Air MK1 - Assembly Document

Abstract

Air MK1 is my first High Power Rocket with the goal of flight testing the TFAC flight computer and teaching me the building techniques required to successfully build and fly a High Power Rocket. This document will take the reader through the process of assembling Air MK1 and getting it ready for flight.

Basic Specs and Component Materials

Air MK1 is 115cm in height and has a dry mass of 1440g.

Its airframe is a 3” cardboard tube (ID: 76.7mm, OD: 83.5mm), and there are two sections to the rocket.

The forward section is 45cm in length and acts as a payload section holding TFAC. There is a 20cm 3D-printed Ogive nosecone at the front of the forward airframe and at the Aft is an 18cm long 3D-printed coupler, with an Eye-bolt epoxied on, which connects the forward airframe to the aft airframe. The nosecone and eye bolt are held in place via 4 M3 screws for each component.

The aft airframe is 50cm long and holds the motor assembly along with the recovery system (i.e. parachutes and shock cord).

The Motor Mount Tube (MMT) is a 20cm long, 35mm Inner Diameter cardboard tube. The MMT is held in place by two 5mm thick Plywood centering rings spaced 13cm from each other. The forward-centering ring has an eye bolt attached (which serves as the aft connecting point for the shock cord), and the aft-centering ring has two M4 bolts attached which are there for motor retention (fig 1). There are four fins at the aft of Air MK1, they are through-the-wall fins which means that they are attached to both the airframe as well as the MMT. Each fin is laser cut out of 3mm plywood.

Fig 1 - Motor Mount Assembly

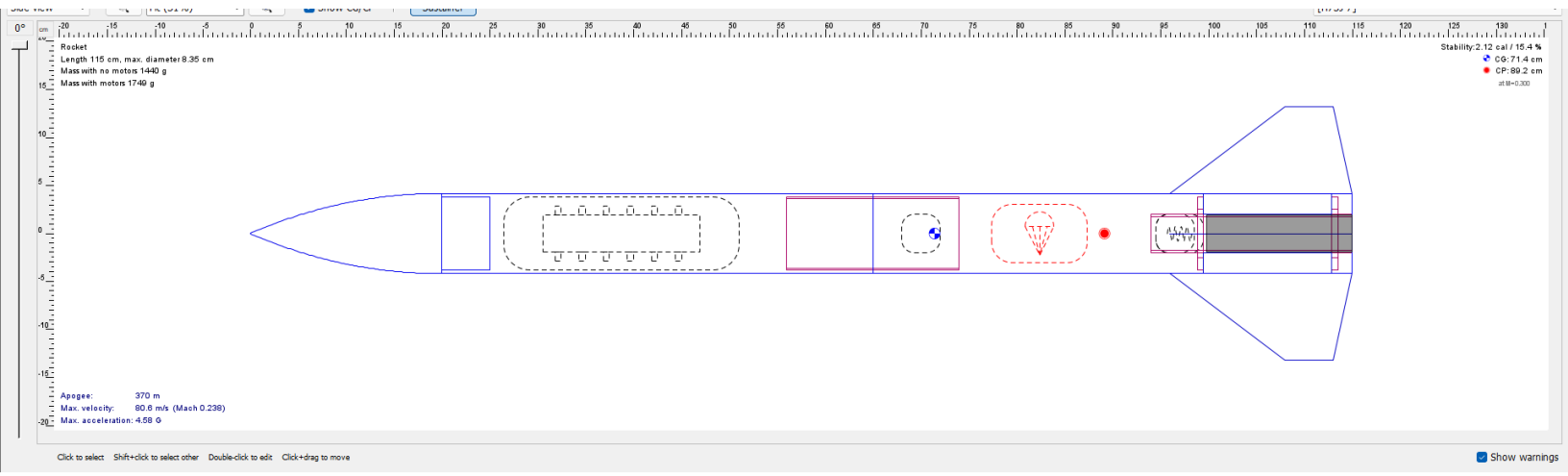
The shock cord must have a length of 2.4m (or over 2m), and the parachute must have a canopy diameter of 100cm to provide for a ground-hit velocity of ~6.4m/s. The parachutes are deployed via an ejection charge on the motor.

Flight Specs and Motor

Air MK1 will utilize an Aerotech H73J equivalent rocket motor. The motor must have a motor delay of 7 seconds to deploy the ejection charge at apogee. Below are the simulated flight details:-

Apogee - 370 meters
Max Velocity - 81 m/s (Mach 0.2)
Max Acceleration - 4.6G

The total flight time (assuming parachute deployment) will be 67.5 seconds. The velocity off the launch rail will be ~9 m/s, and the velocity at parachute deployment will be 6.9 m/s. The vehicle will take 9.5 seconds to reach apogee. Vehicle stability is 2.12 calibers.

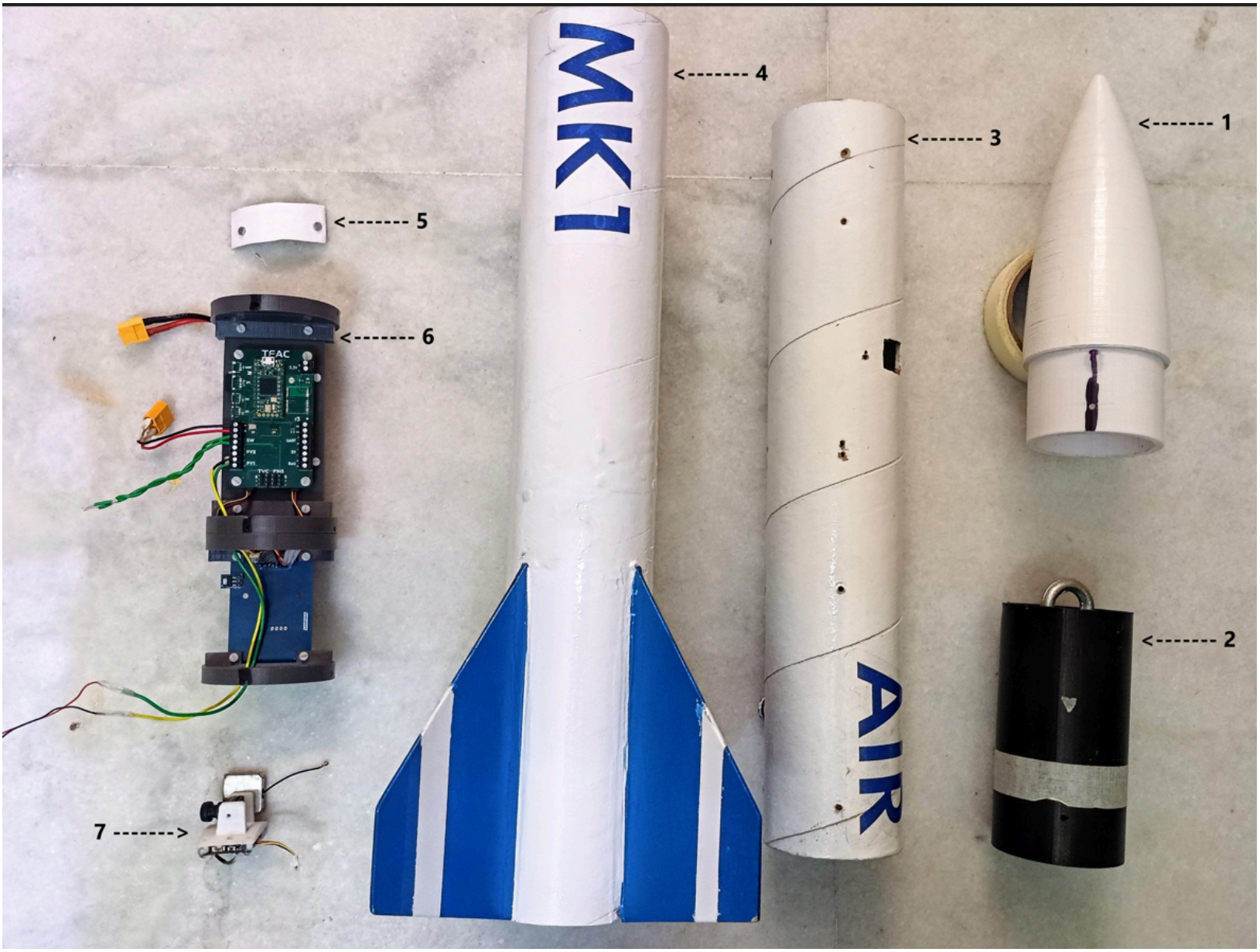


Air MK1 OpenRocket 2D Model

Air MK1 3D CAD Model

Integrating the Vehicle

Air MK1 will arrive in 7 parts along with bags of miscellaneous nuts and bolts



Component Name and Number :

1) Nosecone
2) Coupler

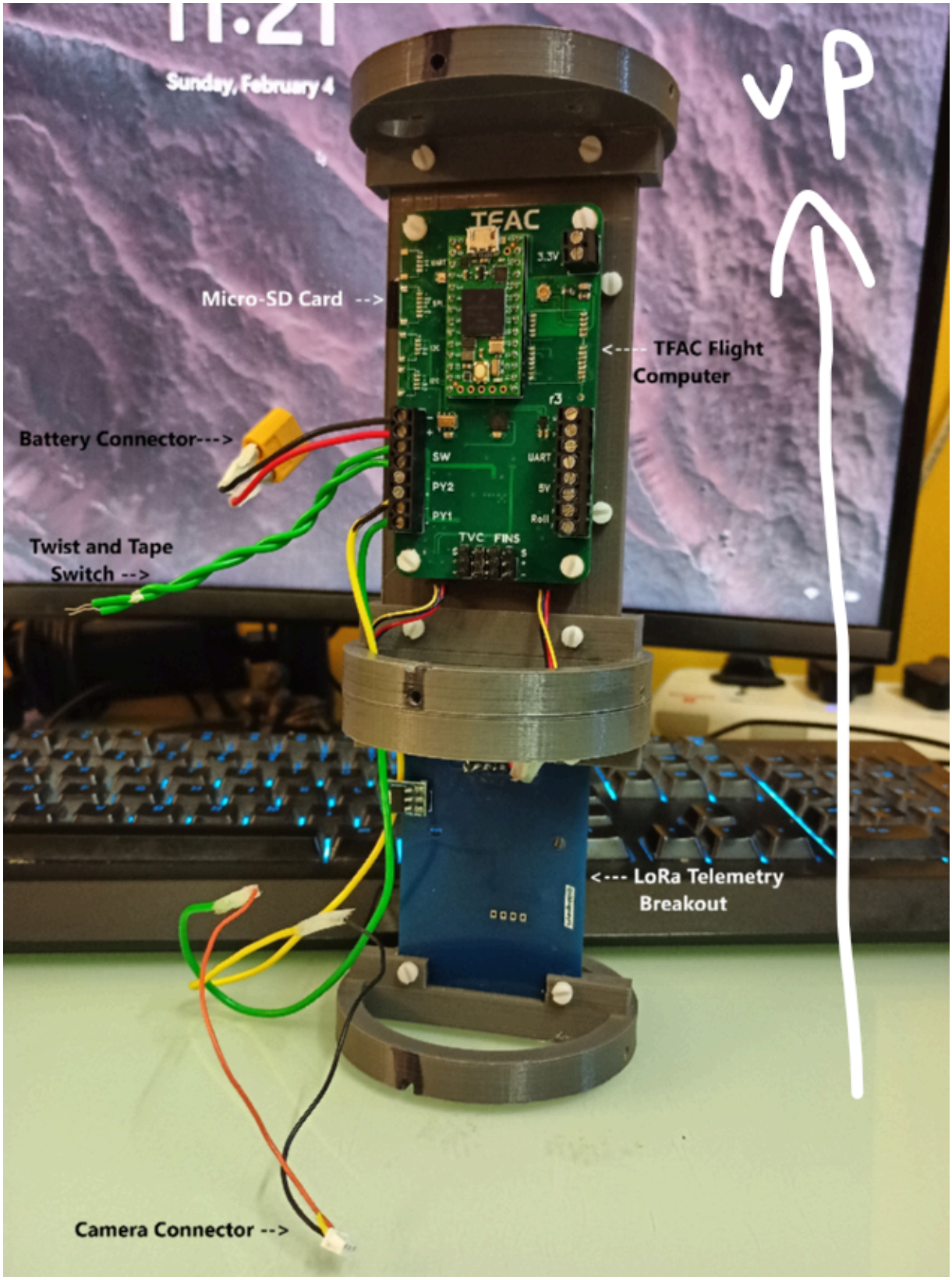
3) Forward Airframe
4) Aft Airframe
5) Forward Airframe Hatch
6) Avionics Stack
7) RunCam Split 3 Mini camera in Camera attachment

Note component 6 (the avionics stack) will arrive integrated already into component 3 (the forward airframe).

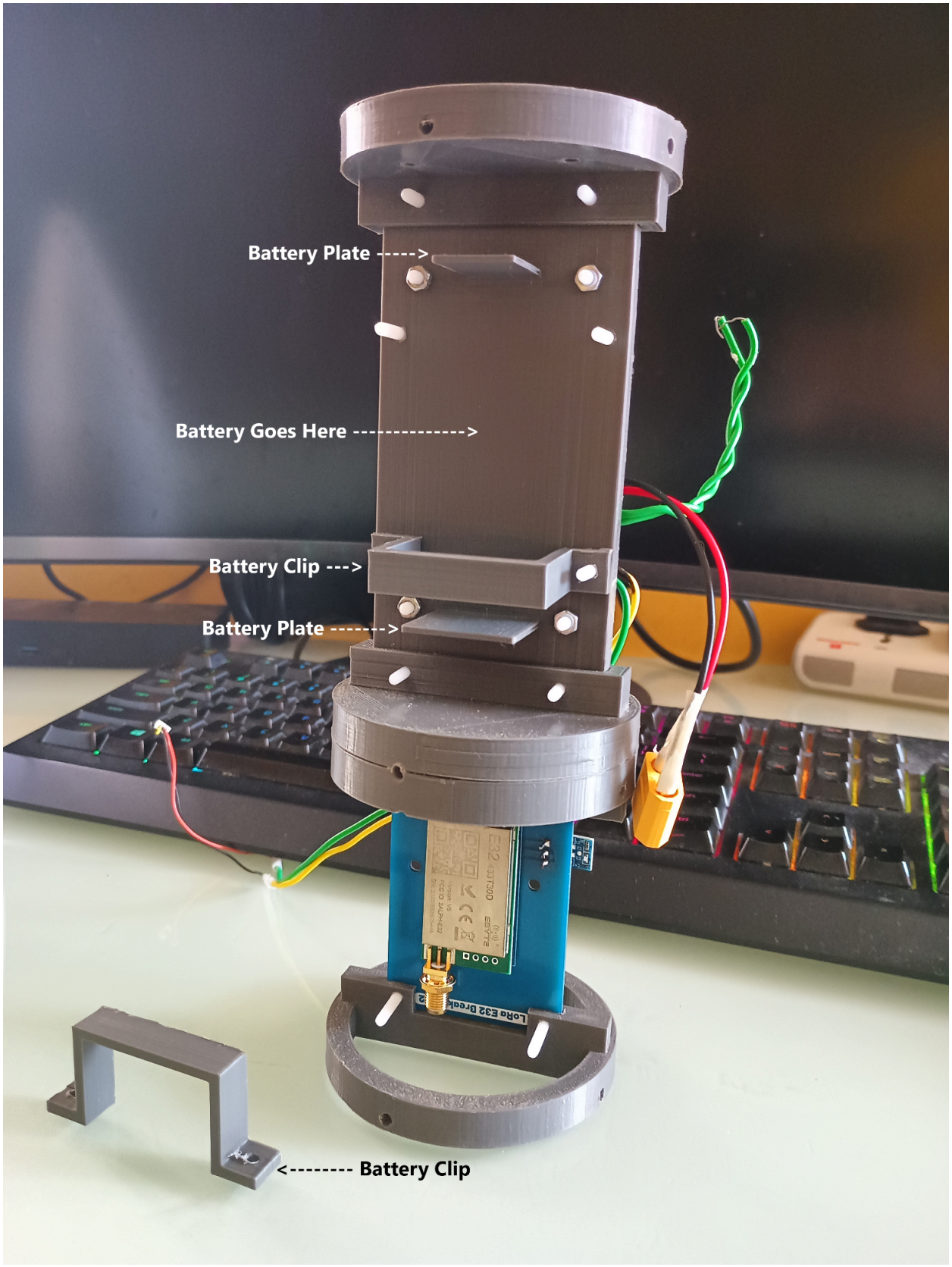
Assembling the Avionics Stack

The avionics stack will arrive almost fully assembled. The only component you will have to integrate is the 3s LiPo battery, as I am unable/it is not safe to ship Lithium Polymer batteries and there are unnecessary shipping costs associated with shipping LiPo's.

Before proceeding with assembling the Avionics Stack, here is a quick overview of the various connectors and components of the stack. The Avionics stack is 3D printed out of PLA and is 23cm in length. The stack consists of a central sled with two bulkheads. The aft bulkhead has a Telemetry mounting bracket attached to it. TFAC and the battery are held in place to the central sled via M3 Screws. The battery is held in place by two plates on the top and the bottom and two brackets are held in place via M3 screws.



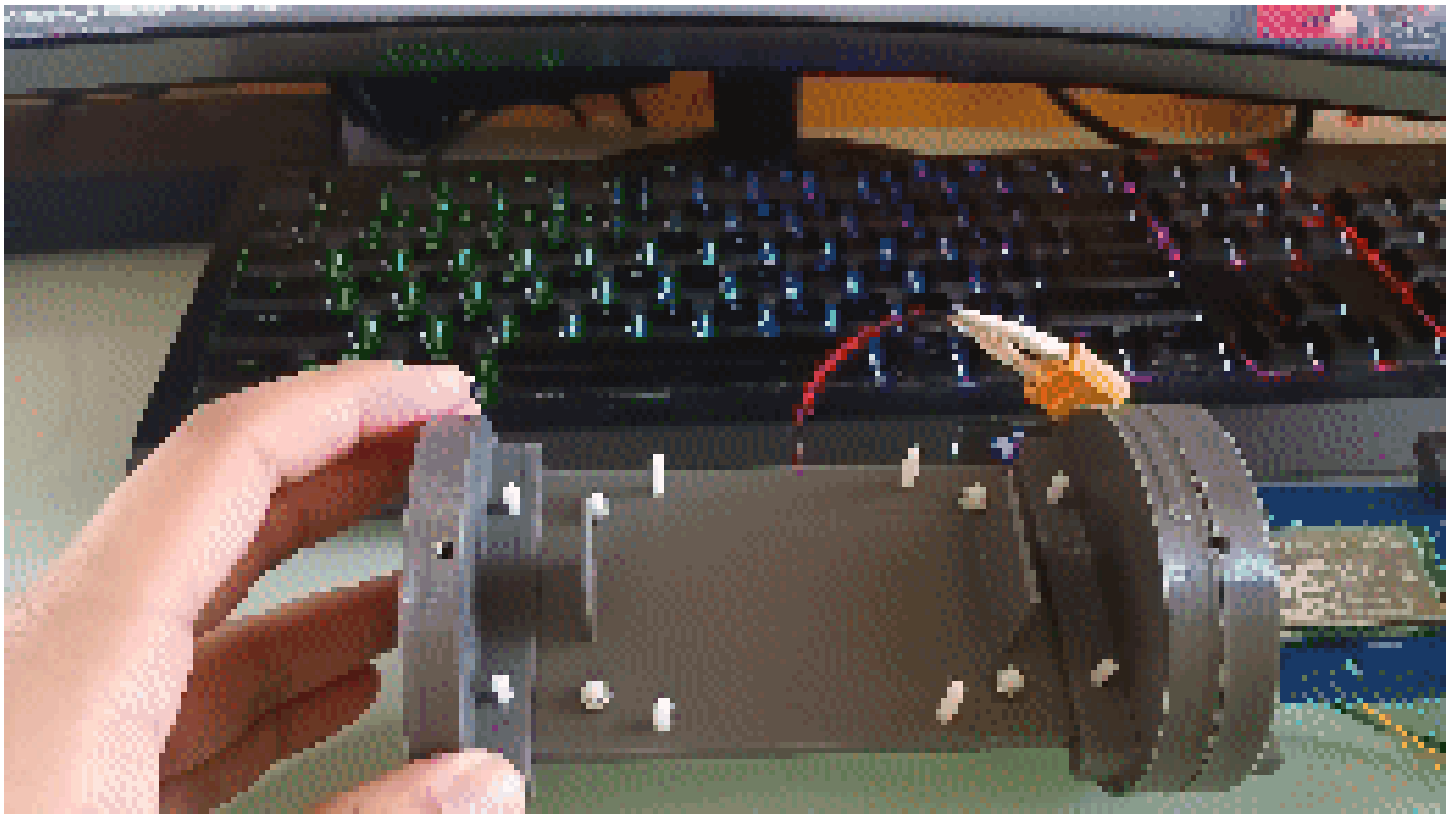
Avionics Stack Front view



Avionics Stack Rear View

Installing the battery

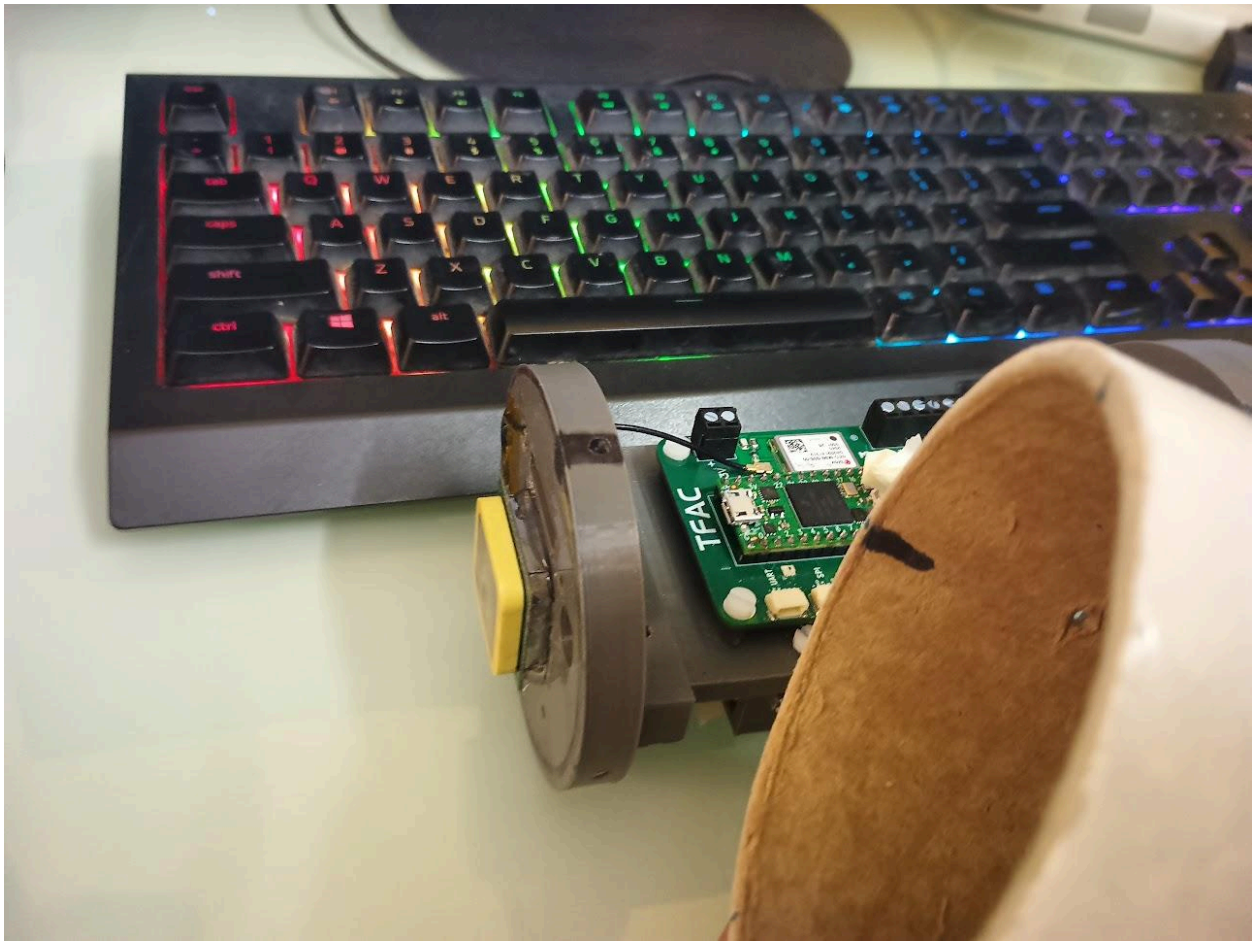
The XT60 connector and balance connector point upwards. Place the battery between the two plates, and install the battery clips on the nylon screws, then install the nuts.



Finally, plug the female XT60 Connector from the battery to the Male XT60 connector from the avionics stack and tape down the connectors and balance port to the battery.

Integrating the Avionics Stack

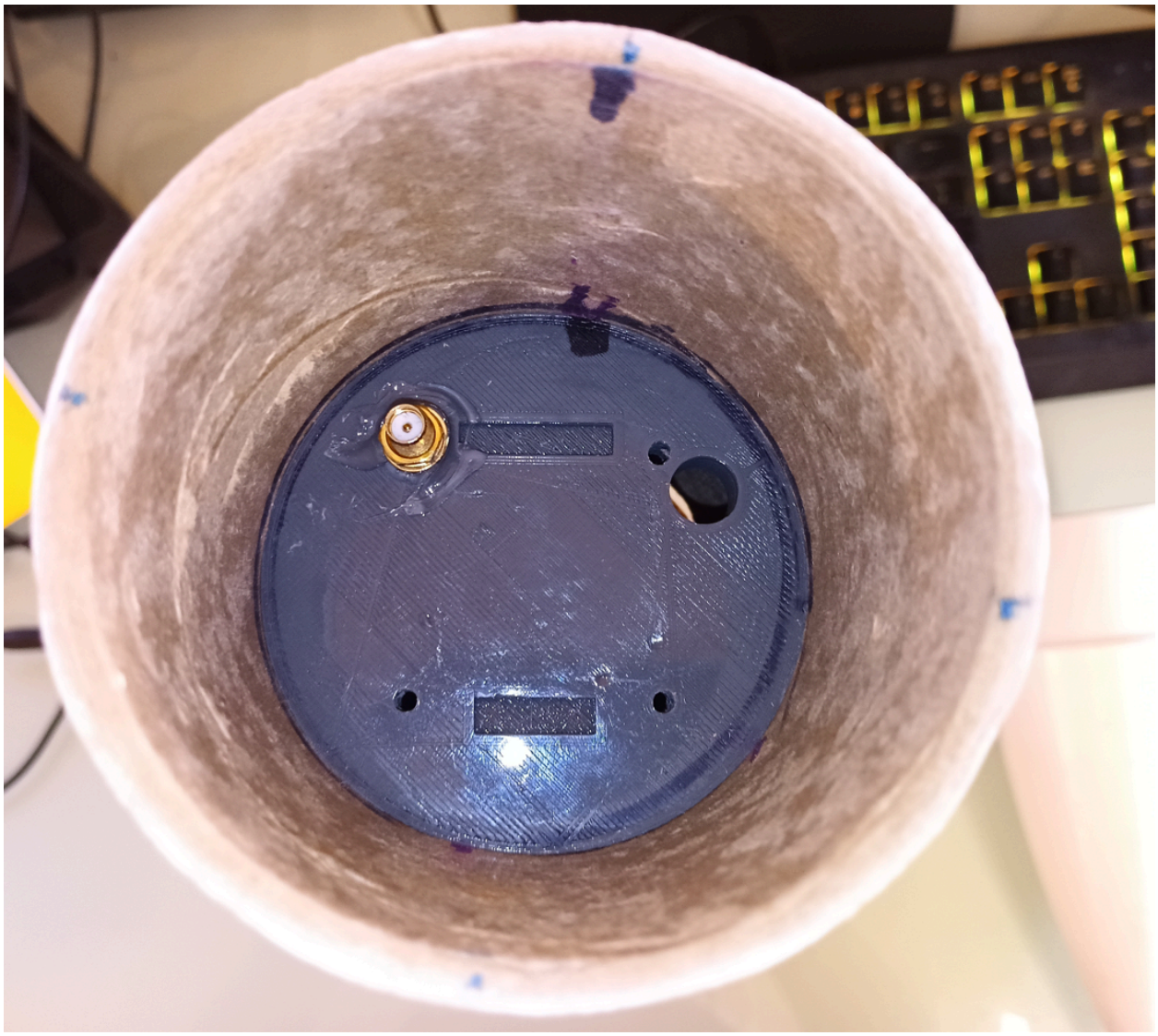
On the forward Airframe the text “Air” is downwards. Orient the black stripe on the avionics stack with the black line on the top of the forward airframe



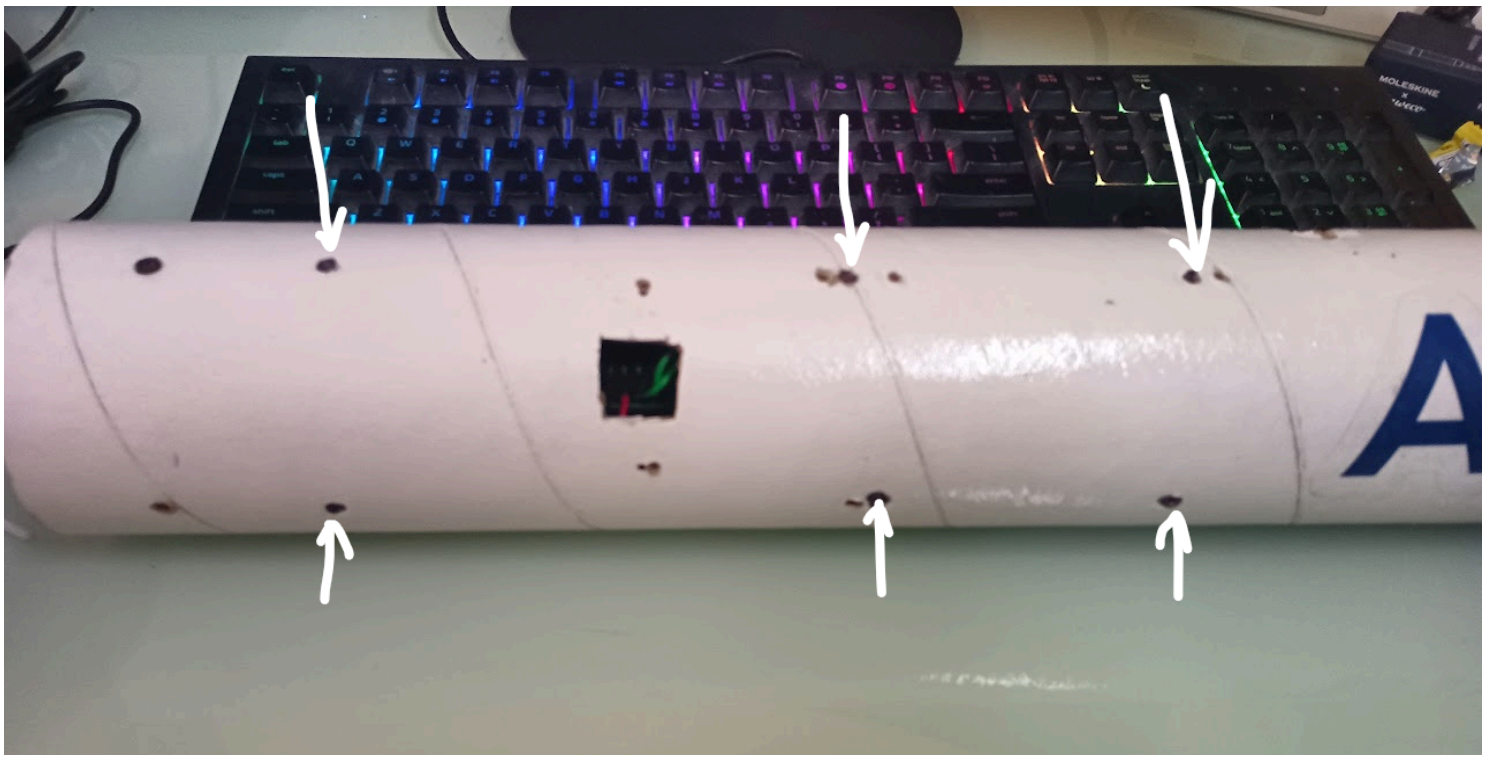
Then insert the avionics stack telemetry antenna first into the airframe

TFAC
UART
TVC FINS

Push the avionics stack into the airframe until it looks something like this



Once the avionics stack is aligned install the M3 screws to the holes that have black outlines on them

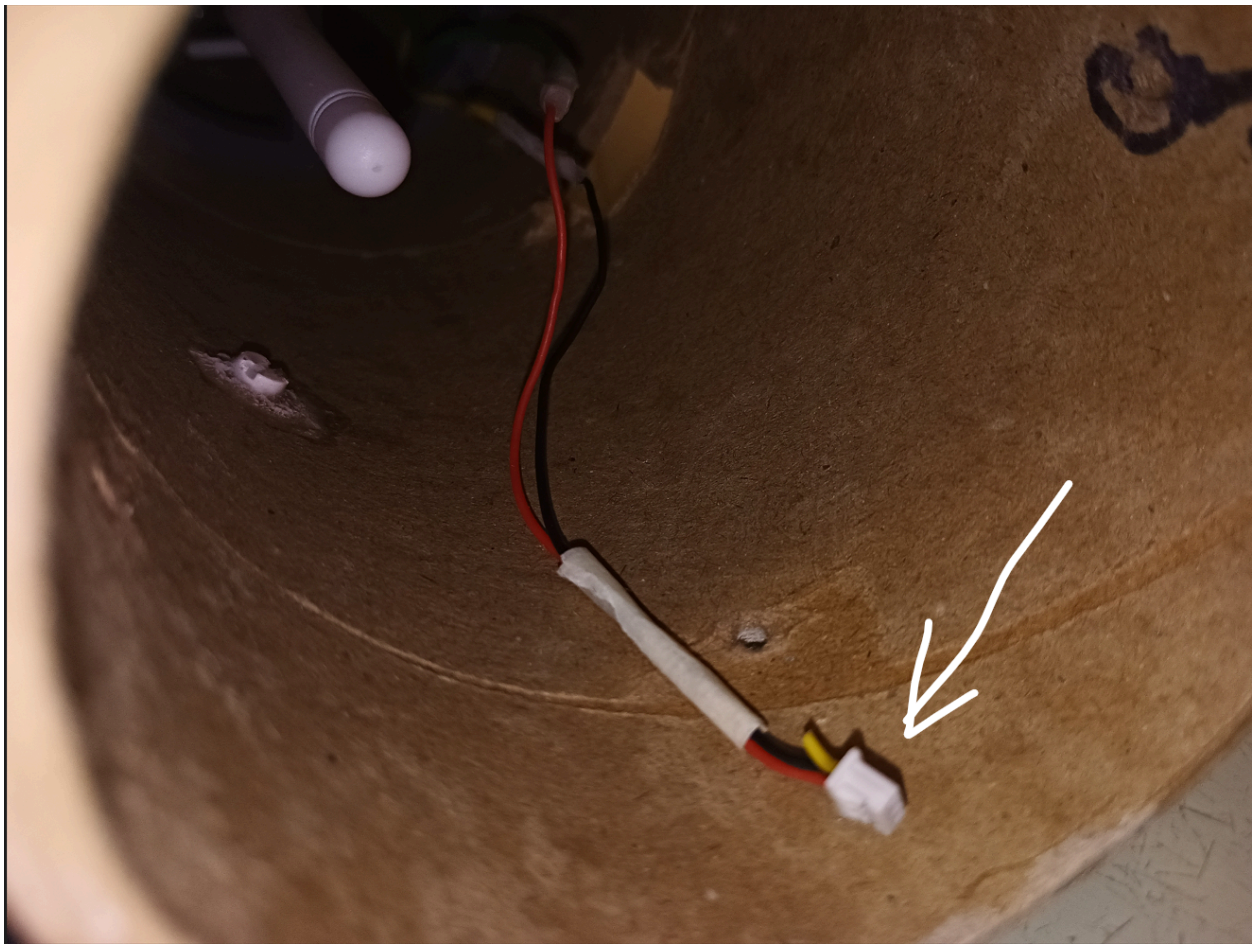

MOLESKINE

If the M3 screws don’t fit quite right push the avionics stack a little higher or lower. Push the 3D-printed components and not the antennas.

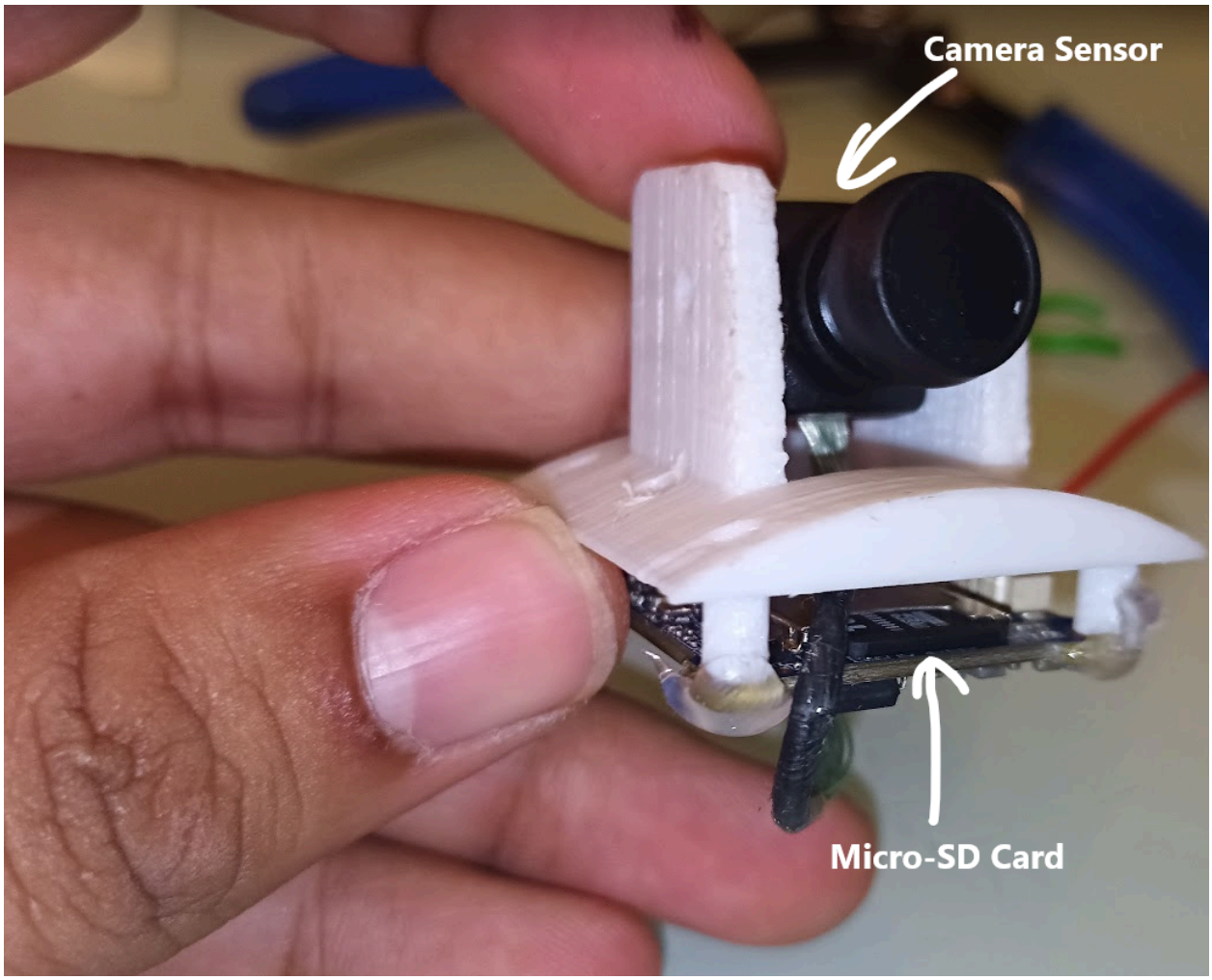
Finally, pull out the avionics switch wire using a non-metallic rod or your fingers. Don’t remove the tape yet. If the two wires touch the avionics system will be powered ON.

Camera Integration

Now it is time to integrate the camera. At the aft of the forward airframe, there will be a white JST connector. That is our camera connector.

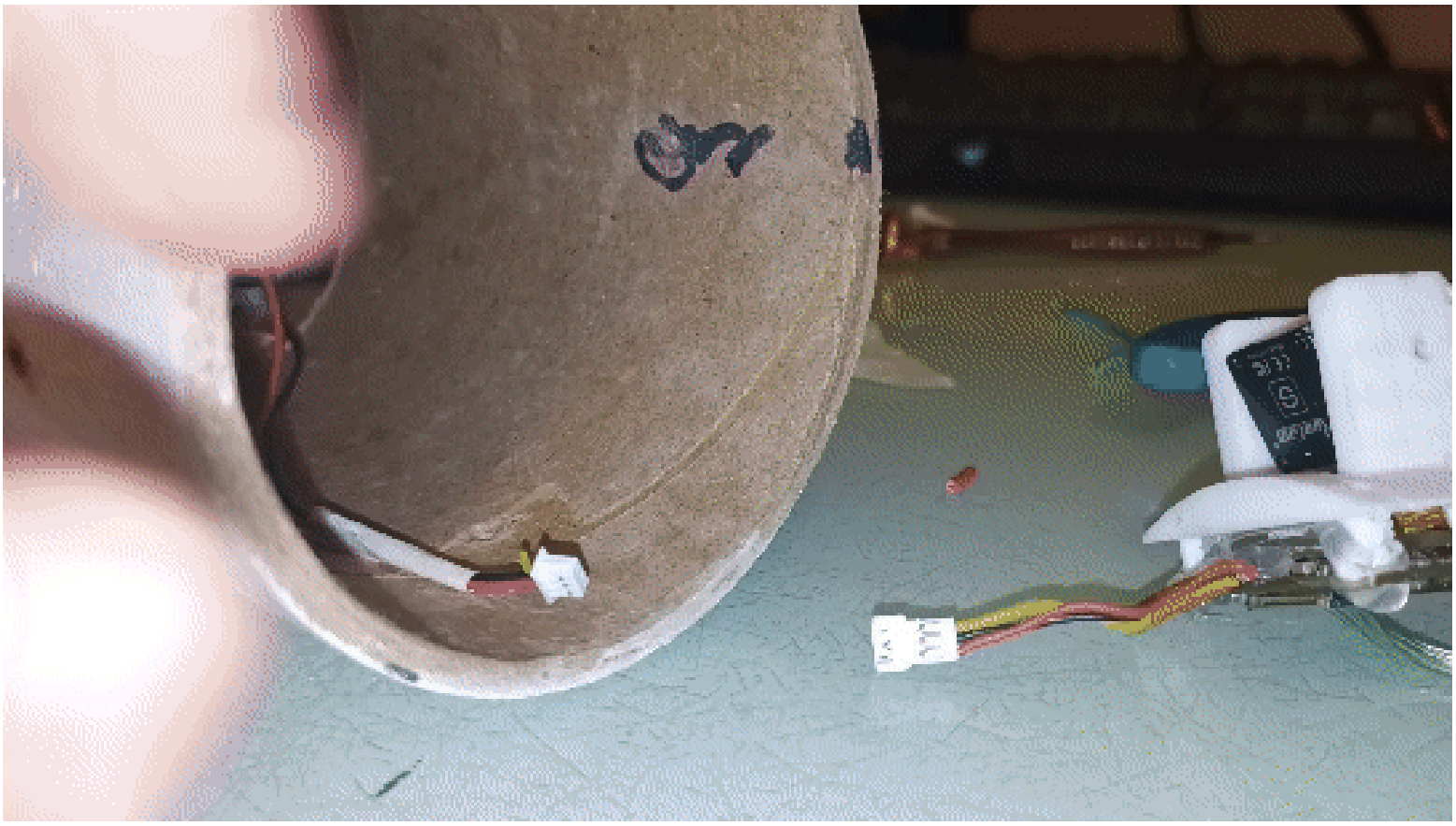


This is the camera mount with the RunCam Split 3 Camera.



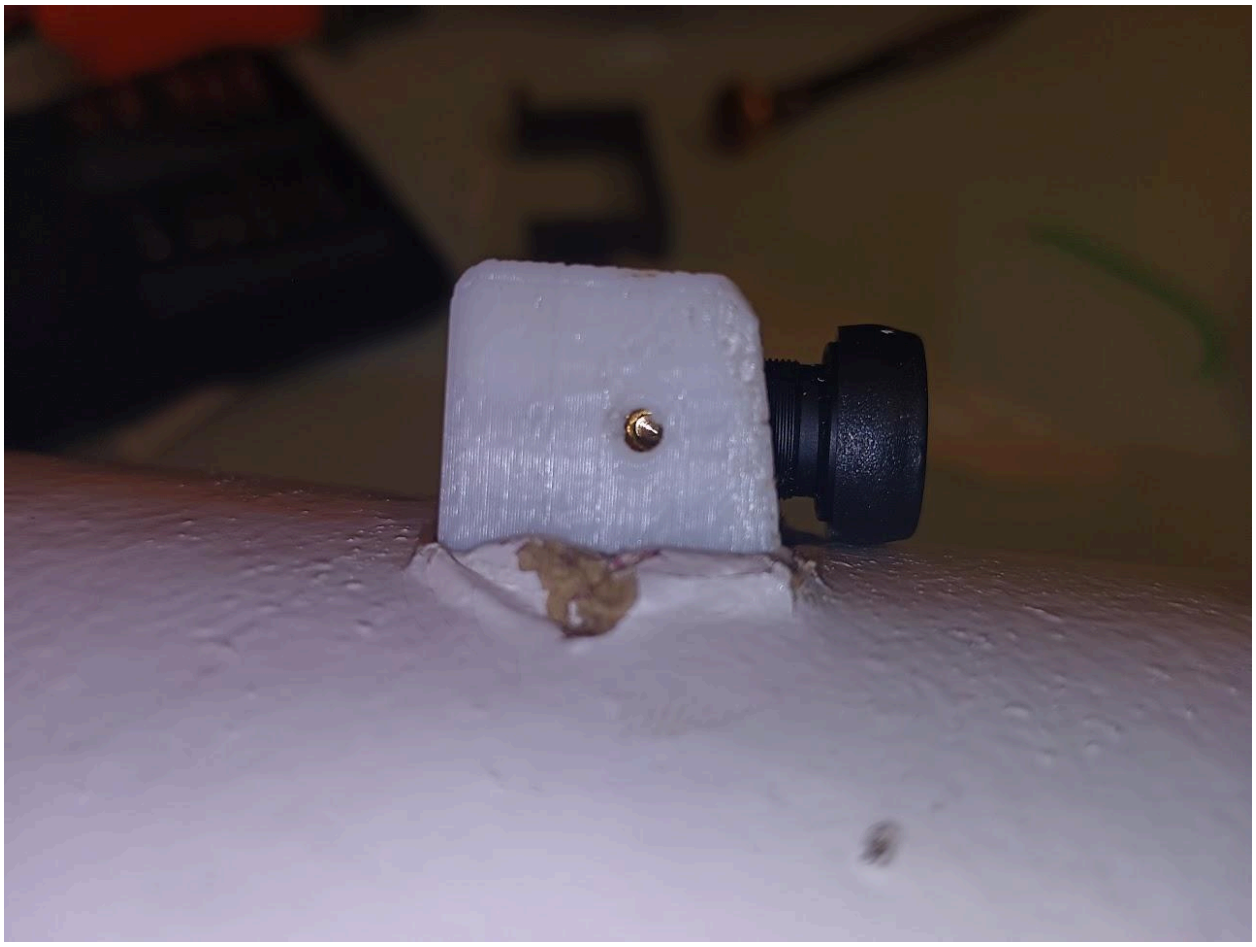
First, orient the camera Sensor so that it points upwards, this is done so that the camera sensor can be slid into the airframe as the camera mount cutout doesn’t account for the extra area of the camera sensor. You may want to push down the camera sensor so it doesn’t move when you slide it into the airframe.

Then plug the Camera’s JST cable with the JST cable connected to the flight computer.

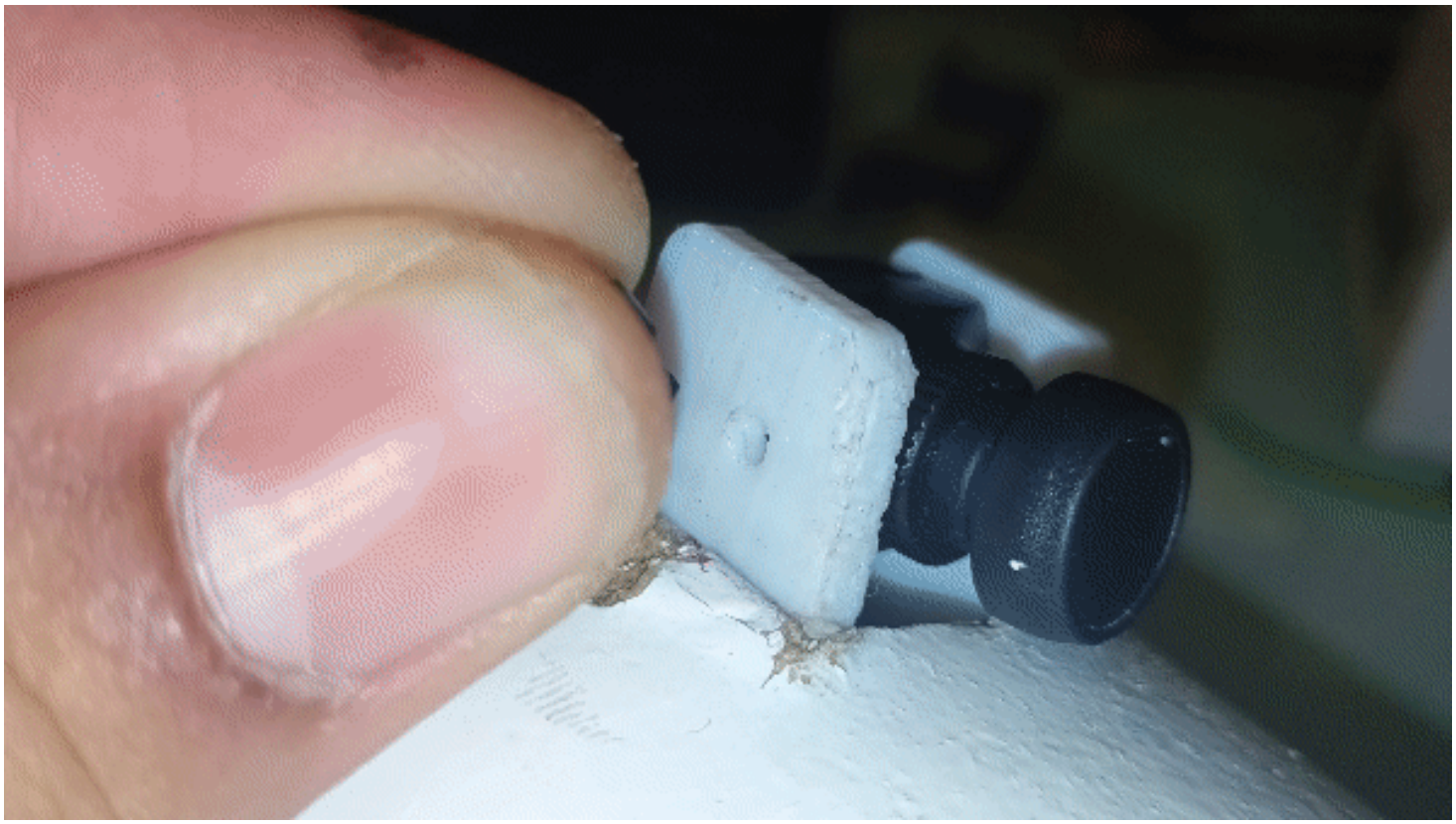


Once that is done slide the camera mount into the camera cutout of the airframe

Orient the camera sensor so that it points downwards. Move the camera sensor so the brass nut of the camera is visible through the mount hole



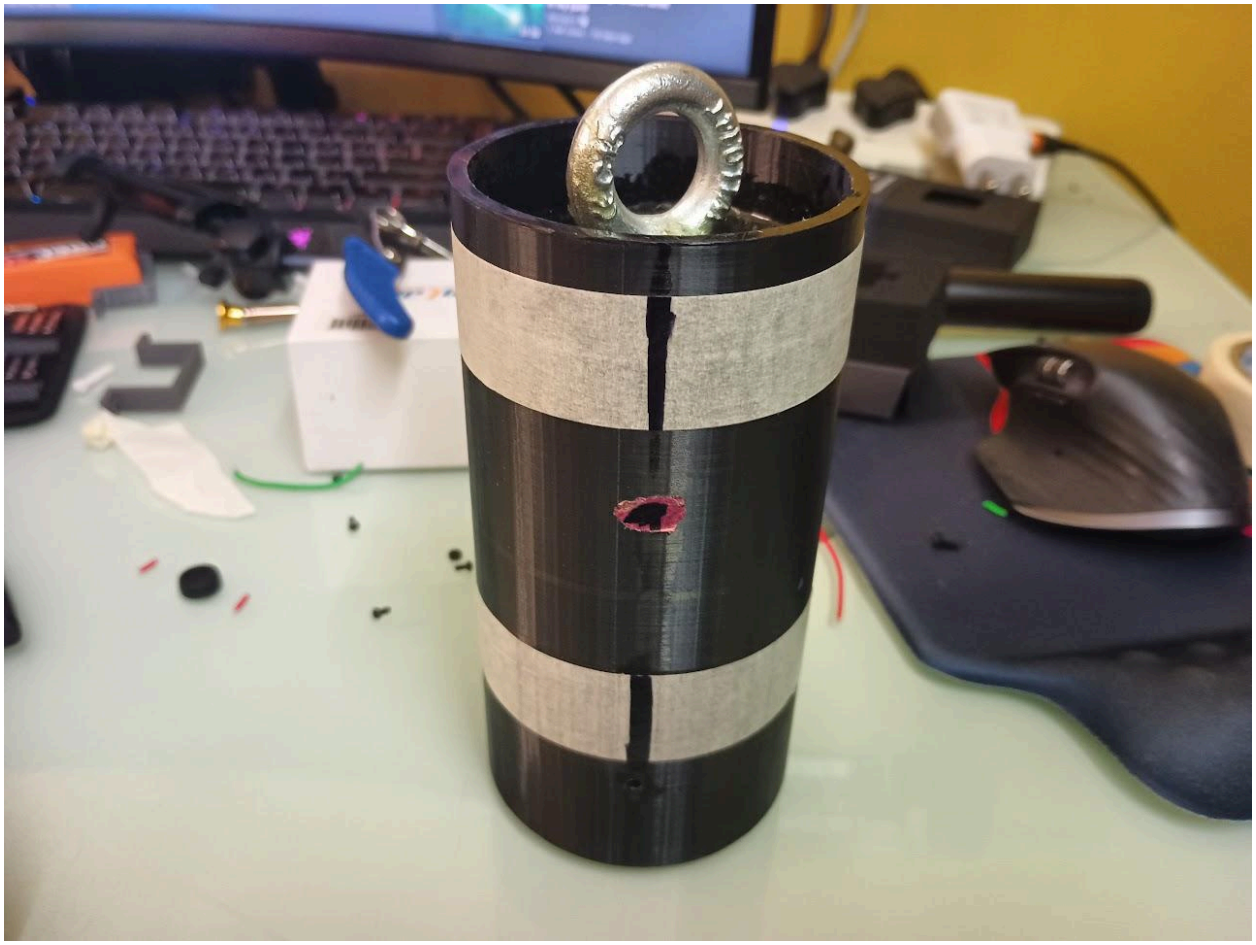
Finally, use the black M2 Screws to hold the camera sensor in place



The camera sensor should look like this. The lens cover can be removed as well

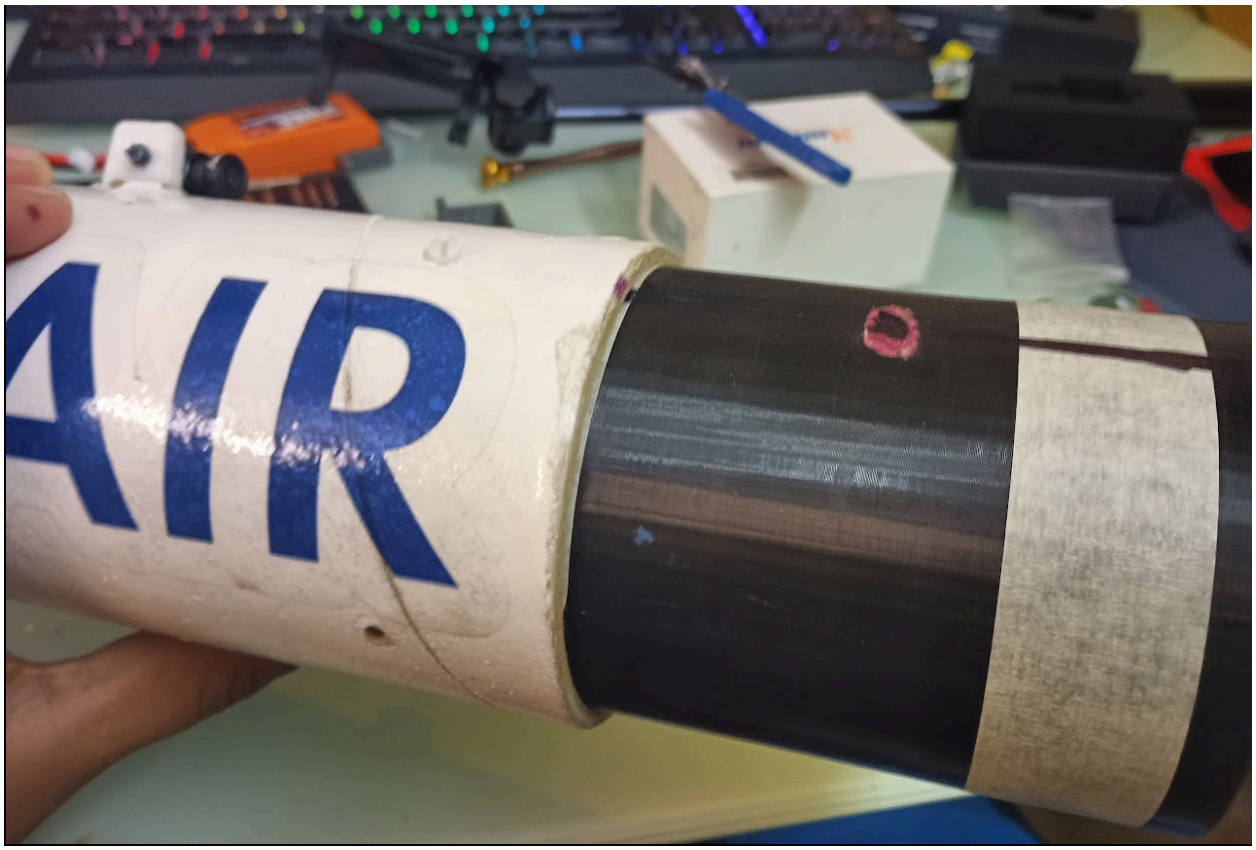
Coupler Integration

The coupler is 3D printed and has an eye bolt epoxied onto the center of it. There are two lines of tape to increase stiffness



The side with the lines must align with the line in the airframe

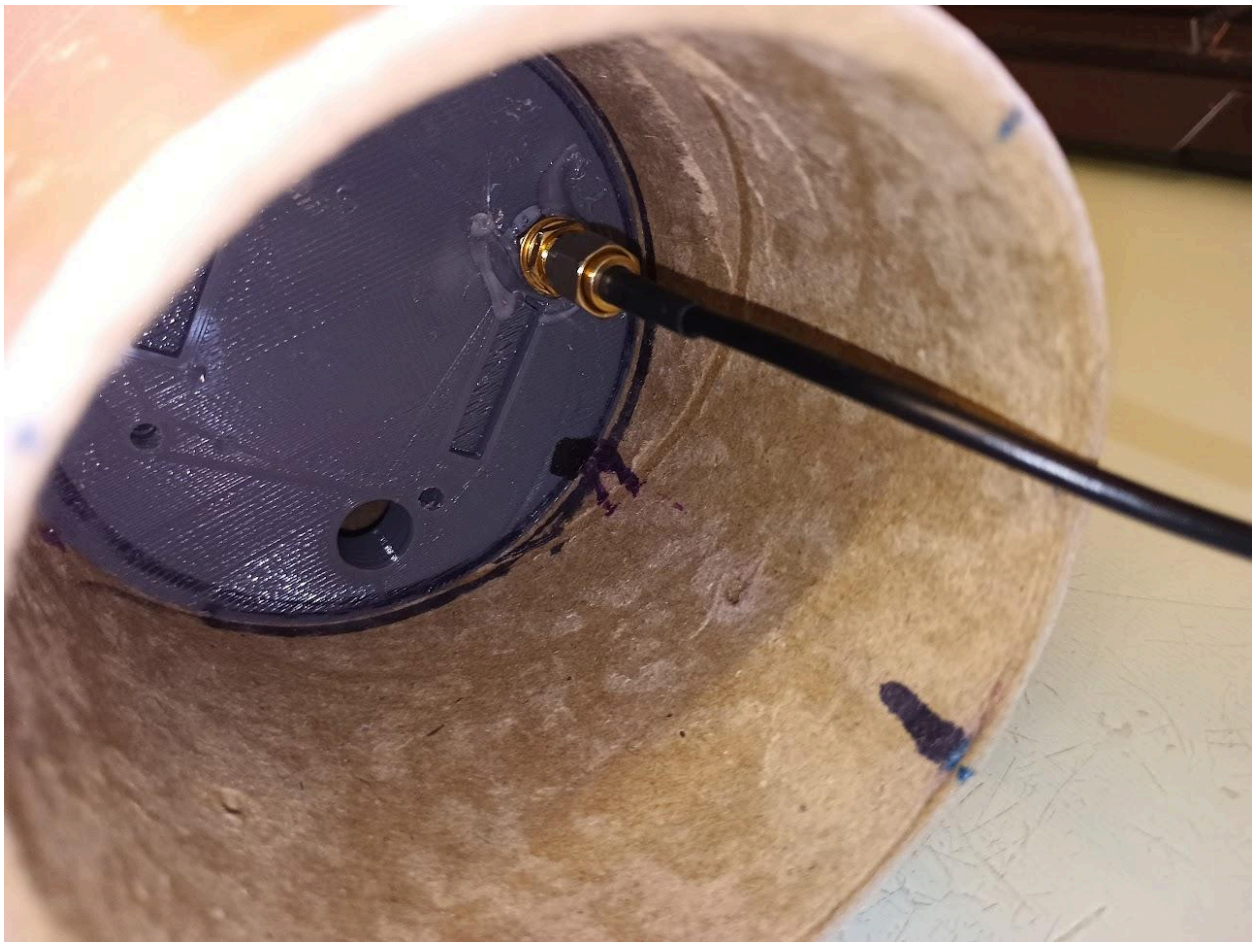
Slide the coupler into the airframe until 1-2mm of tape is shown, then insert the M3 screws


AIR

Nosecone Integration

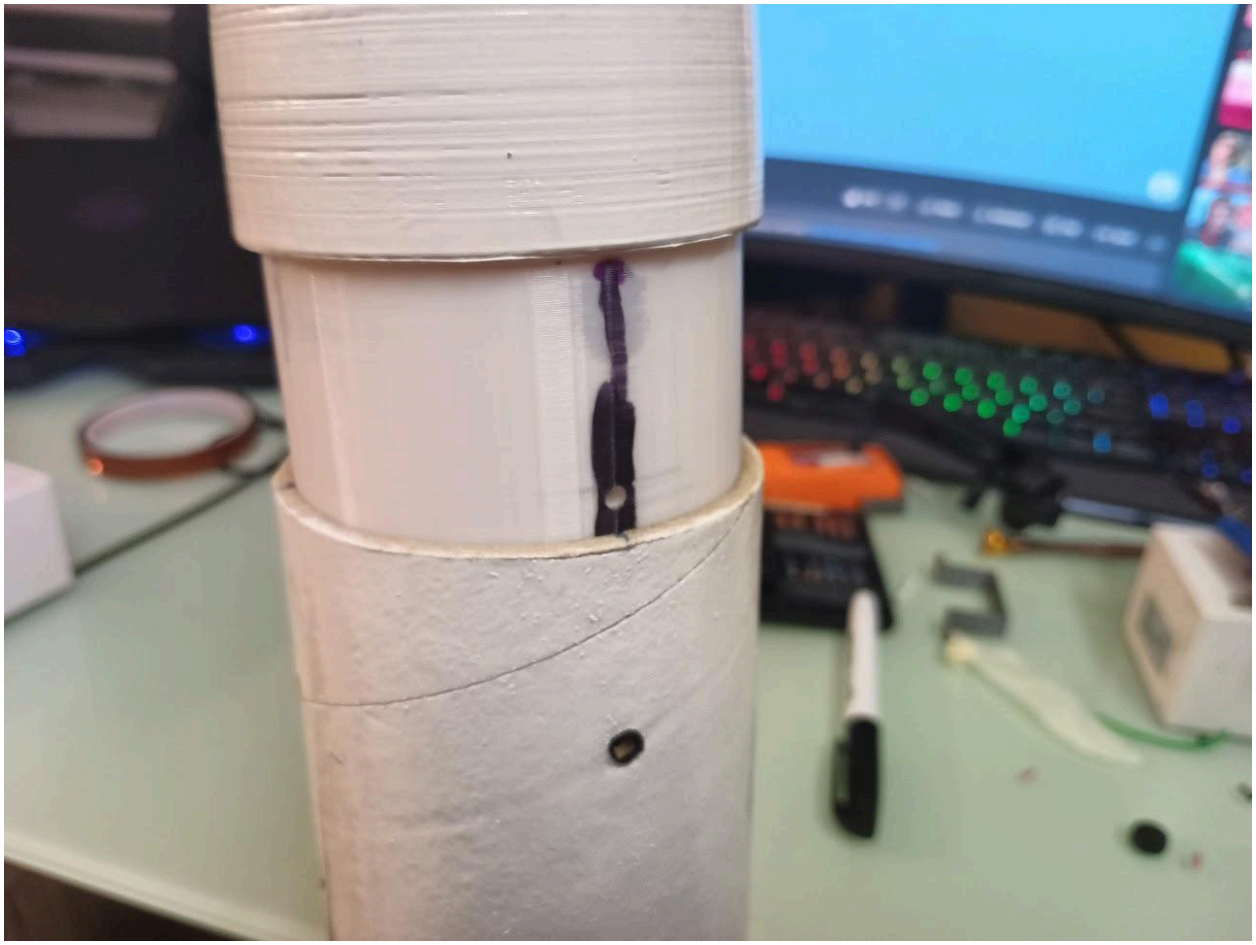
The installation of the nosecone is relatively straightforward. The GNSS antenna is located in the nosecone

First connect the SMA connector coming from the antenna to the SMA connector located on the top of the avionics stack

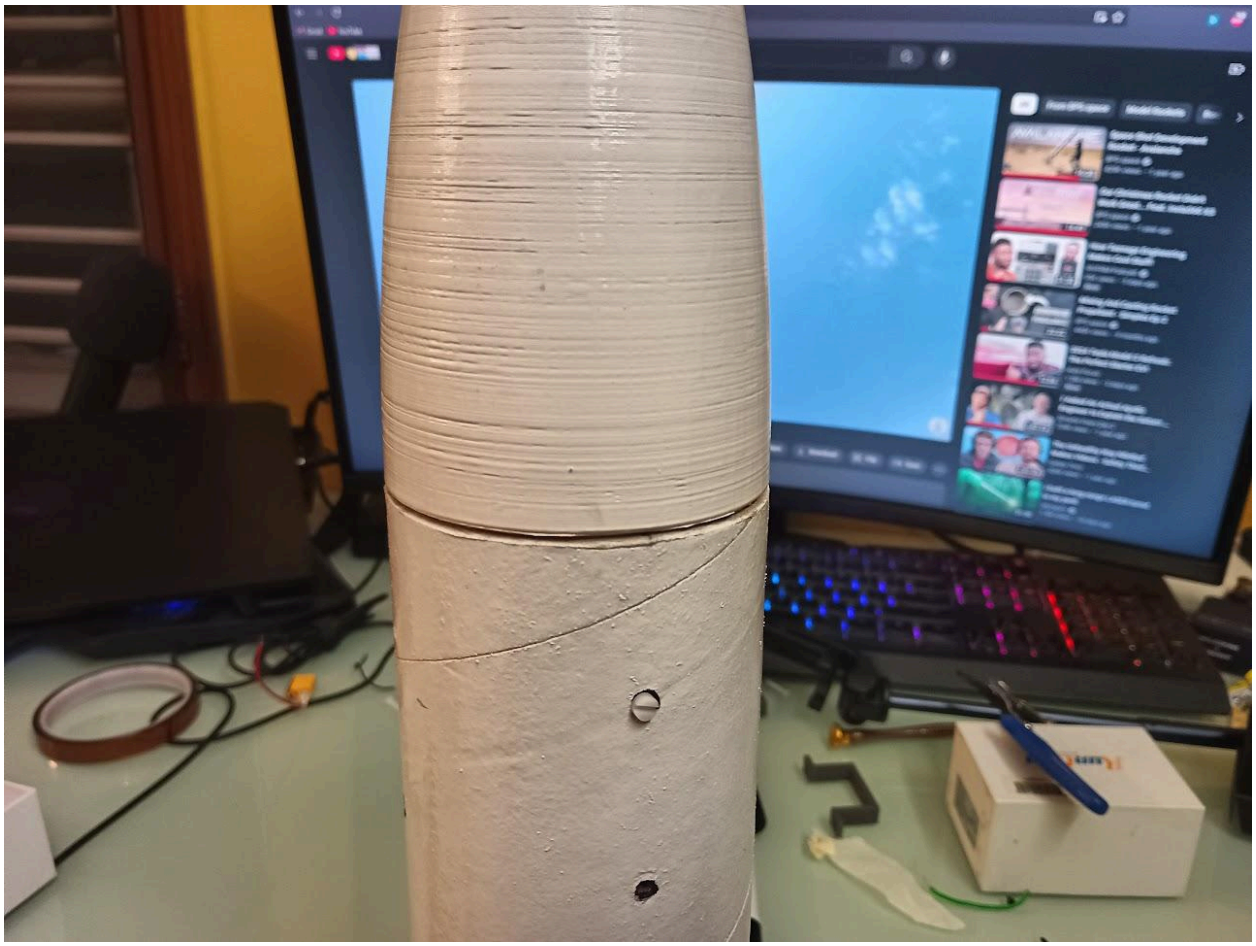


Then push the nosecone into the airframe.

The line on the Nosecone should align with the line on the top of the forward airframe



Then push the nosecone in and add the four M3 screws



Final Integration

This section assumes that the shock cord, parachute, and Nomex blanket are already installed. Insert the forward airframe into the aft airframe. Make sure that the “Air” sticker and “MK1” sticker are aligned

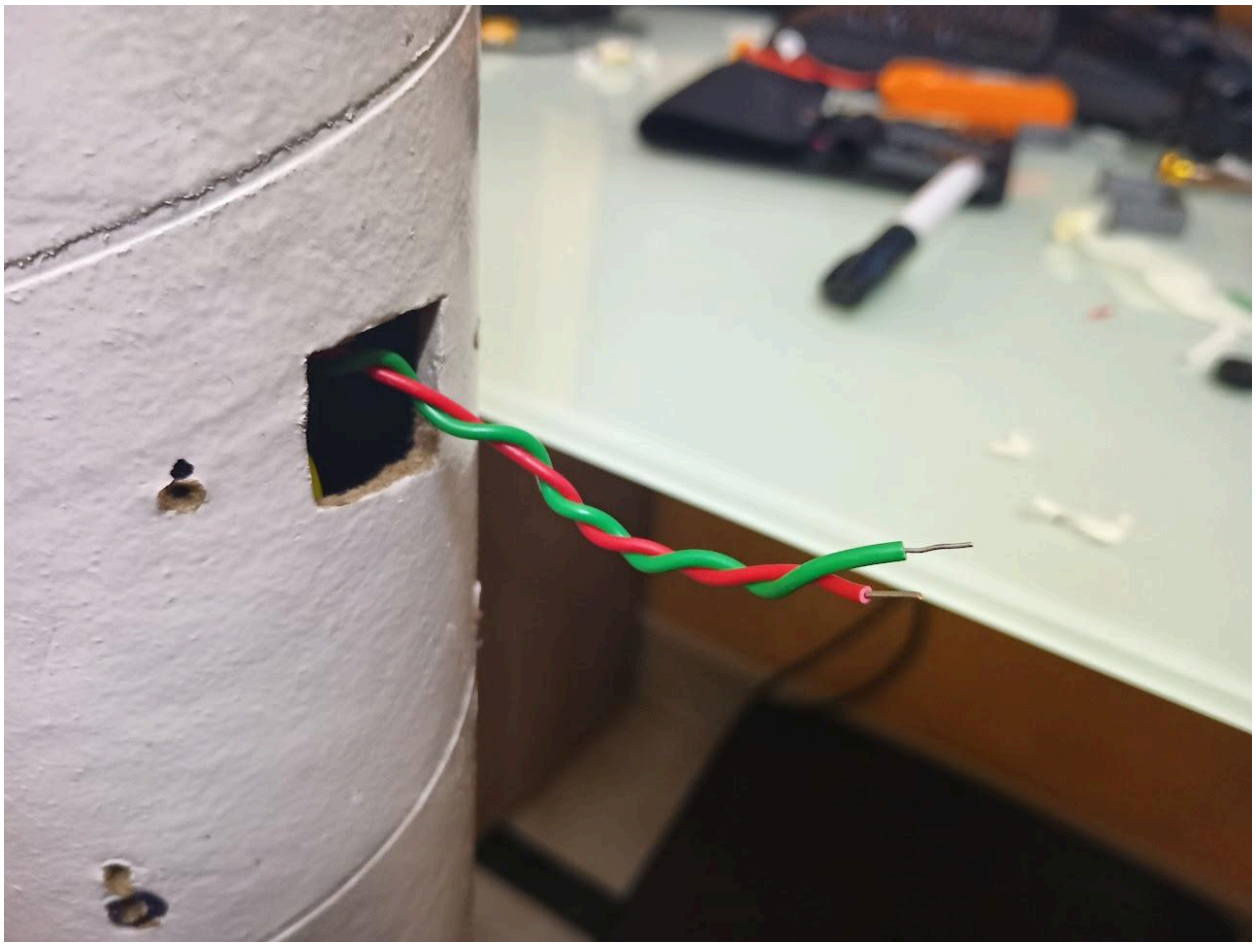
AIR MK1

Air MK1 is almost fully assembled and can be taken to the launch pad.

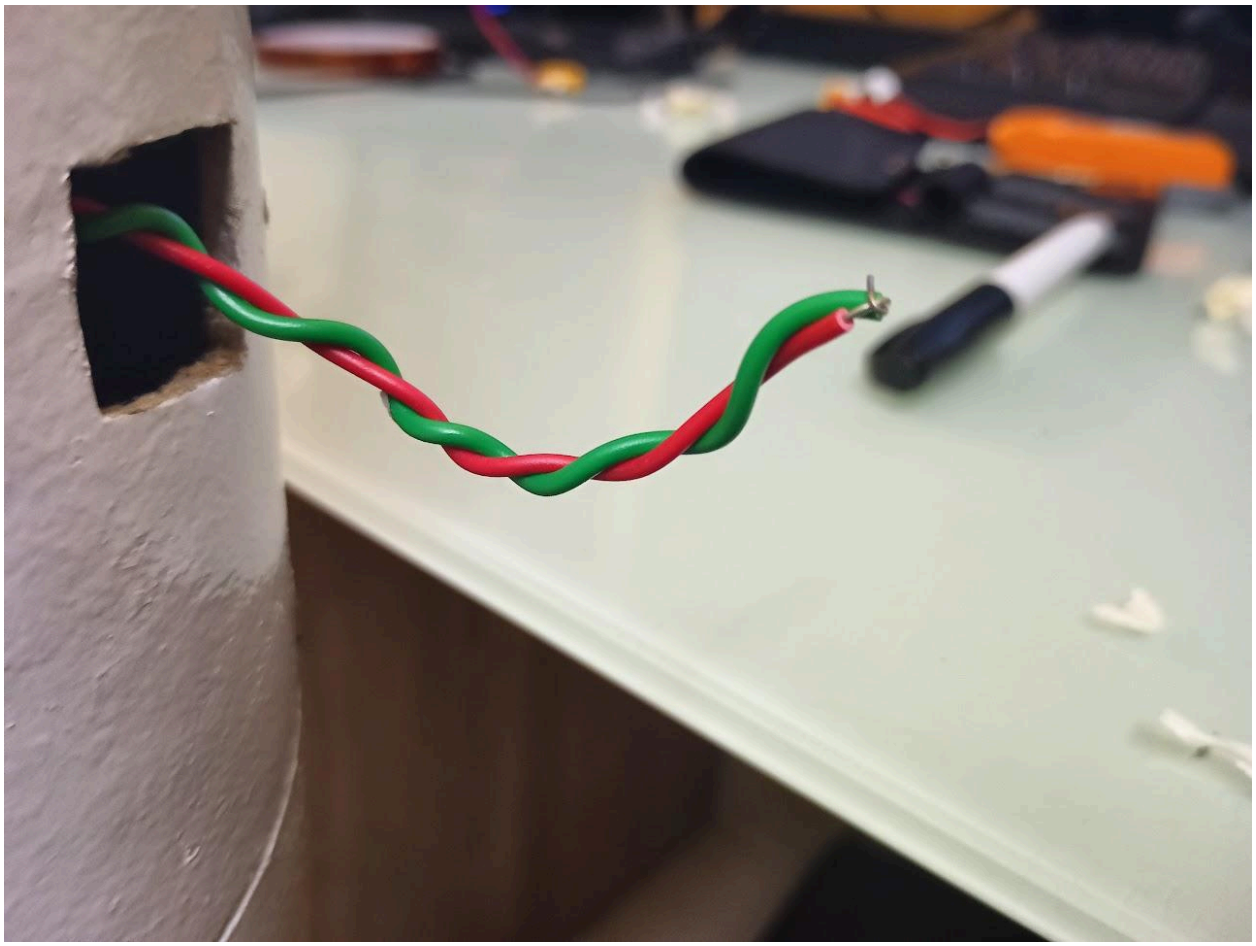
Powering on the Avionics stack

Once the rocket is on the launch rail and vertical it is now time to power on TFAC.

First, remove the tape covering the two wires

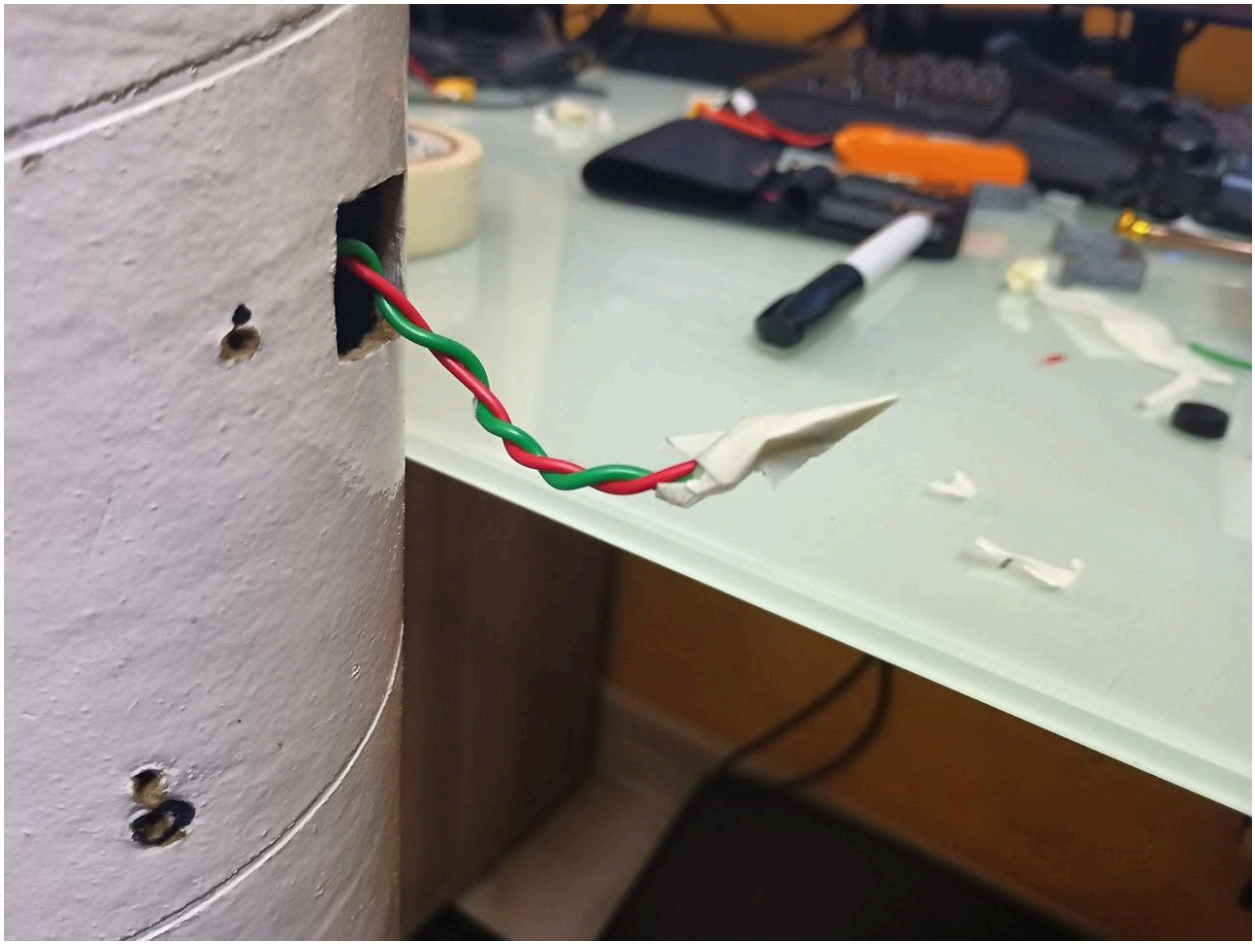


Then twist the wires together and wait until you hear the beeps from TFAC.

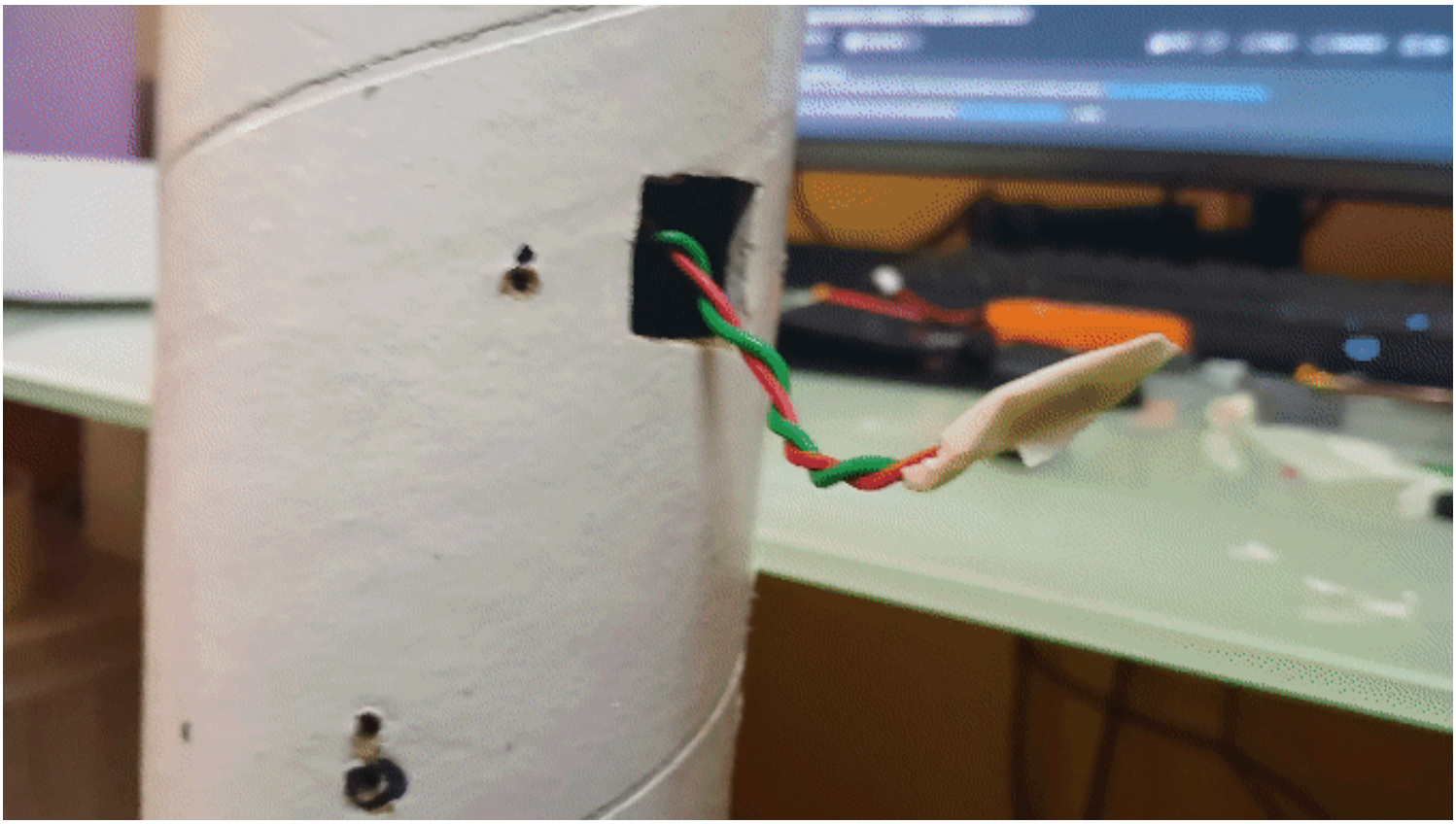


Now TFAC is powered on and should be transmitting Telemetry packets.

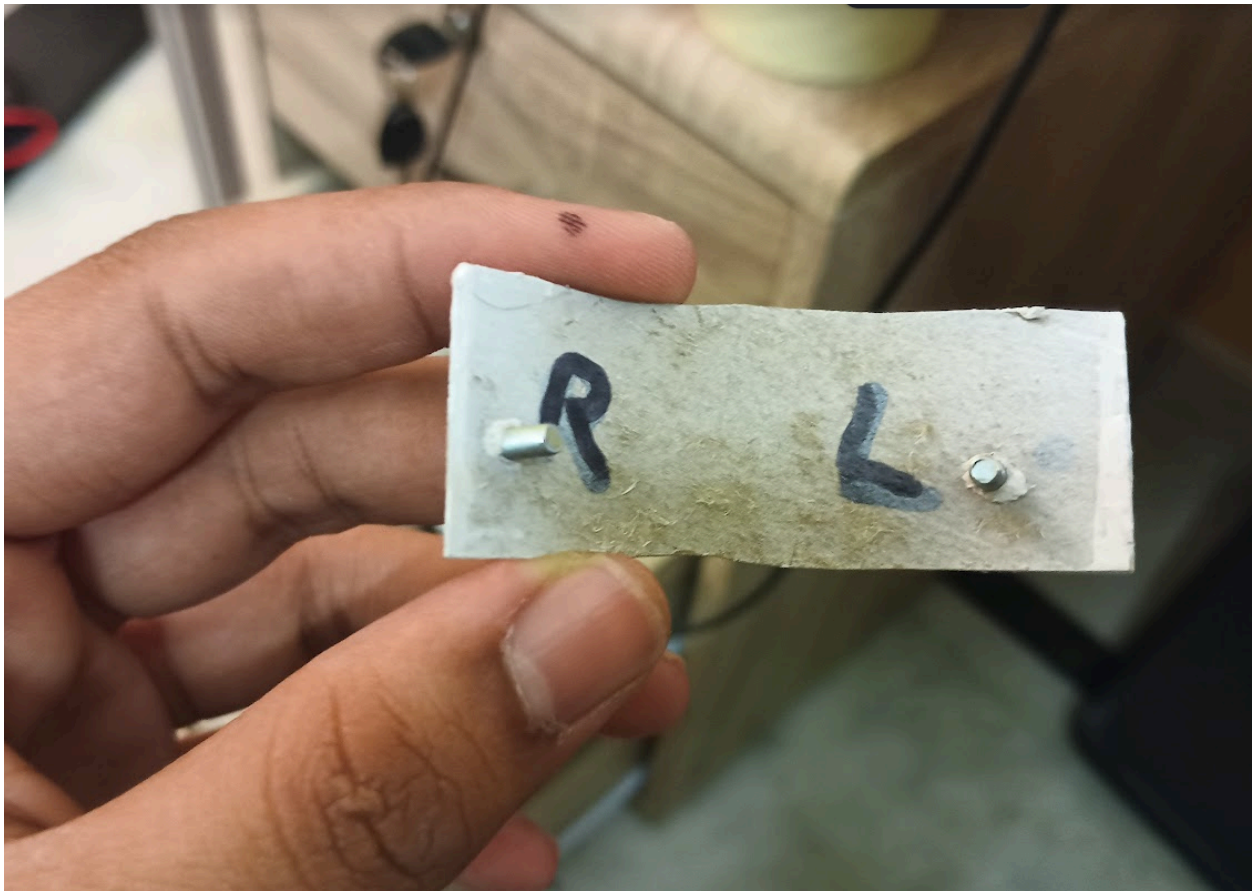
Cover the wires with some tape, this makes sure that the wires don’t come apart in flight and so that we don’t short out any of the other contacts on the flight computer



Now tuck the wires back into the airframe



This is the final step in powering the flight computer, adding the switch cover hatch. The letter R corresponds with the right side and the letter L corresponds with the left



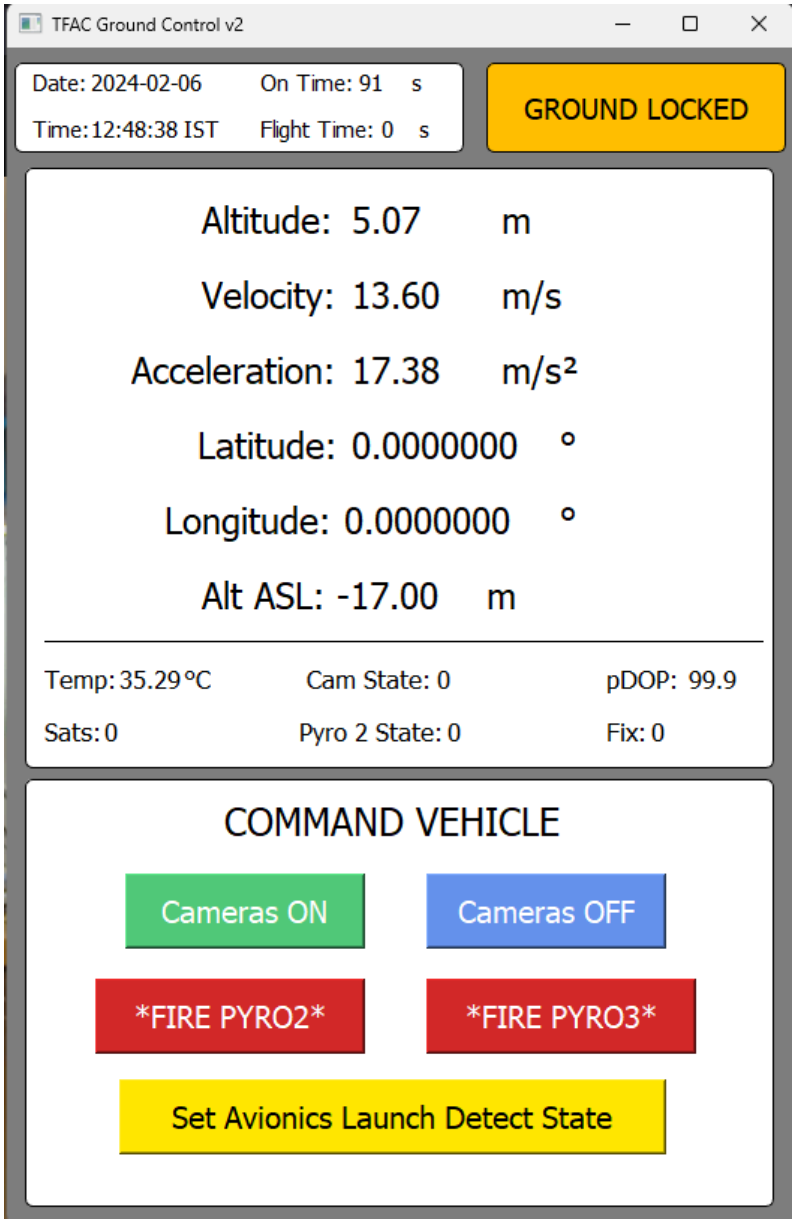
Align the hatch with the holes next to the switch cutout

And finally, push the hatch cover in

With that Air MK1 is fully assembled

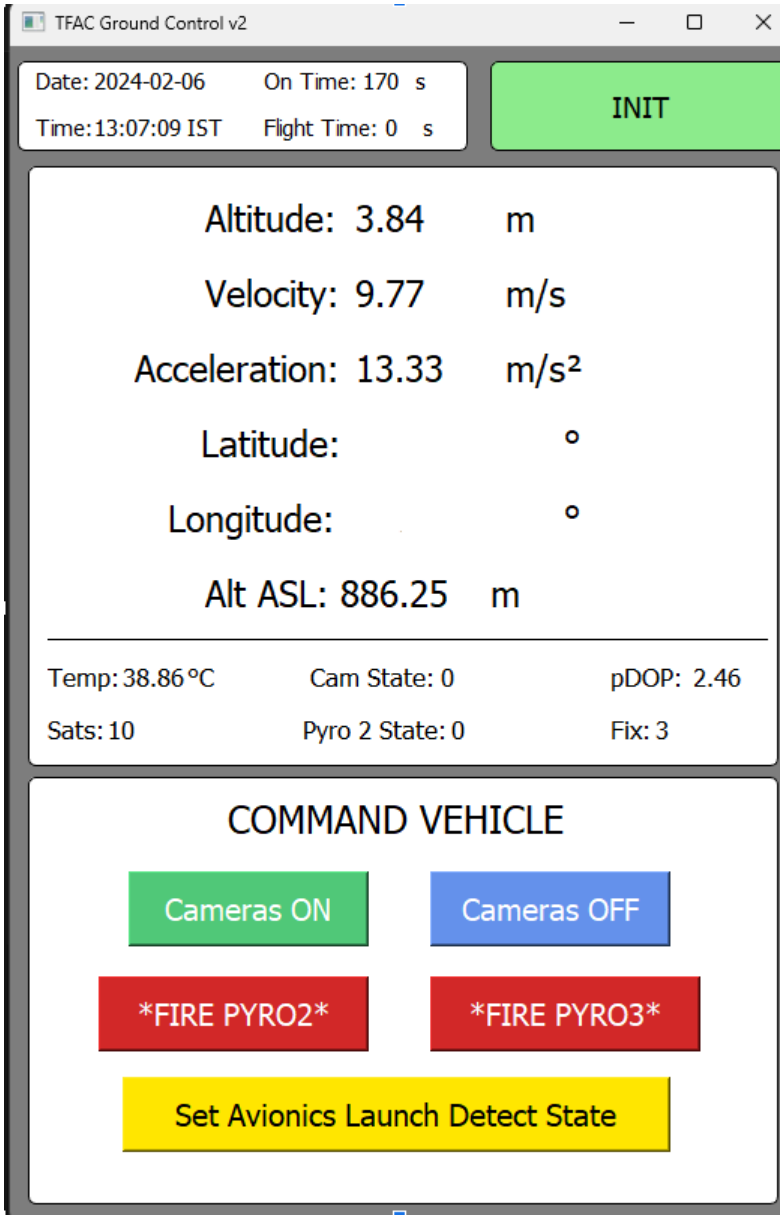
Ground Station

Once the computer is powered on wait for around ~90 seconds to open the Ground Control Software on your PC. The 90-second wait is for the flight computer to erase the flash chip which is a blocking procedure so no data can be transmitted during that period of time. Once the 90 seconds have passed run the GCS python file and you should see a window like this.

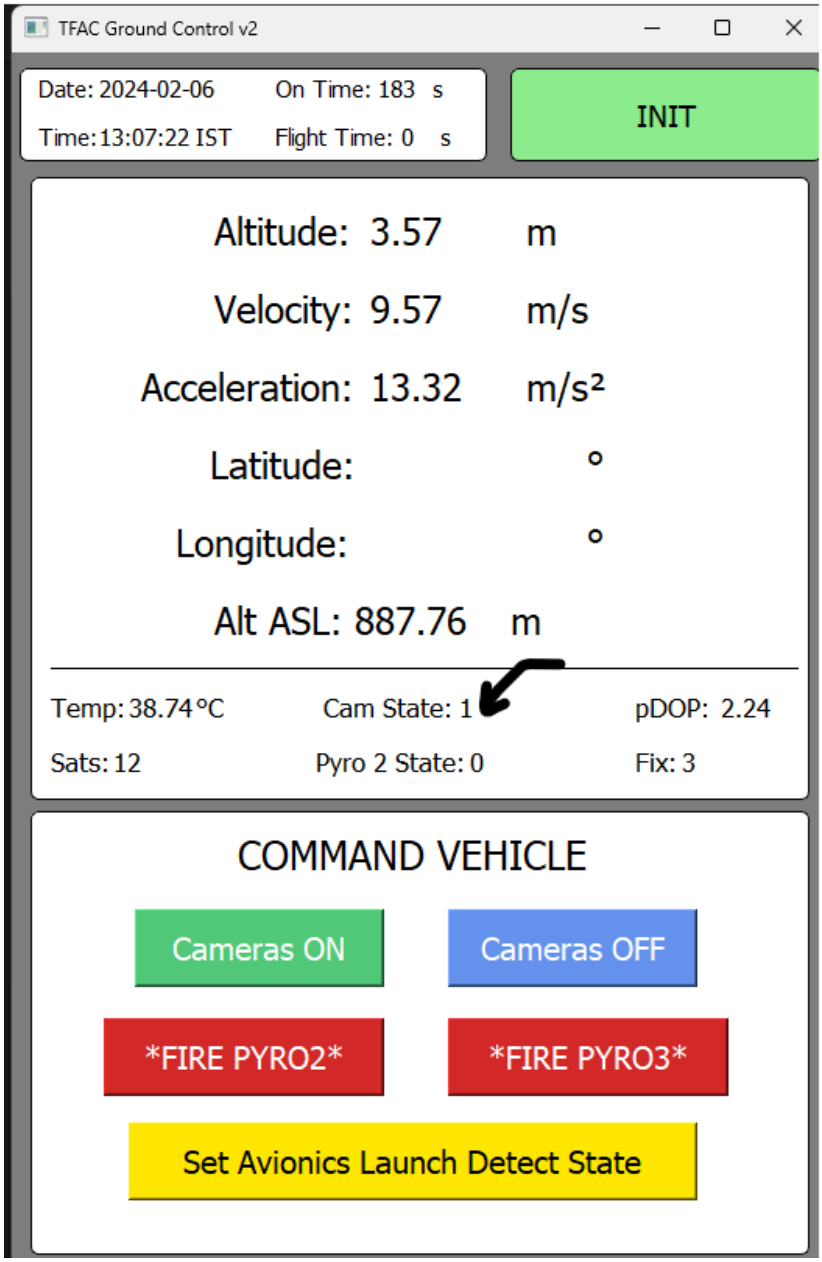


Note the orange “GROUND LOCKED” box in the upper right-hand corner. This means that the computer is waiting for a signal from the Ground Software to go into the “IDLE” state where it can detect launch.

To do this click on the yellow “Set Avionics Launch Detect” button, and the orange box should turn green and the text “IDLE” should be shown. Note: If the state doesn’t switch from “Ground Locked” to “IDLE” the first time you press the button, try pressing the button until the state switches. The GCS should now look like this:



There is one last thing to do before the rocket is ready to launch; turn on the onboard camera. To do this click on the green “Cameras ON” button. When you do this the “Cam State” Value should go from 0 (OFF) to 1 (ON). Note: if this doesn’t happen the first time then click on the “Cameras ON” button a couple more times until Cam State is 1.



With that Air MK1 is ready for launch!

Post Landing

Once the vehicle has landed remove the hatch cover and disconnect the two wires. Once you take apart the vehicle, if the flight has gone nominally you will find a .csv file full of data in TFAC's SD Card, and a .mp4 file with the flight video on the RunCam's micro SD Card.

Check List

1) Integrate the Avionics
    a) Pull test on wires
    b) Micro-SD card is in TFAC
    c) Micro-SD card is in the RunCam
    d) RunCam lens cover removed
2) Coupler
    a) Coupler fit between forward and aft airframe is tight
    b) Shock cord attached to the eye-bolt
3) Aft Airframe
    a) Shock cord is attached properly to th eye bolt
    b) Parachute packed and folded inside nomex blanket
    c) Motor Retention plate is on
4) On the rail
    a) Avionics power on wires taped properly
    b) Avionics power on wires inside airframe with hatch installed
    c) Ground Control UI displaying proper data (i.e altitude, velocity, etc is close to 0)
    d) Ground Control UI showing that vehicle is in IDLE state
    e) Ground Control UI showing that cameras are ON (camera state = 1)