerospace at the time, that I joined the rocketry team and started this journey. You have put up with my shenanigans for many years and I cannot thank you enough for that.

To Ben Murdock: I am forever grateful to have been able to work under you for multiple years, and even after you graduated still giving me advice and helping me along the way. Even through my failures and mistakes you were always there to lend me a hand and to impart wisdom. Without the numerous slack messages I have sent you over the years none of this would have been possible.

To Wildcat Rocketry: Thank you for allowing me to be a member of the team these past 4 years. We have made a lot of progress from where we were when I first joined the club and I am looking forward to seeing what we are able to accomplish next.

To my friends: Thank you for allowing me to constantly discuss rockets when they have absolutely nothing to do with what we are currently doing. I know many of you were very concerned the first day I said "So, I started building a rocket..."

To my family: Austin, I know we have our differences. Like as I am writing this you are trying to get me to play American Trucking Simulator at 2:00 in the morning instead of working on this report. However, I do know that you realize just how important this is to me and you have sat through many conversations of me just ranting about rockets. Dad, You have no idea how much it meant to me when you first started to come to my robotics meetings in high school. Even though we were not working on the same sub-team just having you around meant the world to me. Through you I learned to never give up and to always do what you can to persevere. Even through my failures you never stopped believing in me, even helping shovel out one of my Level 2 attempts. Mom, I know at times you have had serious concerns about my sanity. Specifically when I first came and told you "Hey mom, I am building rockets now." that could not have been the easiest conversation for your stress levels. Then of course seeing me right before a launch, or after a failed launch was not easy. However, you always believed in me and encouraged me to never give up. Even when I was at my worst. In case you all had not realized yet, the name TYMAD is an acronym for "Thank You Mom and Dad" (Sorry Austin, could not think of a good way to also get your name in there without it sounding awful, we will pencil you in there somewhere).